European Online Journal of Natural and Social Sciences 2014;
Vol.3, No.3 pp. 619-627
ISSN 1805-3602

Developing Methods and Optimal Conditions of Rice Bran Processing with the Purpose of Increasing its Storage Stability

A.A. Boldina
Department of Agricultural Production Storage and Processing at FSBEI HPE, Kuban State Agrarian University, Krasnodar, Russia
E-mail: aa_boldina_kubsau@mail.ru

Received for publication: 12 May 2014.
Accepted for publication: 30 July 2014.

Abstract

The article provides research findings on changes in quality indicators and biochemical properties of rice bran during storage. Efficient conditions for quality stabilization have been developed.

Keywords: Rice bran, storage, acid value of lipids, enzyme activity, infrared heat processing, microwave processing.

Introduction

Integrated grain processing, the fullest extraction of its valuable components and rational utilization of secondary raw material resources are the most vital provisions for increasing production output and performance.

One of the fundamental directions of rational utilization of raw material resources is the transition towards low- and non-waste technologies.

Currently the proportion of advanced raw material processing amounts to 30% in Russia and 90-98% in European countries and the USA. Thus, as a result of processing grain into grits, a relatively small portion of valuable raw materials (45-67%) is extracted, while the other portion is comprised of waste or by-products.

By-product of processing rice into grits is rice bran, which is a high-quality secondary raw material. However, now it is utilized mostly in the production of mixed feed, although its chemical composition suggests a wider range of application.

The analysis of literature data has shown that rice bran is characterized by lower storage stability than whole grain, since grain processing destroys the integrity of grain biological system. Grain by-products are constantly exposed to various unfavorable factors (temperature, humidity, oxygen from the surrounding air, microorganisms and enzymes), which has a significant impact on the activity of a wide range of chemical and biochemical processes (Ponamaryov, 2011).

In view of the above, the development of methods and optimal conditions of rice bran processing with the purpose of increasing its storage stability is of immediate interest.

Materials and Methods

The object of research was rice bran left as secondary raw material after rice milling at the LLC “Zhytnitsa Kubani”. Storage changes in organoleptic indicators, acid value of lipids, microbial flora (total viable count by GOST 10444.15-94, coliform bacteria by GOST P 50474-93, Salmonella bacteria by GOST 50480-93, yeast and mold fungi by GOST P 52816-2007), enzyme

activity and fatty acid content of enzymes (using gas chromatograph Shimadzu C-R6A) of rice bran have been evaluated.

Results

Due to reduction of rice bran quality upon storage it seemed reasonable to study its microbial flora. Test samples were stored in desiccators for 90 days at a temperature of 20°C and relative humidity of 70%. The obtained results of sanitary and microbiological analysis of rice bran upon storage were compared to the requirements of Sanitary regulations and standards 2.3.2.1078-01 and technical regulations of the Customs Union 021/2011 (Table 1).

Table 1. Changes in microbial flora of rice bran upon storage

Storage time, days	Microbiological indicators, CFU/g								
	Total viable count			Yeast			Mold fungi		
	SanPiN 2.3.2.1078-01	TR CU 021/2011	test values	SanPiN 2.3.2.1078-01	TR CU 021/2011	test values	SanPiN 2.3.2.1078-01	TR CU 021/2011	test values
0	$5,0*10^4$	$5,0*10^4$	$0,8*10^2$	No more than 100	No more than 100	21	No more than 100	No more than 100	13
30			$1,7*10^2$			51			35
60			$2,6*10^2$			88			78
90			$4,0*10^2$			115			109

The analysis results show that rice bran storage time influences its microbial flora significantly. There is observable negative growth dynamics of mesofphilic aerobic and facultative anaerobic bacteria; within 3 months their number increased 4.0 times, while the quantity of yeast increased from 21 to 115 CFU/g. Growth rate of mold fungi should also be noted; their quantity increased 2.7 times in the first month, 6.0 times – in the second month and 8.4 times – in the third month.

Considering high content of lipids in rice bran it seemed reasonable to evaluate its storage stability. Acid value of lipids in rice bran appeared to be the most exposed to change upon storage. Fresh rice bran was stored with the initial moisture content of 10.4%, at temperatures from -20°C to +20°C and acid value of processed raw material of 7.6 mg KOH. The research results are presented in figure 1.

