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Carbohydrate-amylase Complex of By-products of Rice Grain Processing

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The results of studying the carbohydrate-amylase complex of by-products of processing rice grain have been presented. The composition and the content of carbohydrates in the studied products have been determined. The studies have shown that attacks of starch by exogenous α-amylase in various by-products are not identical. Starch of immature grains of rice, grits of rice, and broken rice are most available to the action of this ferment. Studying activity of amylolytic enzymes in the products of processing rice grains showed that their effect was insignificant, while the highest activity of the amylase was observed in immature grains of rice. Studying the physico-chemical properties of the carbohydrate-amylase complex of by-products of grain rice processing showed that they contained amylolytic enzymes with high enzymatic activity. High water absorption ability of starch that is a part of by-products of rice processing, and its availability to the action of exogenous amylases make it possible to use these products for intensifying the biochemical processes in bread production.

Key words: processing products, rice, carbohydrate-amylase complex, enzyme activity

One of the ways to increase efficiency of public production is to create progressive, low waste and waste-free technologies, save material resources and efficiently use all kinds of raw materials[1].

An important reserve for reducing materials consumption in food production and saving natural resources is increased usage of by-products.

In baking, traditional raw materials are wheat and rye flour, salt, sugar, various fats. The baking industry knows the use of by-products of the milling industry with high content of useful, digestible substances - vitamins, amino acids, proteins, carbohydrates, minerals, etc. These raw materials, which are untraditional for bakery, can serve as a valuable additive in bread production, which results in saving material resources, and at the same time, in increasing the nutritional value of finished products[2, 3]. There also seems to be an opportunity to intensify the technological process of baking bread and to improve its physico-chemical properties[4, 5].

Among crops, along with wheat and rye, rice belongs to world's leading cereal crops; it takes an important place in the diet. In converting rice to corn, valuable by-products are obtained: hulling bran after various systems of rice milling, broken rice, fine rice grits, immature and hollow rice grains, corcules, etc[6].

At present, the by-products are used impractically. In the best case, they are used in forage production. At the same time, these products of rice processing feature valuable chemical composition, and can be used in food industry[7, 8].

However, chemical components of rice

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processing and their active enzyme complex can influence components of wheat flour and dough, which would strongly affect the quality of ready products. Therefore, studying the chemical composition of these products and their interaction with the components of wheat flour may be significant for improving the baking technology, and for creating new varieties of products.

The decisive role in bread formation and its volume is played by the carbohydrate-amylase complex of the wheat flour. Starch, along with other light-hydrolyzing carbohydrates, is the main reserve substance of seeds[9]. It is used as an energy material during seed germination, and in using grain for food; it is a source of energy.

One of the tasks that we faced was to study the peculiarities of the carbohydrate-amylase complex of rice by-products in order to determine the possibility of using them in the baking industry.

Methods

The studies used the generally accepted and special organoleptic, physical, chemical, and mathematical research methods. The composition of carbohydrates was determined by HPLC. The content of soluble and insoluble fractions of carbohydrates was determined with the use of the multistage fermentation method (after preliminary homogenization of the sample) AOAC Official Method 2001. 03 with the use of the Fibertec filtration system, E 1023 filtration module and the 1024 shaking water bath manufactured by FOSS, Sweden. Activity of the amylolytic enzymes was determined with the use of the colorimetric method with a RS-10 photocolorimeter. To determine the amylographic characteristics, a Brabender amylograph was used.

RESULTS AND DISCUSSION

Our studies showed that the studied products of rice grain processing significantly differed in the content of carbohydrates (Table 1).

Analysis of the experimental data in Table 1 shows that the greatest amount of starch is contained in broken rice and rice grains. Corcules contain negligible amount of starch[10], but due to the complexity of extraction, the fraction of rice corcule contains fine rice grits. This fact explains the presence of 32.2% of starch in this fraction.

In hulling bran, starch content increases from system to system, since in course of milling it takes more and more of starchy endosperm.

