UDC: 663.6, 628.16.081.32, 628.16.162.1

THE USE OF RICE IN THE TECHNOLOGY OF GLUTEN-FREE FERMENTED NON-ALCOHOLIC BEVERAGES

O. Dulka[1], Candidate of Technical Sciences, assistant,
V. Prybylskiy[1], Doctor of Technical Sciences, Professor
A. Kuts[1], Candidate of Technical Sciences, Associate Professors
S. Oliinyk[1], Candidate of Technical Sciences, Associate Professors
O. Vitriak[2], Candidate of Technical Sciences, Associate Professors,
Nguyen Phuong Dong[1], Postgraduate
[1]Department of Biotechnology for Fermentation and Winemaking Products,
National University of Food Technology
68, Volodymyrska str., Kyiv, Ukraine, 01601
[2]Department of Technology and Organization of Restaurant Business,
Kyiv National University of Trade and Economics,
19, Kyoto str., Kyiv, Ukraine, 02156

DOI: https://doi.org/10.15673/fst.v14i4.1892

Article history

Received 02.07.2020
Reviewed 14.09.2020
Revised 20.11.2020
Approved 08.12.2020

Correspondence:

O. Dulka
E-mail: olga.ds210791@gmail.com

Cite as Vancuver style citation

Dulka O, Prybylskiy V, Kuts A, Oliinyk S, Vitriak O, Dong NP. The use of rice in the technology of gluten-free fermented non-alcoholic beverages. Food science and technology. 2020;14(4):4-12. DOI: https://doi.org/10.15673/fst.v14i4.1892

Цитування згідно ДСТУ 8302:2015

The use of rice in the technology of gluten-free fermented non-alcoholic beverages / Dulka O., et al // Food science and technology. 2020. Vol. 14, Issue 4. P. 4-12 DOI: https://doi.org/10.15673/fst.v14i4.1892

Abstract. Drinks are important in the human diet. The most promising ones include fermented beverages enriched with bioactive substances of their raw materials and with products of their fermentation. Gluten-free foods, too, are becoming popular as there are more and more people worldwide suffering from coeliac disease. The paper presents the results of theoretical and experimental research on developing a technology of a fermented soft drink based on rice as a gluten-free raw material. The domestic cultivars of husked and unhusked rice described in the paper are Agat, Prestizh, and Premium. Their physical, biological, and physicochemical parameters have been studied, and their amino acid and vitamin composition, the content of macronutrients and trace elements have been determined. According to the research results, it is practical to use rice of the Agat variety in the technology of fermented beverages. Compared with the samples of Premium and Prestizh, the extractivity of Agat is higher by 2–5%, and as to the soundness of its kernels and the husk content, it exceeds them, respectively, by 2.5 and 5.5%. The fat content, which reduces the amount of esters formed during fermentation and adversely affects the foam retention of a drink, was lower in Agat by 28–37%. The content of protein compounds, vitamins, macronutrients and trace elements in grain is essential for the technology of fermented beverages. It has been established that Agat is higher in amino acids than other varieties are: by 5.7% (husked) and by 18% (unhusked). The highest content of vitamins has been found in Agat rice (on average, by 9.4% more of them). Compared with the other cultivars, unhusked Agat rice is higher in the macronutrients and trace elements that are vital for yeast activity: calcium – by 28%, magnesium – by 24%, iron – by 10–18%, copper – by 16.6%. The optimal initial concentration of yeast cells in the wort is 3–5 million/cm^3. When using husked rice, the acidity of the wort at the end of fermentation was higher by 7.6% than it was in the wort made with unhusked rice. When comparing different varieties of rice, the acidity values of the fermented wort did not differ significantly. All samples had high sensory qualities characteristic of fermented beverages.

Keywords: rice varieties, gluten-free fermented beverages, yeast, fermentation.

Introduction. Formulation of the problem

The food industry of Ukraine is one of the leading sectors of economy and has significant prospects for development due to raw materials and labour resources [1].

Gluten-free foods play an important role in the preventive and curative nutrition of people with celiac disease. Rice is a gluten-free crop and is mainly used in food in the form of cereal grains containing up to 88% of starch, 8% of protein, 0.5% of sugar, 1% of fat, as well as vitamins B_1, B_2, PP, and others. The average

calorific value of rice is 360kcal/100g (that of wheat is 330, of maize 348, of sorghum 332) [2,3]. Bakery technologies using rice have developed significantly. Rice-based products contain essential amino acids, particulary lysine, valine, methionine. Rice protein is more useful than protein of other cereals [4].

Drinks are an important part of the diet. The most promising ones are non-alcoholic fermented beverages, including bread kvass, a traditional Slavic drink common in Ukraine. Besides quenching your thirst, it provides the body with energy, as it contains easily digestible carbohydrates. Bread kvass is obtained by combining alcoholic and lactic acid fermentation of wort from kvass wort concentrate. Kvass provides the human body with B vitamins, macronutrients and trace elements, organic acids, amino acids [5]. However, the technology of kvass wort concentrate involves the use of malt from barley and rye which contain gluten. So, bread kvass is unacceptable for people with celiac disease.

Analysis of recent research and publications

According to Health Focus International, taking care of one's own health notably determines a person's choice of food [6-8]. Healthy nutrition, in particular, consuming functional foods and beverages strengthens the body defences, helps to adapt to environmental impacts, improve water-salt metabolism, normalise functioning of the gastrointestinal tract, and contribute to assimilation of other foods that are crucial in nutrition [9-12]. Soft drinks enriched with natural physiological and functional ingredients belong to the most developed products on the beverage market [5].

The scientific basis for the creation of special-purpose foods was laid in the twentieth century, when metabolic disorders (diabetes, coeliac disease, phenylketonuria, etc.) became widespread and consumers suffering from these diseases needed special-purpose beverages [7,10].