As a result of research it has been established that rice bran storage at a temperature of -20°C slows the increase of acid value; however, at a temperature of 0°C it has grown 7.8 times. The highest increase of the acid value of lipids could be observed at temperatures of +5°C and +20°C: it has grown 10.3 and 18.0 times respectively.

It has been established that organoleptic indicators of rice bran go down, when acid value of lipids reaches 25 mg KOH.

It is known that lipids are predominant in the chemical composition of rice bran. Therefore storage changes in fatty acid content of rice bran have also been studied (Table 2) (Morozova, 2011).

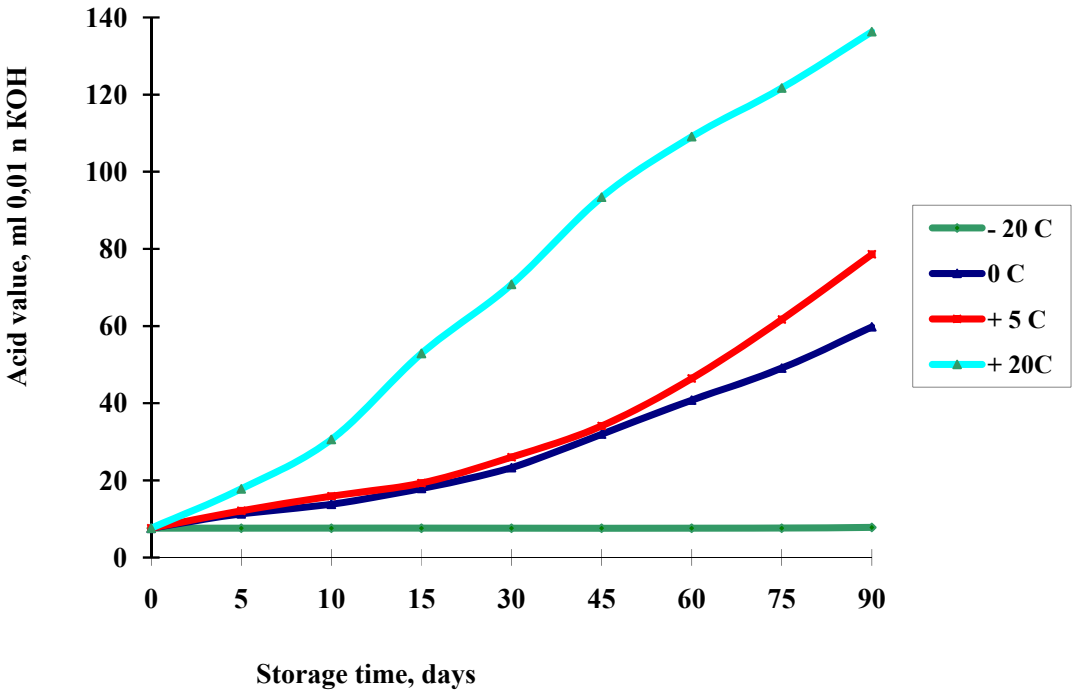

Figure 1. Storage changes in acid value of lipids in rice bran

Table 2. Storage changes in fatty acid content of rice bran

Fatty acid, %	Storage time, days			
	0	30	60	90
Myristic acid ($C_{14:0}$)	0,22	0,22	0,21	0,21
Palmitic acid ($C_{16:0}$)	14,48	14,68	14,99	15,12
Palmitoleic acid ($C_{16:1}$)	0,03	0,04	0,04	0,05
Stearic acid ($C_{18:0}$)	1,32	1,32	1,31	1,32
Oleic acid ($C_{18:1}$)	39,58	39,39	39,39	39,17
Linoleic acid ($C_{18:2}$)	41,80	41,77	41,47	41,55
Linolenoic acid ($C_{18:3}$)	1,44	1,44	1,45	1,43
Arachic acid ($C_{20:0}$)	0,69	0,70	0,70	0,71
Eicosenoic acid ($C_{20:1}$)	0,44	0,44	0,45	0,44

Based on the data presented in table 2 it can be concluded that fatty acid content of lipids in rice bran did not undergo significant changes upon storage.

It should be noted that rice bran has an active enzyme system, which determines the development of undesirable hydrolytic and oxidation processes of lipids upon storage.

