Impact of degree of polishing on technological and biochemical grain quality traits of rice varieties of Russian breeding

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Abstract. The article presents the results of evaluation of rice varieties grown in the conditions of Krasnodar region by technological and biochemical quality traits in connection with the degree of grain polishing. The experiments were carried out in the laboratory of grain quality of Federal Scientific Rice Centre, Krasnodar. Grain of four rice varieties of Russian breeding (Rapan, Flagman, Polevik and Olimp) was subjected to five different degrees of polishing (0 %, 10 %, 12 % and 14 %). The degree of polishing significantly (P ≤ 0.05) influenced the total yield of polished rice, head rice content, and the content of protein and amylose. An increase in the degree of polishing led to a further decrease in the protein content, total yield of polished rice and head rice content in it. However, an increase in the amylose content was found for simulated samples. With an increase in the degree of polishing to 14%, the amylose content increased in varieties Rapan, Flagman, Polevik and Olimp, respectively, by 1.3 %, 1.4 %, 1.5 % and 1.2 %, the protein content decreased by 1.5 %, 1.7 %, 1.6 %, 1.7 %.

1. Introduction

Rice is a staple food for the population of many countries of the world. In Russia, rice consumption is in the range of 3-5 kg per capita per year. About 600 thousand tons of milled rice per year can meet the needs of the population. A variety of processing technologies and culinary processing techniques are associated with bringing the main morphological part of the rice plant – grain – to the state of the food product. Seed (caryopsis) is enclosed in a flower shell, which, as a rule, is removed during peeling, and is covered on the outside with a fruit shell, or pericarp. Under the pericarp there is a seed coat. The storage part, the endosperm, and the embryo of the new plant are surrounded by layers of aleurome layer with a high protein content. The pericarp, seed coat, embryo and part of the aleurome layer are removed during grinding of the grain.

Rice is used as food mainly in the form of a whole kernel of white rice, which is obtained after peeling and grinding grain and subsequent cooking. The amount of protein in rice is about 60, compared with 49 for wheat and 36 for corn; rice is relatively non-allergenic [1]. Grinding and polishing of rice is carried out to improve physical and organoleptic properties, its stability during storage, under-polished rice is stored worse [2].

As a result of increased storability, rice requires a longer time for cooking, the volume expansion and absorption of water increases, and the total amount of solids in the water for cooking decreases compared to fresh rice, which is undesirable [3]. The distribution of cargo rice ash is shown: ash is...
51% in bran, 10% in embryos, 11% in polished and 28% in broken rice [4]. Rice processing leads to the removal of most nutrients [5, 6]. Production of white rice changes its quality: physicochemical properties, nutritional value, quality of the finished product [7], activity of amylase and peptidase enzymes [8]. The bulk of the fat is present in the seeds and surface layers of the grains, and during grinding, most of the fat is removed along with bran [9, 10]. Black rice is recommended for use in food in a lightly polished form due to a higher nutritional value [11]. The peak viscosities of starch dispersion for all rice varieties increase with the degree of grinding, the growth rate is higher for medium-grained than for long-grain varieties, the degree of grinding does not affect the final viscosity for all tested varieties [12].

In Russia, more than 60 rice varieties developed in breeding centers of the country are allowed for growing. The breeding process is accompanied by an assessment of the material at all stages of the process [13]. A characteristic is given for the physicochemical and biochemical parameters of grain quality, including the amylose content [14]. In rice processing enterprises, rice processing is carried out in various modes, which is accompanied by a decrease in the nutritional value of the finished product. In connection with the increasing consumer requirements for the quality of food products and the manufacturers’ need to reduce the cost of their production, it is important to study the effect of grinding regimes of grain of domestic varieties on processing and food quality attributes.

2. Problem statement
Due to relevance of the production of food products with high nutritional value, the goal was to study the effect of varying degrees of grain polishing on the technological and biochemical grain quality traits of rice varieties in production.