Coeliac disease (gluten enteropathy) is one of the most common genetic diseases. It affects the small intestine and impairs absorption of food nutrients. People with coeliac disease do not digest gluten, which is present in wheat, rye, barley, oats. Drinking gluten-containing drinks damages the small intestine. This disease is an autoimmune disorder and is characterised by persistent gluten intolerance. In Europe, coeliac disease is considered the most common genetic disorder and affects 0.5–2.0% of the population. In Ukraine, coeliac disease is found in 5.9% of adult people [13,14].

By the Ukrainian laws, consumers do not have to be informed about the gluten content in products, although in the countries of the European Union, the United States, Canada, there exists special labelling "gluten-free." Besides, for patients with coeliac disease, these countries manufacture gluten-free products with a special symbol on the packaging [14].

The main treatment for coeliac disease is a gluten-free diet. Gluten-containing foods are excluded from the diet. Gluten-free cereals include rice, buckwheat, and maize [15].

Varieties of rice differ in the grain size (long-grain, medium-grain, short-grain), method of processing (polished, unpolished, parboiled), varietal characteristics, and other parameters.

Long-grain rice is the most common type of rice. It is used to make pilau, side dishes, and desserts. The best cultivars are grown at the foot of the Himalayas in Northern India, in some parts of Pakistan, and in Thailand [16].

Short-grain rice is used to cook various porridges. Grown mainly in Italy, it is found in almost all Mediterranean dishes, from risotto to soups. Due to its "stickiness," this rice is used for sushi [15].

Wild rice is a perennial herb of the genus *Zizania*, family *Poaceae*. This herb is grown in the North American Great Lakes region. Wild rice contains significant amounts of nutrients, vitamins, and fibre, and helps to lower cholesterol. Wild rice grains are very stiff and have a specific taste. Wild rice is produced on a relatively small scale, and this tells on its price (it is one of the most expensive types of rice) [17].

Brown rice in Asia is eaten mainly by children and the elderly. In Europe and America, it is valued by supporters of a healthy lifestyle, because it is higher in nutrients than common rice is. During processing, brown rice retains some of its nutritious hull, which its unusual light brown colour is due to. Most of the nutrients are contained in the grain hull [18].

Parboiled rice is steamed by a special technology to improve its quality characteristics. After steaming, rice becomes amber-yellowish and translucent. Steamed rice has a number of advantages: when steamed, up to 80% of vitamins and minerals contained in the bran layer, passes into the grain [19]. The yellowish tint of parboiled rice disappears during cooking.

Unpolished rice contains many more minerals and B vitamins, and is recommended for dietetic nutrition [20].

Grains of husked rice have a smooth, even surface, a characteristic white colour, and are translucent. In terms of vitamins and minerals, white rice is inferior to brown or parboiled rice. However, it is the main type of rice consumed in the world [15,21].

To date, more than 35 cultivars of rice have been breeded by artificial selection in Ukraine. Their production reaches 65–72 thousand tonnes a year [22]. According to the NAAS Institute of Rice, Ukraine, the most promising cultivars are Dniprovsky, Agat, Yantarny, Serpnevy, Prestizh, Debyut, Ukraine-96, Pamyati Hychkina, Antey, Premium, Vikont, and Ontario. They have an acceptable vegetation period and yielding ability, are highly vitreous and low-cracky. The characteristics of these cultivars are given in Table 1 [22].

Table 1 – Characteristics of rice cultivars

Cultivar	Vegetation period, days	Yielding ability, tonnes/ha	Vitreousness, %	Crackiness, %	Weight of 1000 grains, g	General output, %
Dniprovsky	115	7.0	96	6	31.0	69.0
Agat	115	7.5	98	4	33.5	69.5
Yantarny	115	7.0	96	10	30.5	68.0
Serpnevy	112	8.0	96	4	28.0	69.0
Prestizh	100	7.0	98	4	28.0	68.5
Debyut	95	7.5	98	4	31.0	68.5
Ukraine-96	125	8.0	96	10	29.0	68.5
Pamyati Hychkina	125	8.5	96	8	34.0	68.5
Antey	128	9.0	98	8	29.0	69.0
Premium	120	8.0	100	4	31.0	69.5
Vikont	122	9.0	98	4	30.0	70.0
Ontario	125	8.5	98	6	32.0	70.0

In Japan and other Asian countries, fermented alcoholic beverages (sake, awamori, happoshu, etc.) are common. Their technology involves using rice (or malted rice) as the main raw material. When using malt for fermentation, they take wort obtained after hydrolysis of starch by its own amylolytic enzymes, and when using rice, starch is hydrolysed by enzyme preparations or enzymes of specially cultured moulds [15]. Drinks like these do not contain gluten, but are alcoholic and not intended for a wide range of consumers. Besides, they are not manufactured in Ukraine.

According to the literature, starch of cereals is important in the technology of fermented beverages. The contents of amylose and amylopectin in cereal grains are given in Table 2 [16].

Table 2 – Amylose and amylopectin content in cereals

Raw material	Content, %	
	amylose	amylopectin
Wheat	25.0±0.6	75.0±2.5
Rice	18.0±0.4	82.0±2.1
Maize	22.8±0.7	77.2±2.3

These data show that the content of amylopectin in rice is higher than in other cereals by an average of 7.5%. For fermented beverages, this is significant because dextrins, including ones of low molecular weight, affect the foam retention and the fullness of the taste of a finished beverage. Hydrolysis of amylose provides the required amount of glucose for fermentation of the wort.

In the production of beverages (especially of fermented), an important factor is raw materials. Not only must they meet the technological requirements, but also be competitive on the market. Comparing the cost of husked rice with that of unhusked rice, the latter is by 48–51% cheaper [17,19].