It is known that rice starch consists of complex starch grains characterized by small size of grains of 5 to 15 μm, and the smaller starch granules are found in the peripheral parts of caryopses[11-12].

In this regard, rice starch is highly attacked by amylases[12, 13], which is very important in studying the possibility of using rice by-products in baking.

Studying this issue is not only of scientific, but also of practical importance, since, on the one hand, starch being subjected to the action of amylases may have a negative impact on the seed and on the commercial batches of rice; but on the other hand, this phenomenon may be positive, improving the nutritional quality of by-products of rice processing, making absorption of starch by the human body easier.

As it has been shown by results of the studies shown in Table 2, the attacking of starch by exogenous α-amylase is not identical for various

Table 1. Content of carbohydrates in the by-products of rice processing

Products of rice processing	Carbohydrates content		
	Cellulose, %	Starch, %	Reducing sugars, mg/g
Hulling bran, mix from all systems	9.98	52.5	1.21
Hulling bran from the 3d milling system	5.95	60.8	1.54
Hulling bran from the 4th milling system	4.6	68.5	1.76
The corcule fraction	3.7	32.2	10.6
Immature rice grains	1.21	75.3	0.63
Fine rice grits	1.7	84.3	0.49
Broken rice	0.93	85.0	0.46

by-products. The ±-amylase mostly attacks starch in immature grains of rice, fine rice grits and broken rice, and slightly less - in the hulling bran from various milling systems. The action of the exogenous ²-amylase on starch in all by-products of rice processing is virtually the same.

The amount of cellulose in the mixture of hulling bran from all systems 10 times exceeds the content of cellulose in broken rice, 1.7 times exceeds the content in the hulling bran from the third milling system, and 2.7 times exceeds the content in the corcule (Table 1).

There is a very significant difference in the content of reducing sugars. The greatest amount of reducing sugars is in the corcule fraction, 10.6%. The immature rice corns contain 0.63% of reducing sugars, which is 2.5 times less than in the hulling bran from the third and fourth milling systems. Fine rice grits and broken rice contain little reducing sugars (0.46 – 0.49%).

It is known that amylolytic ferments exhibit the highest activity during germination, and activity of the α-amylase increases 24-40 times, as compared to the air-dry seeds.

Studying the activity of amylolytic enzymes in the products of processing rice grains showed that their effect was insignificant, while the highest activity of the amylase was observed in immature rice grains. This is because in the immature rice grains, the process of forming complete caryopsis has not yet been completed, and the enzymes are in the active state. The activity of amylase is slightly lower in the corcule and hulling bran, whereas in rice grits and broken rice, their activity is relatively high, and amounts to 12% of their activity in the corcule, and to 10% in immature grains.

Table 2. Starch being attacked by exogenous amylases in by-products of rice grains processing

Products of rice processing	Starch subject to attacks, mg of glucose/ g lt.	
	α-amylase	β-amylase
Hulling bran, mix from all systems	21.65	28.43
Hulling bran from the 3d milling system	21.71	28.72
Hulling bran from the 4th milling system	21.58	28.17
The corcule fraction	19.44	28.03
Immature rice grains	22.93	29.79
Fine rice grits	22.42	29.13
Broken rice	22.74	29.34

Table 3. Activity of amylolytic enzymes in by-products of processing of rice grains

Products of rice processing	Activity of amylases, mg of starch/mg of protein		
	α+β	α	β
Hulling bran, mix from all systems	37.5	18.0	19.5
Hulling bran from the 3d milling system	48.9	18.8	30.1
Hulling bran from the 4th milling system	38.7	16.3	22.4
The corcule fraction	59.8	29.4	30.4
Immature rice grains	66.6	35.2	31.4
Fine rice grits	10.4	2.1	8.3
Broken rice	7.3	1.5	5.8

The share of β-amylase in the corcule and the hulling bran is 58 to 62% of the total amylolytic activity, whereas in rice grits and broken rice, the activity of β-amylase is 80% (Table 3).

