Technological assessment of the suitability of domestic raw materials for beer production as an important link in the country's food security

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Abstract. The existing malting barley varieties differ in their quality and technological characteristics depending on the peculiarities of cultivation, soil and climatic conditions. In the work, there were four varieties of malting barley: Beatrice, Vorsinsky, Grace and Margret. They were evaluated according to the physical and chemical indicators established by regulatory documents for this grain. It has been determined that Vorsinsky variety contains protein that is a technologically important component above the normalized value. This problem is solved during germination of the grain due to active influence of proteolytic enzymes of the grain on protein. In this connection, it is necessary to create conditions intensifying a technological process of malting, provoking strengthening of biochemical transformations. On this basis, the use of organic acids complex at the stage of barley soaking is justified, which should be applied to the last retted water in the amount of 10⁻⁹ mol/dm³ and barley should be kept with it for six hours. This speeds up physiological and biochemical transformations in the grain. The effectiveness of this treatment was confirmed by an example of increase in the enzymatic activity. The possibility of obtaining barley malt on the basis of the proposed varieties with high quality characteristics in accordance with the requirements of the malt standard is shown. The expediency of regulation of the chemical composition of barley malt of Vorsinsky variety by means of an organic stimulator is shown, which allows obtaining malt with indicators not inferior to those of other studied varieties. The use of an individual approach to certain barley varieties at the malting stage will expand the raw material base of the brewing industry and provide the industry with domestic malt.

1. Introduction
Malting engineering is currently undergoing significant changes. This is primarily due to an insufficient raw material base for brewing production and restriction of its replenishment at the expense of foreign supplies due to applicable sanctions against the Russian Federation.

In this regard, it is necessary to consider the problem comprehensively and solve it not only by improving the technological regimes of malting, but also by conducting scientific research on the selection of new samples of cereal crops with distinctive characteristics in terms of improving both the chemical composition and immunity to various types of microbiological and physiological diseases.
It takes a long time to create a new variety of grain crop and bring it to industrial production, because the parameters of malting barley cultivation are quite stringent. This is primarily due to the fact that the new varieties are cultivated for a specific territory with certain soil and climatic conditions. A specific barley variety, which gives a high yield in the Central Non-Chernozem Zone, will be not always the same when cultivating it, for example, in the Altai Territory.

Malting barley is a plant which is very demanding for its growing atmosphere, weather and climatic conditions. The potential for the cultivation of this grain crop is great for different regions and climatic zones.

The technology of malting barley cultivation has a number of features, primarily related to the task of obtaining high quality raw materials for the processing industry.

It is planned in such a way that at the maximum yield of grain it will allow obtaining a finished product that meets the quality requirements in force.

In the main harvesting areas of malting barley, the highest yield can be obtained by placing it on tilled crops, which makes the soil clean of weeds with sufficient nutrients.

When malting barley is cultivated, it is especially important to create optimal nutritional conditions for the formation of the right quality grain. Types and doses of fertilizers are determined taking into account the permissible reserves of nutrients in the soil and the planned yield.

Thus, nitrogen in doses above 50-60 kg/ha of the active ingredient can have a negative impact due to crops lodging. Biological losses due to early lodging are 15-40 %. Therefore, when choosing the dosage of nitrogen fertilizers the features of the variety should be taken into account. In humus-rich chernozems after ploughed crops, it is advisable to exclude nitrogen fertilizers. Nitrogen fertilizers are usually applied in spring for pre-sowing soil tillage.

Doses of phosphate and potash fertilizers vary very widely - from 30-45 to 90-100 kg/ha depending on the content of elements in the soil.

Available results on the impact of mineral fertilizers on yield and barley quality showed that the highest yield can be obtained against the background of $45^90^8^90$ [1, 2].

Barley is referred to be the most acidity sensitive crop in the soil. Liming to full hydrolytic acidity in numerous experiments of scientific institutions of Non-Chernozem Zone, Belarus and Baltic States increased barley yield 1.5-2 times and more. The role of liming increases with increasing doses of mineral fertilizers [1, 2].

Malting barley should be harvested during full ripeness (grain moisture – 20-22 %) due to the fact that starch synthesis is most intensive in the last phase of ripening.

If it is necessary to harvest barley with high (28-30 %) moisture of grain, it is advisable to use two-phase mode of threshing. This method allows obtaining grain that meets the requirements of malting barley standard even in extremely hazardous years.