Thus, to expand the range of gluten-free foods, we can choose from domestic rice cultivars to determine whether they can be used in the technology of fermented soft drinks.

The purpose of the research is to study domestic rice cultivars as a promising raw material for preparation of gluten-free fermented soft drinks. The research objectives are

- to determine the physical, biological, and physicochemical parameters of domestic varieties of rice, and the content of bioactive substances in husked and unhusked rice;
- to study the dynamics of wort fermentation; to determine quality parameters of a finished drink.

Research materials and methods

The research was conducted with the use the domestic rice cultivarsAgat, Premium, and Prestizh, husked and unhusked, harvested in the Kherson Region in 2015–2018 (DSTU 4965:2008), drinking water (DSanPiN (State Sanitary Rules and Regulations) 2.2.4-171-10), the pure yeast culture *Saccharomyces cerevisiae*, race MP-10 according to its passport data.

The research methods used in the work were those commonly accepted in the brewing and non-alcoholic industry. In the test samples, the bulk density was measured with a grain tester (ISO 7971-2:1995), the mass of 1000 grains was determined by weighing (ISO 520:2015). The starch content was determined by the Ewers method, the protein substances by the Kjeldahl method (ISO 1871:1975), the extractivity by Pawlowski's method, the moisture content by the accelerated drying method (ISO 712:2007), the physiological parameters according to [23], the fat content according to ISO 7302:2003, the husk content and soundness of the kernel according to GOST 26312.4-84, the amino acids by ion exchange chromatography on a single-column Biotronik Amino Acid Analyser LC2000. The content of vitamins was determined microbiologically by the ability of testing cultures to grow in the presence of certain vitamins. The parameters also determined were: thiamine (vitamin B_1) and riboflavin (vitamin B_2) by the fluorometric method; tannin-catechin complex (vitamin PP) by the Löwenthal method using

permanganate. The macronutrients and trace elements were determined by a method based on acid treatment, isolation and quantification of cations by capillary electrophoresis. The determination of the components was performed at the wavelength 254 or 267nm (Kapel-103RT/104T, Kapel 105/105M).

The wort with the concentration 16% of dry matter was prepared by enzymatic hydrolysis of polymers of the original grain at 85–95°C for 2.5–3.5 hours, and cooled down to 30°C. Then it was fermented for 12–30 hours with the pure-culture yeast *Saccharomyces cerevisiae* MP-10 at 30°C till the dry matter content was reduced by 0.8–1.5%. The fermented wort was cooled to 3–5°C, and the yeast deposit was removed by decantation. The physicochemical and organoleptic parameters of the finished drink were determined according to DSTU 4069-2016.

Results of the research and their discussion

Based on the data from literature, the cultivars Agat, Premium, and Prestizh were selected for the research on how domestic rice varieties could be used to make gluten-free fermented soft drinks, taking into account the weight of 1000 grains and the total yield. Their physiological, biological, and physicochemical parameters are given in Tables 3 and 4.

It has been found that the bulk density of Agat was, on average, by 7% higher than that of the other cultivars. This indicator was also correlated with the weight of 1000 grains. This is important in technological processes, as it is directly related to the extractivity of the dry matter of grain, and therefore, of the wort. All the rice cultivars under study are highly germinable, so they can be used in the malt technology.

The rice samples studied differed in their physicochemical parameters. The extractivity and starch content of Agat are by 2–5% higher than those of the other samples. At the same time, Agat is by 28–37% lower in fat, and the latter reduces the amount of esters formed during fermentation and adversely affects the foam retention of the drink. The kernel soundness and husk content of this cultivar exceed those of Premium and Prestizh by 2.5 and 5.5% respectively.

In the technology of fermented beverages, it is essential how rich their grain is in protein compounds. These are hydrolysed at the stage of mashing, and, in the form of amino acids, are used by yeast as nitrogenous nutrition in wort fermentation affecting the sensory properties of the finished product. Amino acid nitrogen is the most suitable for yeast. The contents of amino acids in the husked and unhusked rice of the cultivars under study are given in Table 5.

It has been found that in Agat, the content of amino acids was higher than in the other cultivars: by 5.7% in husked, and by 18% in unhusked grain. While rice is husked, some components of the original grain, in particular, protein substances are removed. The lower content of amino acids in husked rice is due to their partial removal during husking. For the cultivar Agat, the higher content of amino acids can be explained by its anatomical structure.

One of the yeast growth factors is vitamins. Yeast enzymes are complex substances, They contain the protein part (apoenzyme) and the chemically bound non-protein part (a coenzyme). Coenzymes determine the specific effects of an enzyme, participate in its contact with the substrate, and stabilise apoenzymes. A coenzyme has two functional regions: one is responsible for binding to the apoenzyme, and the other is directly involved in the catalytic process. As a rule, coenzymes contain vitamins that provide the necessary rate of biochemical and physiological processes, in particular, in yeast cells. Participation of vitamins as coenzymes in the chemical mechanism of alcoholic fermentation is diagrammed in Fig. 1 [17].

PDC – pyruvate decarboxylase, TA – transaminase, PC – pyruvate carboxylase, PD – pyruvate dehydrogenase, SDH – saccharide dehydrogenase, ADH-1 – alcohol dehydrogenase, B_1 – thiamine, B_6 – pyridoxine, NA – nicotinic acid, Biotic acid, Biotic acid oxaloacetate, AcetAl – acetaldehyde.

The content of vitamins in husked and unhusked rice is given in Table 6.