3. Materials and methods
Research material was represented by rice varieties of Federal Scientific Rice Centre breeding: Rapan, Flagman, Polevik and Olimp grown in Krasnodar region. The Rapan variety was used as a standard. The studied rice varieties are included in the State Register of Breeding Achievements approved for use in the North Caucasus region: Rapan - in 1996, Flagman - in 2007, Polevik and Olimp - in 2015. Rice grain samples were taken in the phase of full ripeness. Rice grains were peeled and polished a polisher manufactured by Satake Manufacturing Co., Japan, with a degree of 10%, 12%, 14% for 55, 65 and 85 seconds. Processing quality traits were determined by GOST methods: grain size by weight of 1000 dry grains (weight of 1000 a. d. grains) - according to GOST 10842-89. Protein content was determined in polished rice on an Infratec 1241 instrument, Foss, Denmark. Amylose content – colorimetrically with the Juliano method. Mathematical and statistical data processing was performed by calculations in Microsoft Excel.

4. Results and discussion
The effects of various degrees of rice grain polishing on the processing quality traits are presented in Figures 1-3. The grain size without flowering scales was the largest in Rapan variety (21.8 g) and the smallest in Olimp (19.5 g). The indicators for Flagman and Polevik occupied intermediate positions (Figure 1). With an increase in the degree of polishing, 10%, 12% and 14%, weight of 1000 absolutely dry grains decreased by 2.5, 3.2, 3.8 g, respectively, in Rapan variety; by 2.4, 3.1 and 3.5 g in Flagman; 2.5, 3.1, 3.4 g in Polevik; 2.4, 2.9 and 3.3 g in Olimp. The decrease in grain size with an increase in the degree of polishing was associated with the removal of the embryo, pericarp, seed coat, aleuron layer of the endosperm and a part of the endosperm.

The trait "total milled rice" characterizes the yield of the finished product when polishing grain. The indices (except for grain without polishing) were the highest in all varieties in the experiment with a polishing degree of 10% (72.8% in Rapan, 71.3% in Flagman, 69.0% in Polevik, 71.5% in Olimp) (Figure 2). With an increase in the degree of grain polishing, the overall yield of milled rice significantly decreased with a 10% degree of polishing by 9.5% in the Rapan variety, 9.6% in the Flagman variety, 9.8% in the Polevik variety and 10.1% in the Olimp variety. At a 12% degree of
Grain polishing, it was 12.1% for Rapan, 12.4% for Flagman, 12.3% for Polevik, 12.2% for Olimp. At 14% - by 14.4%, respectively, in Flagman, 14.0% in Polevik, 14.7% in Olimp. The trait values were significantly higher in the variety Rapan.

| Variety         | Degree of grain polishing, % |
|-----------------|-------------------------------|
|                 | 0%   | 10%  | 12%  | 14%  | LSD₀₅ |
| Rapan           | 21.8 | 19.3 | 18.6 | 18.0 | 0.11  |
| Flagman         | 20.3 | 17.9 | 17.2 | 16.8 | 0.10  |
| Polevik         | 20.1 | 17.6 | 17.0 | 16.7 | 0.12  |
| Olimp           | 19.5 | 17.1 | 16.6 | 16.2 | 0.11  |

**Figure 1.** Weight of 1000 a.d. grains at different degrees of grain polishing

The maximum head rice content in the experiment was noted at polishing degree of 10% and amounted to 99.0% for Flagman, 98.3% for Polevik r, 92.0% for Olimp, which was significantly higher than the trait values for the standard variety Rapan (Figure 3).

With an increase in the degree of grain polishing, the head rice content decreased: at 12% compared with 10% by 4.6% in the Rapan variety, 3.0% for Flagman, 3.3% for Polevik, 2.0% for Olimp; at 14% by 5.9%, 5.3%, 2.9% in varieties, respectively. The decrease in the head rice content and the increase in the amount of broken rice with an increase in the degree of polishing is associated with an increase in the fragility of the grains during longer polishing [15].