Until the 70s of the twentieth century, the brewing industry in the West Siberian region and Altai Territory was provided with locally produced barley. Subsequently, this region was excluded from the malting barley harvesting zone due to the instability of climatic conditions and, as a consequence, the low yield of the considered grain crop.

At present, malting barley is imported into the region annually from the European part of the country and from abroad in the amount of more than 100 thousand tons. This, of course, affects both the logistics of deliveries and the emerging cost and price of the finished product.

Therefore, the creation of a reliable raw material base in the regions of Western Siberia and the Altai Territory, taking into account the existing experience in malting barley cultivation, is an important government task.

The purpose of this work is to study the possibility of producing and using regional malting barley varieties for malting in order to expand the domestic raw material base.
2. Research materials and methods
The objects of study were domestic malting barley varieties: Margrethe, Vorsinsky, Grace, Beatrice, selected in different regions of the Russian Federation, but grown in the Altai Territory of the 2017-2018 harvest.

We used standard methods and techniques, adapted and well-proven in brewing production for the main qualitative indices research: sampling (GOST 13586.3); humidity (GOST 13686.5); starch (GOST 10845); protein (GOST 10846); absolute weight (GOST 10842); nature (GOST 10840); germination (GOST 10968); extractivity (GOST 12176); acidity (GOST 10844); proteolytic activity by modified Anson method; amyloolytic activity according to Windish-Kolbach method [9]; malt quality indicators were determined by GOST 29294.

The research was conducted three to five times. Quantitative values of research materials, shown in the illustrative material of the work, are the average values of the sample population (A) ±Δ (radius of the confidence interval, calculated in the MS Excel program).

Statistical processing of experimental data was carried out using industrial statistics («Statistica 8.0»).

3. Discussion of results
Since the quality of barley determines the properties of the finished malt as the main raw material for brewing, the new cultivated varieties are also subject to quite stringent requirements.

To produce high quality beer, the grain must be clean, biologically mature, with good germination, and certain biochemical composition [2-6].

The high content of crumbs, which have bitter substances in its composition, worsens the bitterness of beer and sharply reduces its individual physical, chemical and organoleptic characteristics.

Among the dry substances that determine the value of brewing varieties, attention should be paid to the content of water-soluble components and, above all, starch, as this directly depends on the yield of the extract in beer preparation. This indicator should be as high as possible, in contrast to fodder high-protein barley with a large content of individual grains. The size of starchiness is what the technological indicator, such as nature, depends on. The brewing industry needs to produce highly starchy barley.

Nitrous substances of barley perform different functional loadings. They are responsible for the stability of the finished beverage, for the quantity and quality of the foam produced, as well as for the complete nutrition of the yeast during the accumulation of its biomass. The increase in the amount of protein of excess values immediately leads to a decrease in the extractivity of malt, reducing the degree of dissolution. The decrease, in its turn, leads to the lack of compounds responsible for the completeness of taste and foaming ability.

The absolute weight of malting barley depends directly on the barley variety and its extractivity: the higher the absolute weight, the higher the weight of the high-class grain.

One of the important indicators by which one can predict the quality of grain and indirectly assess its microbiological state is acidity. The main reason for the increase in acidity of the grain is the action of hydrolytic enzymes, which leads to the accumulation of acidic products.

We have examined malting barley varieties to assess their suitability for malting purposes.

Margret barley belongs to the category of double row barley with well-matured large grains, a variety of Nutans of German selection. This variety is early, high-yielding, and its ripening period reaches 90 days. The variety can be cultivated on a wide territory (from the Central part to the Far East region) due to its universality. However, it should be noted that during the selecting of this variety, due attention was not paid to the creation of a stable immunity to various types of diseases, including the defeat of powdery mildew and root rot [5, 7].

Vorsinskiy variety is specially zoned for regions with sharply continental climate and low winter temperatures, which is typical of Western Siberia and Altai Territory. It was obtained by multiple selecting from Belarusian barley of Zhodinsky-5 variety. It is adapted to growing conditions in a
region with unstable climatic conditions. It has, as well as the previous variety, high susceptibility to physiological and microbiological diseases, particularly root rot [7, 8].