Table 3 – Physical and biological parameters of the unhusked rice cultivars (n=3; P≥0.95)

Rice cultivar	Bulk density, g/dm^3	Weight of 1000 grains, g	Germinability, %
Agat	622.1±1%	31.4±1%	88.0±1%
Premium	576.0±1%	26.1±1%	87.5±1%
Prestizh	600.0±1%	27.1±1%	87.0±1%

Table 4 – Physicochemical parameters of the unhusked rice cultivars (n=3; P≥0.95)

Parameter	Rice cultivar		
	Agat	Premium	Prestizh
Starch content, %	75.0±0.2	72.0±0.2	69.0±0.2
Protein content, %	11.2±0.2	9.6±0.2	8.5±0.2
Extractivity, %	78.5±0.3	76.4±0.3	74.5±0.3
Moisture content, %	11.7±0.1	11.6±0.1	12.0±0.1
Sound kernel, %	99.0±0.1	98.4±0.1	96.5±0.1
Husk content, %	21.9±0.1	20.7±0.1	20.5±0.1
Fat content, %	0.5±0.05	0.7±0.05	0.8±0.05

Table 5 – Amino acid composition of rice (n=3; P≥0.95)

Amino acid	Amino acid content, mg/100 cm^3 ±5 %, in each cultivar					
	Agat		Premium		Prestizh	
	unhusked	husked	unhusked	husked	unhusked	husked
Essential						
lysine	0.32	0.29	0.30	0.25	0.31	0.28
valine	0.59	0.54	0.52	0.49	0.47	0.42
leucine та isoleucine	1.05	0.95	0.9	0.86	1.0	0.91
phenylalanine	0.46	0.42	0.42	0.37	0.42	0.37
methionine	0.19	0.15	0.17	0.17	0.185	0.15
threonine	0.29	0.26	0.27	0.23	0.29	0.245
Non-essential						
asparagine	0.14	0.1	0.14	0.12	0.15	0.11
aspartic acid	0.64	0.65	0.61	0.58	0.61	0.55
proline	0.39	0.34	0.375	0.33	0.40	0.345
alanine	0.510	0.47	0.48	0.44	0.50	0.45
glycine	0.40	0.36	0.38	0.33	0.39	0.35
histidine	0.20	0.17	0.18	0.15	0.19	0.16
tyrosine	0.28	0.18	0.28	0.19	0.26	0.26
glutamine	0.61	0.56	0.4	0.3	0.63	0.2
glutamic acid	1.06	1.06	1.15	0.9	1.03	1.02
serine	0.44	0.39	0.43	0.37	0.42	0.385
cysteine	0.04	0.03	0.04	0.02	0.05	0.04

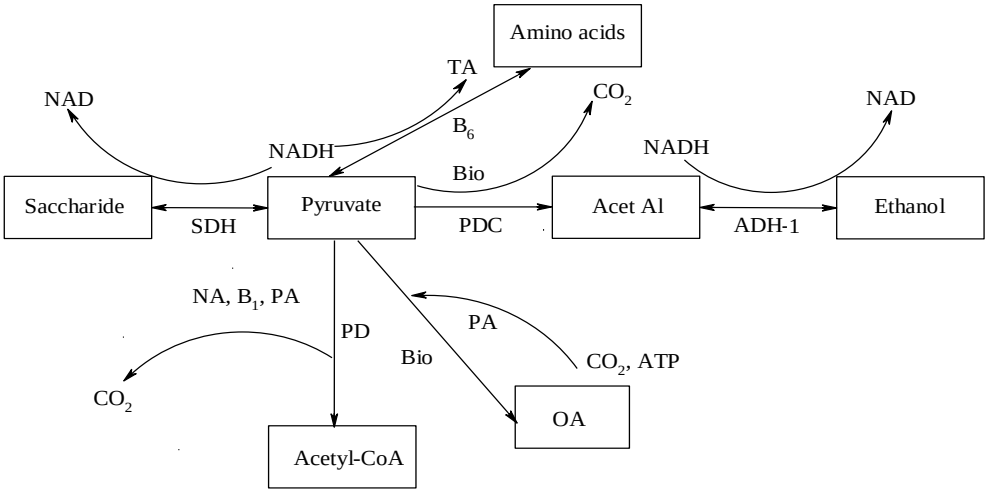

Fig. 1. Metabolism of sugars and amino acids in a yeast cell

Table 6 – Vitamin content in rice (n=3; P≥0.95)

Vitamin	Vitamin content, mg/100 cm^3 ± 5%, in each cultivar					
	Agat		Premium		Prestizh	
	unhusked	husked	unhusked	husked	unhusked	husked
B_1 (thiamine chloride)	0.058	0.045	0.053	0.042	0.059	0.046
B_2 (riboflavin)	0.009	0.007	0.008	0.005	0.009	0.006
B_5 (pantothenic acid)	0.105	0.085	0.098	0.090	0.100	0.090
B_3 (nicotinic acid)	0.49	0.42	0.50	0.44	0.48	0.43
B_6 (pyridoxine)	0.052	0.045	0.049	0.041	0.051	0.046
B_9 (folic acid)	5.15	4.3	4.95	4.1	4.75	4.0
Beta-Carotene	0.95	0.05	1.05	0.02	0.8	0.02
Choline	7.8	4.2	6.5	3.6	7.5	4.0
Vitamin E (alpha-tocopherol)	0.115	0.065	0.095	0.05	0.062	0.045

Table 7 – Content of macronutrients and trace elements in rice (n=3; P≥0.95)