The intensity of triacylglycerol hydrolysis, which leads to formation of free fatty acids, is determined by lipolytic enzyme activity (Bratersky, 1994). Therefore the influence of rice bran storage time on lipolytic activity has been studied (Figure 2). Initial lipolytic activity of rice bran was 4.3 ml 0.01 N KOH/g.

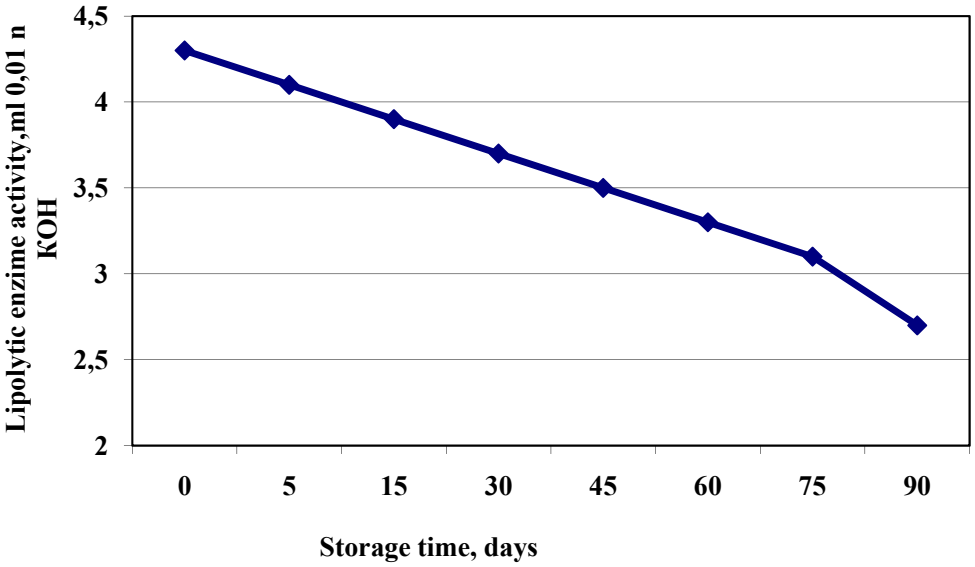

Figure 2. Storage changes in lipolytic enzyme activity of rice bran

It has been established that the extension of rice bran storage time facilitates inactivation of lipolytic enzymes; moreover, with the extension of storage time up to 90 days the specified effect becomes even greater.

Apart from hydrolysis there are also oxidation processes in rice bran lipids, which are influenced by changes of peroxide value of bran. Peroxide value determines the content of primary lipid oxidation products. Therefore it seemed reasonable to study the relation between rice bran storage temperature and its peroxide value. Storage changes in peroxide value of rice bran are presented in figure 3.