In immature grains of rice, along with β-amylase in the active state, there is α-amylase, and its share is 52 to 56% of the total amylolytic activity. Therefore a conclusion may be made that α-amylase is localized to a greater extent in the peripheral parts of the caryopsides and in the corcule of rice, and remains in the hulling bran after milling.

As it is known, wheat flour in its active form contains only β-amylase, therefore, introducing rice processing products, namely, hulling bran, immature rice grains, corcule fractions that contain active α-amylase into bread-making will make it possible to speed up the biochemical processes in its carbohydrate-amylase complex.

It is believed that the most important factor that also influences the technological properties of rice grain processing by-products is amylose content in starch[14, 15]. The research, with it results presented in Table 4, shows that in the hulling bran, in the mixture from all milling systems and in immature grains of rice the content of amylose is by 2.2 to 3% higher than those in fine rice grits and the corcule fraction. However, in the corcule fraction, the percentage is slightly higher than that in fine rice grits (Table 4).

The quality of by-products from processing rice grains is also influenced by the content of water-soluble amylose in starch, the less it is, the better the technological properties of these products are, when they are used in bread making[6,7]. The data in Table 4 shows that the corcule fraction contains less water-soluble amylose than other products.

Studying the qualitative features of starch components using the method of meta-column chromatography according to Ullmann showed that the amylopectine area in all studied by-products consisted of two sub-fractions – the highly polymerized one, which became dark-violet in reaction with iodine, and the fraction of light purple color, i.e., with lower molecular weight. In starch, amylose is represented by one sub-fraction of blue color, which indicates the high degree of polymerization of this polysaccharide [14]. It should be noted that amylose in the hulling bran, the mix from all systems, immature rice grains and the corcule fraction had more intense coloring, as compared to fine rice grits, which fact indicates a greater degree of polymerization of this fraction in these products, as compared to coarse rice grits.

The physico-chemical properties of starch in the studied by-products of processing rice grains are also characterized by the amylograph data analysis.

Table 4. Properties of starch in by-products of rice grain processing

Products of rice processing	Amylose content, %		Color and height, mm of chromatogram		Amylograph characteristics		
	General	Water-soluble	Amylose	Amylopectine	Gelatinization point, °C	Aminogram peak, u.a.	Deliquating point, °C
Hulling bran, mix from all systems	21.5	13.6	blue35	dark purple -10;light purple -7	63	1,540	88
The corcule fraction	20.6	11.4	blue35	dark purple -7;light purple -10	66	1,520	87
Immature rice grains	22.8	14.1	blue35	dark purple -11;light purple -6	65	1,530	89
Fine rice grits	19.8	12.5	light blue30	dark purple -6;light purple -8	61	1,580	89

It is known that starch, which is gelatinized at high temperatures, has tighter mycelial structure, and the products containing such starch are decomposed hardlier when exposed to high temperatures. The products with lower amylograph curve peak, low rate of starch granules decomposition, and high viscosity gradient feature better technological properties[6, 16].

The data in Table 4 shows that starch in immature grains of rice has the highest point of gelatinization (65°C), and fine rice grits have the lowest (61°C) point of gelatinization. However, starch in fine rice grits has the best amylograph characteristics (amylograph peak, the rate of starch granules decomposition, viscosity gradient). Lower quality of starch that characterizes the technological properties of by-products of rice grains processing is characteristic of immature grains of rice, and the worst amylograph characteristics are observed in the starch from the corcule fraction.

CONCLUSION

Thus, the study of the physico-chemical properties of the carbohydrate-amylase complex of by-products of rice grain processing has shown that they contain amylolytic enzymes with high enzymatic activity. High water absorption ability of starch that is part of by-products of rice processing, and its availability to the action of exogenous amylases make it possible to use these products for intensifying the biochemical processes in bread production.

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