Name	Content of macronutrients and trace elements, mg/100 cm^3 ± 5 %, in each cultivar					
	Agat		Premium		Prestizh	
	unhusked	husked	unhusked	husked	unhusked	husked
Calcium	1.8	1.3	1.3	0.9	1.4	0.95
Magnesium	17.0	14.5	12.5	9.5	14.2	11.5
Sodium	0.45	0.3	0.35	0.25	0.4	0.27
Potassium	32.0	29.1	28.5	26	31.0	28
Iron	0.22	0.12	0.18	0.1	0.2	0.12
Manganese	4.2	2.5	3.9	2.3	4.2	2.7
Zinc	2.8	1.5	2.6	1.2	2.8	1.5
Copper	0.3	0.2	0.25	0.15	0.25	0.18
Cobalt	0.01	0.007	0.01	0.006	0.008	0.004
Silicon	43.1	36.0	41.5	35.5	39.0	32.0
Phosphorus	48	35	45	32	46	34
Aluminium	0.95	0.82	0.95	0.80	0.93	0.80
Iodine	0.01	0.005	0.009	0.005	0.007	0.004
Fluorine	0.1	0.06	0.08	0.05	0.07	0.05

It has been found that unhusked rice of all cultivars was higher in vitamins by 36% due to the presence of vitamins in the hull. The highest vitamin content of was observed in Agat (by 9.4%). The lower content of vitamins in husked rice is because it loses them in the course of husking.

It is known that metals play an important role in the life of yeast. Macronutrients and trace elements, in ionic or bound form, are components of accessory substances, that is why they have an effect on physiological processes. The most important ones are sodium, potassium, magnesium, iron, manganese, zinc, copper, which significantly affect the biosynthesis of proteins and polysaccharides [18,19].

The content of macronutrients and trace elements in rice is given in Table 7.

It has been found that the unhusked Agat rice, compared with the other cultivars, was higher in the macronutrients and trace elements most important for yeast activity: in calcium by 28%, in magnesium by 24%, in iron by 10–18%, in copper by 16.6%. The lower content of macronutrients and trace elements in husked rice is because they are removed with the hulls in the course of husking.

Thus, it has been established that unhusked rice has a higher content of amino acids, vitamins, macronutrients, and trace elements than husked rice has. This is essential, because it tells on the activity of yeast and directly affects the biological value of the drink. All the rice cultivars studied can be used to prepare a fermented beverage, but unhusked Agat rice should be viewed as the most promising.

One of the factors determining the fermentation process is the initial concentration of yeast cells in the wort. The intensity of fermentation and the quality of the finished drink depend on it. Therefore, it is necessary to establish the optimal initial amount of yeast inoculum to ensure intensive fermentation of the wort, the excellent sensory qualities, and the normative physicochemical parameters of the finished drink. Fig. 2 and 3 show how decrease in the dry matter content during fermentation of wort from husked and unhusked rice depends on different initial concentrations of yeast cells.

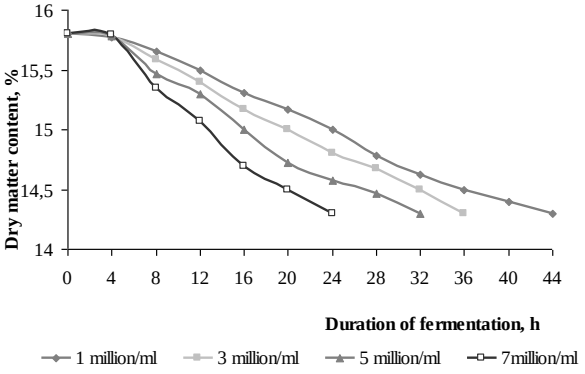

Fig. 2. Dynamics of dry matter concentration in wort from husked rice at different initial yeast concentrations

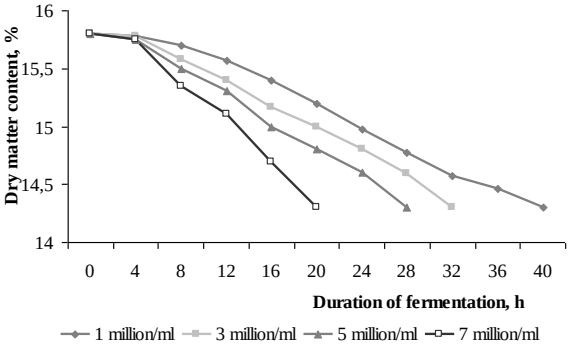

Fig. 3. Dynamics of dry matter concentration in unhusked rice wort at different initial yeast concentrations

It has been found that during fermentation of unhusked rice wort, the dry matter content decreased much faster than it did in the wort from husked rice. At

the end of the process, it decreased to the required value four hours earlier for all initial yeast concentrations. Comparison of the initial yeast concentrations in the wort has proved that yeast ferments the wort most intensively at the initial cell concentration 7million/cm^3, which is 1.7 times more than at the concentration 1 million/cm^3. However, the highest taste and aromatic properties were observed in the samples where the initial concentration had been 1–5 million/cm^3. At the concentration 7 million/cm^3, an unpleasant yeasty taste and aroma was felt.

Thus, it has been established that the optimal initial concentration of yeast cells in the wort should be considered 3–5 million/cm^3. It results in appropriate fermentation of wort from husked and unhusked grain, in the high sensory qualities of the finished drink, and in its physical and chemical parameters meeting the standard.

The acidity of the fermented wort at the initial concentration of yeast cells 3million/cm^3 is given in Table 8.

It has been found that when husked rice was used, the acidity of the wort at the end of fermentation was higher by 7.6% than it was with unhusked rice. This can be explained by the physiological state of yeast when there is not enough nutrition and production of organic acids. When comparing different rice cultivars, it was found that the acidities of the fermented wort did not differ significantly.

The sensory characteristics of the finished fermented beverage based on the husked and unhusked rice of the cultivar Agat, are given in Table 9.

All the samples tested had high organoleptic characteristics. The taste and aroma were characteristic of fermented beverages. By the sensations of carbonation, the first sample was more acceptable. This might be due to the more intensive fermentation of unhusked rice wort, which is richer in vitamins and amino acids than husked rice is.