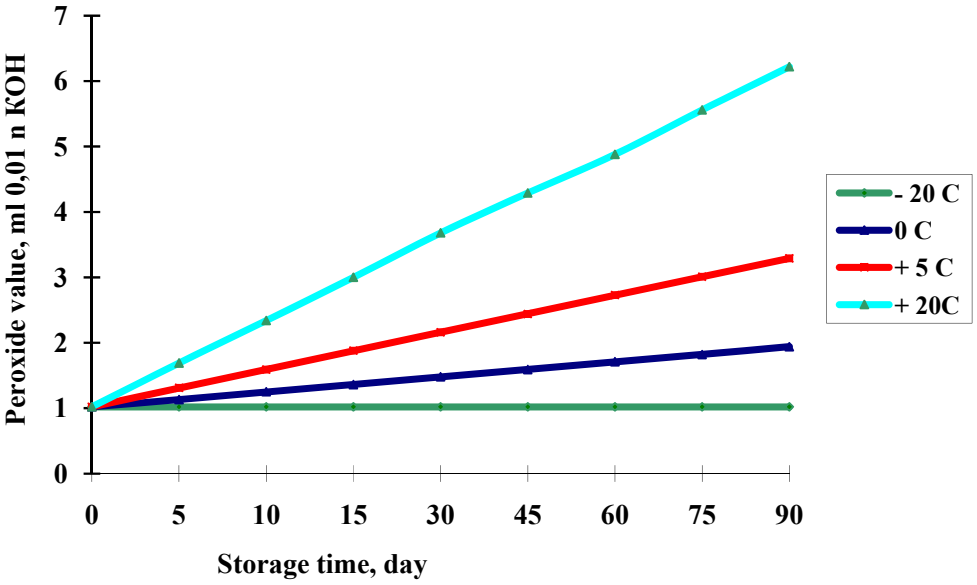

Figure 3. Storage changes in peroxide value of rice bran

The analysis has shown that the rate of increase in peroxide value at a temperature of 0°C slows down significantly, although it does not fully stop. Peroxide value of rice bran stored at a temperature of +5°C has grown 3.2 times in 3 months, and 6.1 times at a temperature of +20°C.

We have studied the influence of storage time on lipoxygenase enzyme activity (Figure 4). Lipoxygenase activity in fresh rice bran was 2.86 mmol of active oxygen/kg.

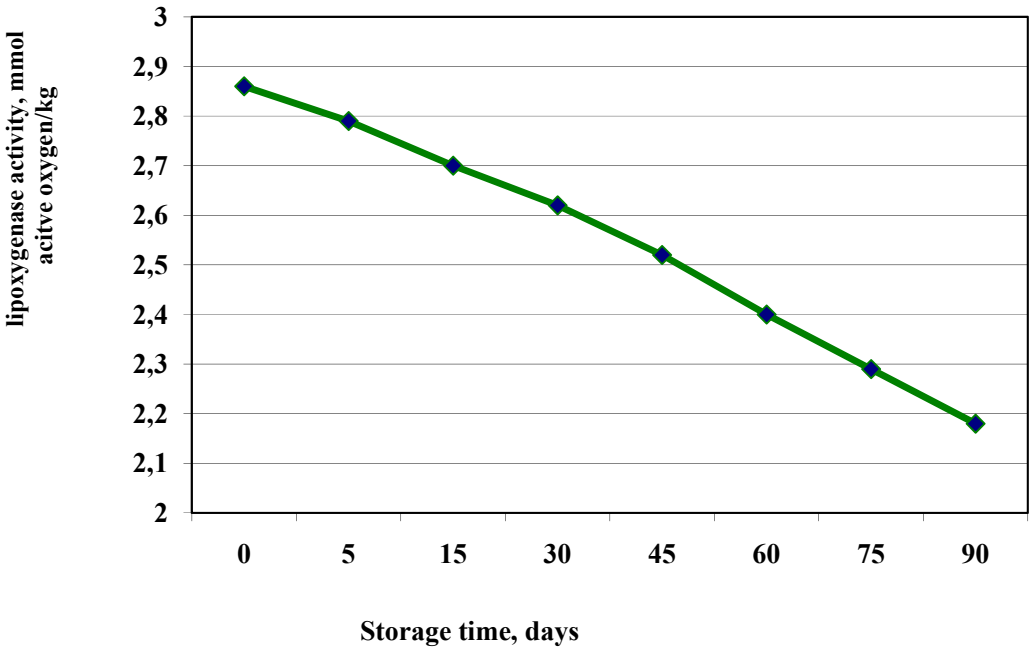

Figure 4. Influence of rice bran storage time on lipoxygenase enzyme activity

Lipoxygenase acivity upon storage went down 1.3 times and amounted to 2.18 mmol of active oxygen/kg.The analysis has shown that lipase and lipoxygenase activity decreases upon rice bran storage.

Based on the obtained data it can be concluded that rice bran is contaminated with microorganisms, has a high lipase and lipoxygenase enzyme activity and high content of unsaturated fatty acids, which determines its low storage stability and prevents its wide application.

In order to preserve rice bran quality upon storage the following stabilization methods were applied: infrared heat processing, microwave processing (Nikiforova, 2001; Kulikov 2010)

The effectiveness of chosen stabilization methods was estimated based on storage changes in acid value of lipids in rice bran.

Infrared heat processing of rice bran was conducted in the electrical cabinet “Universal – CD-4-40 R” with the following technical parameters: radiation flux density E=28kW/m^2, drying zone temperature from +25°C to +80°C, heating rate of 10°C per minute. Processing time was from three to six minutes. The experiments provided that the effective processing requires bed depth of rice bran of no more than 3mm.