A different degree of grain polishing also affects changes in the biochemical quality traits of polished rice. The amylose content in rice grain with shells, without polishing, was the smallest: in the varieties Rapan, Flagman, Polevik and Olimp - 16.5%, 17.5%, 16.0%, 17.1%, respectively. With a 10% degree of polishing, there was a slight increase in the amylose content in the kernels of all varieties: Rapan - 0.8%, Flagman - 1.0%, Polevik - 0.5% and Olimp - 0.7%. With an increase in the
degree of polishing to 12%, the amylose content in the varieties increased, respectively, by 1.0%, 1.2%, 0.9%, and 0.9%. With an increase in the degree of polishing to 14%, the amylose content still increased by 1.3%, 1.4%, 1.5% and 1.2%, respectively. Thus, the removal of bran led to an increase in the amylose content in the kernel, which may be due to its low content in the shells of the grains and the gradient of amylose deep into the grains. In addition, the bulk of fat is present in bran and germ [9]. That is, the concentration of the starch component is lower in the surface layers of grain endosperm and higher in the depth of the caryopsis.

| Variety   | Degree of grain polishing, % | 10% | 12% | 14% | LSD<sub>05</sub> |
|-----------|------------------------------|-----|-----|-----|-----------------|
| Head rice content, % |                  |     |     |     |                 |
| Rapan     | 87.0                         | 82.4| 77.2|     | 1.22            |
| Flagman   | 99.0                         | 96.0| 93.1|     | 2.01            |
| Polevik   | 98.3                         | 95.0| 93.0|     | 1.52            |
| Olimp     | 92.0                         | 90.0| 88.1|     | 1.34            |
| LSD<sub>05</sub> |                      | 0.59| 0.92| 0.81|                 |

Figure 3. Head rice content at different degrees of grain polishing

| Variety   | Degree of grain polishing, % | 0% | 10% | 12% | 14% | LSD<sub>05</sub> |
|-----------|------------------------------|----|-----|-----|-----|-----------------|
| Amylose content, % |                  |    |     |     |     |                 |
| Rapan     | 16.5                        | 17.2| 17.5| 17.8| 0.24|
| Flagman   | 17.5                        | 18.5| 18.7| 18.9| 0.21|
| Polevik   | 16.0                        | 16.5| 16.9| 17.5| 0.32|
| Olimp     | 17.1                        | 17.8| 18.0| 18.3| 0.17|
| LSD<sub>05</sub> |                      | 0.26| 0.25| 0.23|                 |

Figure 4. Amylose content at different degrees of grain polishing

The protein content in unpolished rice grains varied from 8.0% in Olimp to 8.3% in Polevik (Figure 5).

In husked grain (without polishing), the maximum protein content was noted with a slight difference between the varieties (8.4% protein in Rapan, 8.2% in Flagman, 8.3% in Polevik and 8.0% in Olimp). At the initial degree of polishing (10%), the protein content of the Rapan variety decreased by 0.6%, Flagman - by 0.7%, Polevik - by 0.7%, Olimp - by 0.5%. With an increase in the degree of grain polishing, the protein content decreased at 12% polishing by 1.3%, 1.4%, 1.4%, and 1.2% in varieties, respectively. At a 14% degree of polishing - by 1.5%, 1.7%, 1.6%, 1.7%, respectively. As it is known, the protein content in cargo rice is in the range from 4.3% to 18.2%, and in polished - from
5% to 14% [16]. This pattern is observed in connection with the removal of the outer layers of rice grains, which are known to be rich in protein content. In the Rapan variety, in comparison with other varieties, the distribution of protein in the caryopsis is more even or deepest.

| Variety  | Degree of grain polishing, % | Amylose content, % |
|----------|-----------------------------|-------------------|
|          | 0 % | 10 % | 12 % | 14 % | LSD05  |
| Rapan    | 8.4 | 7.8  | 7.1  | 6.9  | 0.08   |
| Flagman  | 8.2 | 7.5  | 6.8  | 6.5  | 0.09   |
| Polevik  | 8.3 | 7.6  | 6.9  | 6.7  | 0.08   |
| Olimp    | 8.0 | 7.5  | 6.8  | 6.3  | 0.07   |

Figure 5. Protein rice content at different degrees of grain polishing

5. Conclusion
The different degrees of grain polishing of Russian rice varieties significantly influenced the technological and biochemical quality traits. An increase in the degree of polishing led to decrease in the overall yield of polished rice and the head rice content. An increase in the degree of grinding to 14% led to an increase in the amylose content and a decrease in the protein content in the kernels, which is associated with a higher concentration of protein bodies in the surface layers of the endosperm of the caryopsis and an increase in the concentration of amylose deep into the caryopsis. The solution to the question of the degree of polishing during the production of rice products from grain of certain varieties should be taken on the basis of data on both the yield of the finished product and its nutritional value.

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