Table 8 – Acidity of fermented wort (n=3; P≥0.95)

No. of sample	Kind of rice	Titratable acidity, cm^3 of sodium hydroxide solution with the concentration 1 mol/dm^3 per 100 cm^3 of wort			Active acidity, pH units		
		Agat	Premium	Prestizh	Agat	Premium	Prestizh
1	Unhusked	1.2	1.2	1.2	3.86	3.84	3.87
2	Husked	1.25	1.3	1.3	3.79	3.65	3.68

Table 9 – Sensory characteristics of a rice-based fermented drink

No. of sample	Kind of rice	Sensory parameters (rating)		Total score
		colour, appearance	taste and aroma	
1	Unhusked	Straw-coloured with a dark shade, no turbidity (9 points)	The taste is characteristic of a fermented drink, with an original aftertaste, refreshing (10 points)	19 points (“Excellent”)
2	Husked	Straw-coloured, no turbidity (9 points)	The taste is characteristic of a fermented drink, with an original aftertaste (10 points)	19 points (“Excellent”)

Conclusion

1. It has been studied how suitable domestic rice varieties are for making gluten-free fermented soft drinks, and the prospects of using the rice cultivars Agat, Premium, and Prestizh have been determined.

2. The physical, biological, and physicochemical parameters of these rice cultivars and the content of bioactive substances in husked and unhusked rice have been determined.

3. It has been established that using unhusked rice, in comparison with husked rice, intensifies fermentation and allows achieving high sensory characteristics of the finished drink.

4. The sensory parameters of fermented drinks made with the use of husked and unhusked rice of the cultivar Agat have been determined.

References:

1. Simahina GO, Ukrayinecz AI. Texnologiya ozdorovchyx xarchovyx produktiv. Kyiv: NUXT. 2009.
2. Shewry PR, Hey SJ. Do we need to worry about eating wheat? Nutrition Bulletin published by John Wiley & Sons Ltd on behalf of British Nutrition Foundation. Nutrition Bulletin. 2016;41(4):6-13. https://doi.org/10.1111/nbu.12186.
3. Reilly R, Green P. Epidemiology and clinical presentations of celiac disease. Seminars in immunopathology. Springer-Verlag. 2012;34:473-478. https://doi.org/10.1007/s00281-012-0311-2.
4. Scherf KA, Poms RE. Recent developments in analytical methods for tracing gluten. Journal of Cereal Science. 2016;67:112-122. https://doi.org/10.1016/j.jcs.2015.08.006.
5. Dulka O, Prybylskyi V, Oliinyk S, Kuts A, Vitriak O. Influence of physicochemical parameters of water on the amino acid composition of bread kvass. Ukrainian Food Journal. 2020;9(3):610-624. https://doi.org/10.24263/2304-974X-2020-9-3-10.
6. Kaprelyancz LV, Petrosyancz AP. Likuvalno-profilaktychni vlastyvosti harchovyh produktiv ta osnovy diyetologiyi. Odesa. 2011.
7. Betoret E, Betoret N, Vidal D, Fito P. Functional foods development: trends and technologies. Trends in food science and technology. 2011;22(9):498-508. https://doi.org/10.1016/j.tifs.2011.05.004.

8. Kaprelyants L, Yegorova A, Trufkati L. Pozhitkova L. Functional foods: prospects in Ukraine. Food Science and Technology. 2019;13(2):15-23. https://doi.org/10.15673/fst.v13i2.1382.
9. Osipova LA. Naukove obgruntuvannya tehnologiyi funkcionalnyx napoyiv na osnovi pryano-aromatychnyh Roslyn. Portal harchovoyi promys-lovosti «Harchovyk» [Internet]. 2007 May 16 [cited 2020 Jan 16]. Available from: http://www.harchovyk.com/content/detail/13/
10. Pasternak D. Na polycyah – zdorova yizha! Portal harchovoyi promyslovosti «Harchovyk» [Internet]. 2010 June 26 [cited 2020 Jan 25]. Available from: http://www.harchovyk.com/ru/content/detail/366.
11. Koltko JuJu. Cuchasnyj stan ta perspektyvy rozvytku rynku napoyiv v Ukrayini. [Internet]. 2016 Apr 28. [cited 2019 Dec 5]. Available from: https://er.knutd.edu.ua/bitstream/123456789/2549/1/20160428-29_TEZY_V3_P179.pdf .
12. Dulka O, Prybylskyi V, Oliinyk S, Kuts A, Vitriak O. Using of clinoptilolite, activated charcoal and rock crystal in water purification technology to enhance the biological value of bread kvass. Ukrainian Food Journal. 2019;8(2):307-316. https://doi.org/10.24263/2304-974X-2020-9-3-10.
13. Farage P, De Medeiros Nóbrega Y, Pratesi R, Gandolfi L. Assunção P, Zandonadi R. Gluten contamination in gluten-free bakery products: a risk for coeliac disease patients. Public Health Nutrition. 2017;20(3):413-416. https://doi.org/10.1017/S1368980016002433.
14. Sapone A, Bai JC, Ciacci C, Dolinsek J, Green PH, Hadjivassiliou M, et al. Spectrum of gluten-related disorders: consensus on new nomenclature and classification. BMC Med. 2012;10(1):1-12 https://doi.org/10.1186/1741-7015-10-13
15. Koshova V, Mukoid R, Parkhomenko A. Influence of low-gluten grain crops on beer properties. Ukrainian Food Journal. 2020;9(3):600-610. https://doi.org/10.24263/2304-974X-2020-9-3-9.
16. Osinnij OA, Averchev OV, Lavrenko SO. Vplyv tepnologichnyp pryjomiv vyroshhuvannya rysu na vrozhajnist zerna pry kraplynnomu zroshenni v umovap Pivdennogo Stepu Ukrayiny. Tavrijskyj naukovyj visnyk. 2020;113:104-113. https://doi.org/10.32851/2226-0099.2020.113.15.
17. Puggioni A. Riso, la rivoluzione di Netafim in una goccia. AgroNotizie. [Internet]. 2014 Oct 22. [cited 2020 April 20]. Available from: https://agronotizie.imagelinenetwork.com/agrimeccanica/2014/10/22/riso-larivoluzione-di-netafim-in-una-goccia/40366.
18. Wayne SC, Dilday H, editors. Rice origin, history, technology, and production. New Jersey: John Wiley & Sons, 2002.
19. Shazzo AA, Czokur PV, Shazzo BK, Kornena EP. Hymycheskyj sostav y pyshhevaya cennost shelushennogo obiknovennogo y krasnozernogo rysa. Pyshh. tehnol. 2009;2-3:117-118.
20. Lyaxovkyn AG. Rys. Myrovoe proyzvodstvo y genofond. Profy-Ynform. 2005.
21. Sudin VM, Petkevych ZZ. Vrozhajnist sortiv rysu riznyh grup styglosti ta tryvalist vegetacijnogo periodu. Zroshuvane zemlerobstvo. 2007;47:73-77.
22. Vozhegova RA. Stanovlennya ta rozvytok selekciyi silskogospodarskyx kultur v Ukrayini. Kyyiv. 2007.
23. Meletyev AY, Todosijchuk SR, Koshova VM. Tehnologichnyj kontrol vyrobnycztva solodu, pyva i bezalkogolnyx napoyiv. Vinnica, Nova kniga; 2008.
24. Berg JL, Tymoczko J, Stryer L. Biochemistry. New York: W.H. Freeman, 2002.
25. Meledyna TV, Davydenko SG. Drozhzhy Sassharomuses serevisiae. Morfologyya, hymycheskyj sostav, metabolyzm. Sankt-Piterburg, 2015.
26. Meledyna TV, Davydenko SG, Vasyleva LM. Fyzyologycheskoe sostoyanye drozhzhej. Sankt-Piterburg, 2013.