The relation between the time and temperature of infrared heat processing of rice bran and acid value of lipids upon storage is presented in table 3.

Table 3. Influence of infrared heat processing on acid value of lipids in rice bran upon storage

Processing time, minutes and temperature, ^{0}C	Acid value of lipids, ml 0,01 N KOH								
	Storage time, days								
	0	5	10	15	30	45	60	75	90
3-60	7,6	7,6	7,6	13,2	18,2	24,8	30,3	32,5	34,0
4-60	7,6	7,6	7,6	11,6	18,0	20,7	29,6	30,8	32,5
5-60	7,6	7,6	7,6	10,8	17,6	18,8	25,4	27,7	28,9
6-60	7,6	7,6	7,6	10,2	17,0	18,4	19,9	22,3	26,6
3-70	7,6	7,6	7,6	9,8	16,2	17,5	18,8	20,1	23,4
4-70	7,6	7,6	7,6	9,3	15,3	16,5	17,8	19,0	21,7
5-70	7,6	7,6	7,6	8,7	14,1	14,7	15,7	17,4	19,9
6-70	7,6	7,6	7,6	8,5	12,8	13,5	14,4	16,2	18,9
3-80	7,6	7,6	7,6	8,1	9,6	10,9	12,5	14,8	17,1
4-80	7,6	7,6	7,6	7,8	8,0	9,5	10,8	12,8	15,5
5-80	7,6	7,6	7,6	7,6	7,8	8,1	9,5	10,4	11,7
6-80	7,6	7,6	7,6	7,6	7,6	7,9	8,3	9,0	10,4

It has been established that infrared heat processing of rice bran during 6 minutes at a temperature of +80°C allows to stabilize growth of the acid value for 30 days. Over a longer processing period irregular browning of rice bran was observed.

It is known that changes in the content of water- and salt-soluble fractions of proteins indicate product exposure to heat. Therefore the influence of infrared heat processing on protein content in fractions has also been studied.

The research results are presented in figure 5.

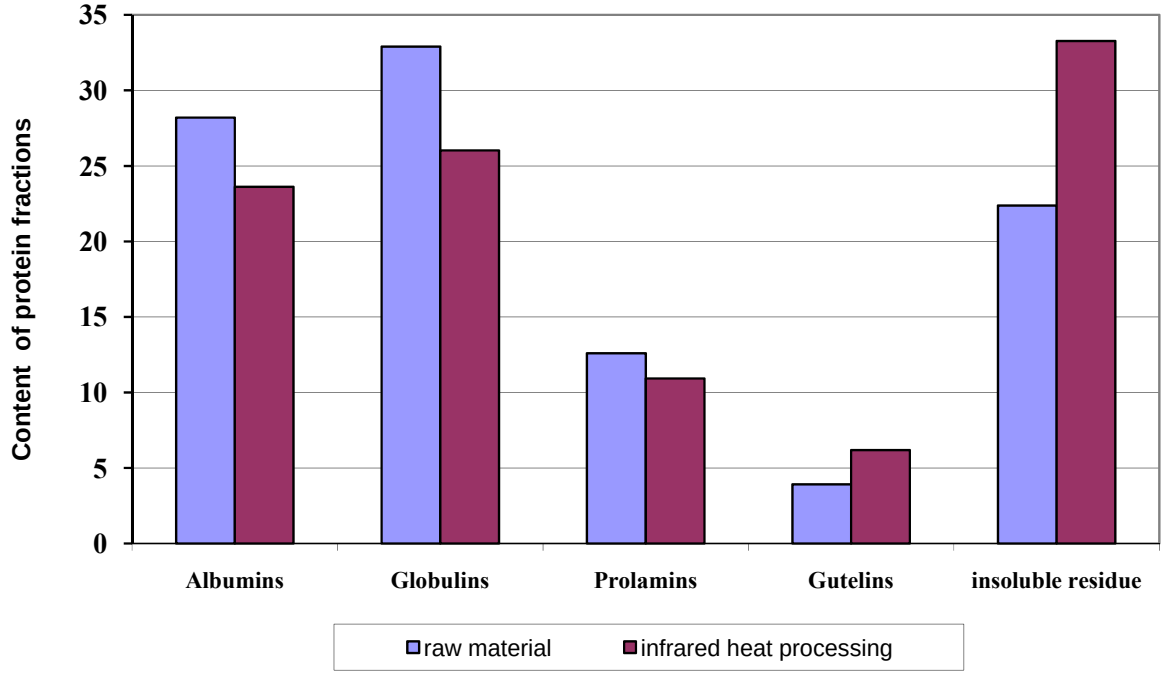

Figure 5. Influence of infrared heat processing on content of protein fractions of rice bran

The obtained data confirms that infrared heat processing of rice bran during 6 minutes at a temperature of +80°C causes changes in content of protein fractions, which leads to reduction in biological value of rice bran.