ВИКОРИСТАННЯ РИСУ У ТЕХНОЛОГІЇ БЕЗГЛЮТЕНОВИХ ФЕРМЕНТОВАНИХ БЕЗАЛКОГОЛЬНИХ НАПОЇВ

О.С. Дулька[1], кандидат технічних наук, асистент, *E-mail*: olga.ds210791@gmail.com
В.Л. Прибильський[1], доктор технічних наук, професор, *E-mail*: undihp63@ukr.net
А.М. Куц [1], кандидат технічних наук, доцент, *E-mail*: anatolykuts@ukr.net
С.І. Олійник[1], кандидат технічних наук, доцент, *E-mail*: lana_ol@ukr.net
О. П. Вітряк [2], кандидат технічних наук, доцент, *E-mail*: vitrox@ukr.net
Нгуен Фионг Донг[1], аспірант, *E-mail*: npdong568@gmail.com
[1]Кафедра біотехнології продуктів бродіння і виноробства
Національний університет харчових технологій, вул. Володимирська, 68, м. Київ, Україна, 01601
[2]Київський національний торговельно-економічний університет, вул. Кіото, 19, м. Київ, Україна, 02000

Анотація. Напої займають важливе місце у раціоні харчування людини. Перспективними є ферментовані напої, які багаті на біологічно активні речовини сировини і продукти бродіння. Стають також популярними безглютенові продукти, оскільки у світі збільшується кількість людей, які хворіють на целіакію. У статті наведено результати теоретичних та експериментальних досліджень з розробки технології ферментованого безалкогольного напою на основі рису, як безглютенової сировини. У роботі наведено характеристику вітчизняних сортів обрушеного і необрушеного рису сортів Агат, Престиж та Преміум. Досліджено їхні фізичні, біологічні та фізико-хімічні показники, амінокислотний, вітамінний склад та вміст макро- й мікроелементів. Результати проведених досліджень свідчать про доцільність використання для приготування ферментованого напою рису сорту Агат, у якого в порівнянні зі зразками Преміум і Престиж екстрактивність була вищою на 2–5%, за показниками доброякісності ядра та плівчастості відповідно на 2,5 та 5,5%. При цьому вміст жиру, який зменшує кількість утворених естерів при бродінні та негативно впливає на піностійкість напою сорт Агат, був меншим на 28–37%. Суттєве значення для технологій ферментованих напоїв має вміст у зерні білкових сполук, вітамінів, макро- та мікроелементів. Встановлено, що вміст амінокислот для сорту Агат у порівнянні з іншими сортами був вищим, зокрема для обрушеного – на 5,7%, для необрушеного – на 18%. Найбільший вміст вітамінів визначено в рисі сорту Агат (в середньому на 9,4%). У порівнянні з іншими сортами, у необрушеному рисі сорту Агат вміст найбільш важливих для життєдіяльності дріжджів макро- та мікроелементів був більшим: кальцію – на 28%, магнію – на 24%, заліза – на 10–18%, міді – на 16,6%. Оптимальною початковою концентрацією дріжджових клітин в суслі є 3–5 млн/см^3. За використання обрушеного рису кислотність сусла у кінці бродіння була вищою у порівнянні з суслом із необрушеного рису на 7,6%. При порівнянні різних сортів рису значення кислотності зброджeного сусла суттєво не відрізнялись. Усі зразки мали високі органолептичні показники, властиві ферментованим напоям.

Ключові слова: рис, безглютенові ферментовані напої, дріжджі, бродіння.

Список літератури:

1. Сімахіна Г.О., Українець А.І. Технологія оздоровчих харчових продуктів. Київ: НУХТ, 2009. 312 с.
2. Shewry P.R., Hey S.J. Do we need to worry about eating wheat? Nutrition Bulletin published by John Wiley & Sons Ltd on behalf of British Nutrition Foundation // Nutrition Bulletin. 2016. Vol. 41, №4. P. 6-13. https://doi.org/ 10.1111/nbu.12186.
3. Reilly R., Green P. Epidemiology and clinical presentations of celiac disease // Seminars in immunopathology / Springer-Verlag. 2012. № 34. P. 473-478. https://doi.org/10.1007/s00281-012-0311-2.
4. Scherf K.A., Poms R.E. Recent developments in analytical methods for tracing gluten // Journal of Cereal Science. 2016. № 67. P. 112-122. https://doi.org/10.1016/j.jcs.2015.08.006.
5. Influence of physicochemical parameters of water on the amino acid composition of bread kvass / Dulka O. et al // Ukrainian Food Journal. 2020. №9 (3). P. 610-624. https://doi.org/10.24263/2304-974X-2020-9-3-10.
6. Капрельянц Л. В., Петросьянц А.П. Лікувально-профілактичні властивості харчових продуктів та основи дієтології. Одеса: Друк, 2011. 269с.
7. Functional foods development: trends and technologies / Betoret E. et al // Trends in food science and technology. 2011. № 22 (9). P. 498-508. https://doi.org/10.1016/j.tifs.2011.05.004.
8. Kaprelyants L., Yegorova A., Trufkati L. Functional foods: prospects in Ukraine // Food science and technology. 2019. Vol. 13, Issue 2. P. 15-23. https://doi.org/10.15673/fst.v13i2.1382.
9. Осіпова Л.А. Наукове обгрунтування технології функціональних напоїв на основі пряно-ароматичних рослин // Харчовик, 2007. URL: http://www.harchovyk.com/content/detail/13 (дата звернення 16.01.2020).
10. Пастернак Д. На полицях – здорова їжа! // Харчовик, 2010. URL: http://www.harchovyk.com/ru/content/detail/366 (дата звернення 25.01.2020).
11. Колтко Ю.Ю. Сучасний стан та перспективи розвитку ринку напоїв в Україні: веб-сайт. URL: https://er.knutd.edu.ua/bitstream/123456789/2549/1/20160428-29_TEZY_V3_P179.pdf (дата звернення 5.12.2019) .
12. Using of clinoptilolite, activated charcoal and rock crystal in water purification technology to enhance the biological value of bread kvass / Dulka O. et al // Ukrainian Food Journal. 2019. №8 (2). P. 307-316. https://doi.org/10.24263/2304-974X-2020-9-3-10.
13. Gluten contamination in gluten-free bakery products: a risk for coeliac disease patients / Farage P. et al // Public Health Nutrition. 2017. № 20(3). P. 413-416. https://doi.org/10.1017/S1368980016002433.
14. Spectrum of gluten-related disorders: consensus on new nomenclature and classification / Sapone A. et al. // BMC Med. *2012*. *№*10(1). https://doi.org/10.1186/1741-7015-10-13.
15. Koshova V., Mukoid R., Parkhomenko A. Influence of low-gluten grain crops on beer properties // Ukrainian Food Journal. 2020. № 9(3). P. 600-610. https://doi.org/10.24263/2304-974X-2020-9-3-9
16. Осінній О.А., Аверчев О.В., Лавренко С.О. Вплив технологічних прийомів вирощування рису на врожайність зерна при краплинному зрошенні в умовах Південного Степу України // Таврійський науковий вісник. 2020. №113. С.104-113. https://doi.org/10.32851/2226-0099.2020.113.15.
17. Puggioni A. Riso, la rivoluzione di Netafim in una goccia // AgroNotizie. 2014. URL: https://agronotizie.imagelinenetwork.com/agrimeccanica/2014/10/22/riso-larivoluzione-di-netafim-in-una-goccia/40366. (viewed 10.01.2020p).
18. Rice origin, history, tehnology, and production / ed. by Wayne Smith C. New Jersey: John Wiley& Sons, 2002. 656 p.
19. Химический состав и пищевая ценность шелушенного обыкновенного и краснозерного риса / Шаззо А.А. и др. // Изв. вузов. Пищ. технол. 2009. № 2(3). С. 117-118.
20. Ляховкин А. Г. Рис. Мировое производство и генофонд. СПб.: Профи-Информ, 2005. 288 с.
21. Судін В.М., Петкевич З.З. Врожайність сортів рису різних груп стиглості та тривалість вегетаційного періоду // Зрошуване землеробство: міжвід. темат. наук. зб. 2007. № 47. С. 73-77.
22. Вожегова Р.А. Становлення та розвиток селекції сільськогосподарських культур в Україні: монографія. Київ: Наукове видання Інституту рису УААН, 2007. 266 с.
23. Мелетьєв А.Є., Тодосійчук С.Р., Кошова В.М. Технологічний контроль виробництва солоду, пива і безалкогольних напоїв: підруч. Вінниця: Нова книга, 2008. 300 с.
24. Berg J., Tymoczko J., Stryer L. Biochemistry. New York: W.H. Freeman, 2002. 949 p.
25. Меледина Т. В., Давыденко С.Г. Дрожжи Saccharomyces cerevisiae. Морфология, химический состав, метаболизм: учебное пособие. СПб.: Университет ИТМО, 2015. 88с.
    Меледина Т. В., Давыденко С.Г., Васильева Л. М. Физиологическое состояние дрожжей. СПб.: НИУ ИТМО ИхиБТ, 2013. 48 с.