The analysis results confirm that infrared heat processing of rice bran allows to stabilize rice bran quality upon storage, although it doesn't completely stop hydrolytic and oxidation processes of lipids as well as deteriorates biological value of bran. Therefore the next stage of the experiment was the development of conditions of microwave processing of rice bran.

According to the latest scientific data, microwave processing has become widely used in grain-processing industry. It can be referred to as a new type of energy-saving technology due to the following advantages in comparison with common thermal processing: 1) thermal inertialessness, that is the ability to switch product exposure to heat on and off almost instantly; 2) high degree of efficiency of energy conversion into heat (90%); 3) the ability to apply selective, uniform and fast heating; 4) environmentally friendly heating, since there are no combustion products; 5) high decontamination effect (Yusupova, 2005).

The experiments provided that the beneficial effect of microwave processing of rice bran is attained under the following parameters: moisture content – 10.4%, processing time – from 1 to 4 minutes, heating rate – 0.90°C/s, final processing temperature – 50-85°C, power level – P=450-600 W.

In the course of the experiment the influence of microwave processing on acid value of lipids in rice bran upon storage has been studied (Table 4).

Table 4. Influence of microwave processing on acid value of lipids in rice bran upon storage

Processing time, minutes and temperature, ^{0}C	Acid value of lipids, ml 0,01 N KOH								
	Storage time, days								
	0	5	10	15	30	45	60	75	90
2 - 55	7,6	7,6	7,6	12,3	17,1	22,7	27,3	29,4	32,7
3 - 55	7,6	7,6	7,6	7,6	11,0	14,6	18,2	23,5	28,1
4 - 55	7,6	7,6	7,6	7,6	7,6	10,7	15,8	19,4	23,6
2 - 65	7,6	7,6	7,6	7,6	10,5	13,3	16,9	20,1	25,0
3 - 65	7,6	7,6	7,6	7,6	7,6	10,0	12,5	15,7	19,8
4 - 65	7,6	7,6	7,6	7,6	7,6	7,6	9,8	12,1	15,2
2 - 75	7,6	7,6	7,6	7,6	7,6	9,4	11,2	13,9	16,7
3 - 75	7,6	7,6	7,6	7,6	7,6	7,6	10,0	10,6	13,4
4 - 75	7,6	7,6	7,6	7,6	7,6	7,6	9,6	10,2	13,0
2 - 85	7,6	7,6	7,6	7,6	7,6	8,3	9,4	9,9	12,7
3 - 85	7,6	7,6	7,6	7,6	7,6	7,6	7,6	8,2	9,1
4 - 85	7,6	7,6	7,6	7,6	7,6	7,6	7,6	7,6	8,1

It has been established that optimal processing time and temperature of microwave processing are 4 minutes and 85°C respectively. Under the following parameters acid value of lipids in rice bran practically did not change over the specified storage time.

The data presented in figure 6 shows that under microwave processing the decrease in albumin and globulin fractions of rice bran amounted to 2.5% and 3.8% respectively, which was determined by low product processing time and temperature.

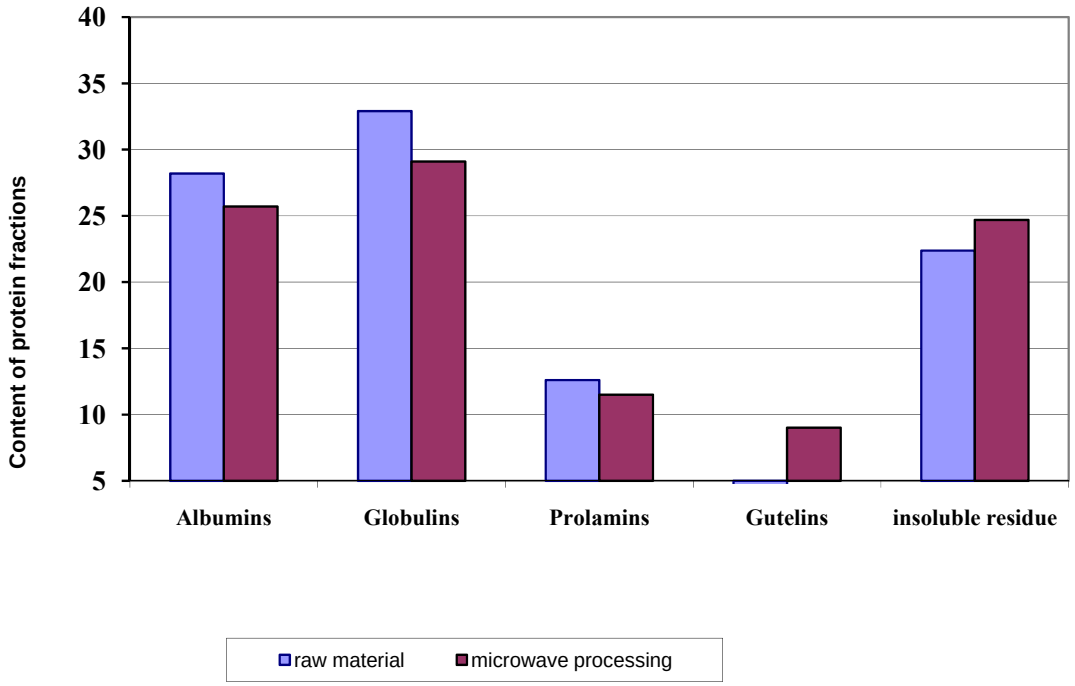

Figure 6. Influence of microwave processing on content of protein fractions of rice bran

The conducted research has shown high effectiveness of microwave processing of rice bran due to significant reduction of contamination with microorganisms and rice bran quality stabilization upon storage. However, in the process of storage secondary contamination can be observed, which leads to the increase in micro-organic content (Table 5).

Table 5. Influence of processing on microbial flora of rice bran upon storage

Microbiological indicators, CFU/g	Processing method	Storage time, days			
		0	30	60	90
Total viable count	initial value	$0,8*10^2$	$1,7*10^2$	$2,6*10^2$	$4,0*10^2$
	infrared heat processing	$0,5*10^2$	$1,0*10^2$	$1,6*10^2$	$2,0*10^2$
	microwave processing	$0,2*10^2$	$0,3*10^2$	$0,5*10^2$	$0,9*10^2$
Yeast	initial value	21	51	88	115
	infrared heat processing	11	15	19	24
	microwave processing	4	6	9	14
Mold fungi	initial value	13	35	78	109
	infrared heat processing	4	12	27	36
	microwave processing	1	3	6	8

Discussion

As the result of research, stabilization methods for rice bran storage quality based on intensive processing methods – microwave and infrared heat processing – were developed. The experiments have shown that the most effective stabilization method is microwave processing, which stops the acid value of lipids from growing and preserves rice bran nutrition value and microbiological cleanliness.

References

Bratersky, F.D. (1994). Grain enzymes. F.D. Bratersky (ed.), Kolos, 256 p.

Kulikov, D.A. (2010). Developing resource-saving utilization technology of grain by-products. PhD dissertation (Technical Sciences), 166 p.

Morozova, A.A. (2011). Rational utilization of secondary raw material resources and their value in the enrichment of food products. Proceedings of the IX research and practice conference of young scientists and students from southern Russia "Medical science and healthcare", P. 182-185

Nikiforova, T.A.(2001). Stabilization of millet bran quality upon storage. Proceedings of Russian research and practice conference "Ensuring food security in the world", P. 185-186

Ponamaryov, S.G. (2011). Developing resource-saving utilization technology of pea by-products. Abstract of PhD dissertation (Technical Sciences), 25 p.

Yusupova, G.G., et al. (2005). Aspects of the effect of microwave electromagnetic field on the development of grain bacteria and by-products. Krasnoyarsk State Agrarian University, 107 p.