Malting barley Grace is characterized by its short ripening period, which reaches up to 85 days. It belongs to the spring barley variety, which is fully capable of ripening during a period of sufficient warm sunny days. Just like Margret, it is a variety of Nutans, so we can safely refer it to the German malting barley range. It is selected for regions with relatively stable climatic conditions by year. It is, primarily, the region of the Central part of Russia and the Non-Chernozem Zone. This variety is susceptible to various diseases, primarily helminthosporiosis [7].

Another barley variety being of interest to our study is Beatrice. Just like the varieties Margret and Grace previously considered, it belongs to the category of Nutans and is therefore a German variety. That is why it meets all the characteristics that were previously given for the varieties considered. The variety is resistant to lodging, but, like other German varieties, is prone to perception of various diseases, namely, helminthiosporiosis and dusty head. This variety is intended for cultivation in the Central zone of Russia.

It was of interest to study the above barley samples, selected for different regions but grown in Western Siberia and Altai Territory in order to predict their technological characteristics as potential raw materials for brewing malt production.

The results of the study on comparative assessment of malting barley quality are presented in Table 1.

Table 1. Quality indicators of barley samples under study

| Name          | Beatrice | Vorsinsky | Grace | Margaret |
|---------------|----------|-----------|-------|----------|
| Mass fraction of moisture, % | 13.8±0.2
| Mass fraction of starch, % | 64.8±0.1
| Mass fraction of protein, % | 11.6±0.1
| Absolute weight, g | 46.5±0.2
| Nature, g/dm³ | 730.0±0.5
| Extractivity, % | 79.4±0.2
| Germination, % | 95.0±0.1
| Acidity, deg. | 1.9±0.1

| p<0.05 |

As can be seen from Table 1, the barley samples under study meet the requirements of the standard by such an indicator as moisture. However, it should be noted that in the variety Vorsinsky, the value of this indicator is in the critical zone, which indicates the possible accumulation of moisture through the appearance of the free and its participation in exchange processes. This may lead to a decrease in technological characteristics.

Comparing such interrelated quality characteristics as mass fraction of starch, absolute mass and nature, it can be concluded that these indicators have a good correlation with each other: the more the starch is contained in the grain and the absolute mass, the higher the important technological indicator is such as nature. It can be noted that in spite of the fact that the variety Vorsinsky meets the requirements of malting barley, it has the average value of the analyzed values. In terms of protein content, all tested samples, except for Vorsinsky barley, meet the requirements of malting barley standard (GOST 5060). Vorsinsky variety has deviations by 2.5 % from the higher boundary on this indicator. Therefore, it is necessary to pay attention to this fact, when designing the modes of processing of this particular batch. It is, firstly, necessary to correct, the soaking mode by increasing the duration of air pause for active accumulation of proteolytic enzymes capable during the germination period to carry out deeper hydrolysis of high-molecular nitrogen compounds in comparison with other samples, which do not require changes in process parameters.
According to the indicator of germination (this is the number of grains that can germinate within five days) all tested barley samples meet the requirements of malting. It is possible to assume the absence of any deviations in the course of the technological process of germination under observance of temperature and moisture conditions.

As we mentioned above, the acidity index indirectly characterizes the state of the grain mass. Well-matured barley has a weakly acidic reaction, which is due to the presence of both phosphoric acid salts and organic acids. All malting barley samples under study have the values of this indicator, which is typical of grain in a normal viable state without signs of deterioration.

Despite the fact that barley of Vorsinsky variety has deviations in individual indicators, its use in malting, and later in the production of beer, can take place provided that its chemical composition is regulated in the process of obtaining malt. At present there are various methods intensifying malt production in order to reduce the duration of individual stages and the process as a whole, to reduce losses and material costs, but above all - to obtain malt with the required chemical composition [10-12].

One of the ways to improve the quality and technological characteristics of grain after malting is to use activator grain at the stage of soaking, which represents a complex of organic acids of Krebs cycle (α-ketoglutar, amber, citric, apple and fumar). Such treatment is known to stimulate plant growth by improving permeability of cell walls under the influence of organic acids in certain concentrations [13-14].

In order to change the chemical composition and, primarily to reduce protein content, and to increase proteolytic activity, it was decided to germinate barley of Vorsinsky variety using a stimulant. All stages of malting (duration and technological parameters) for this variety are similar to the stages of germination of other barley samples (Beatrice, Grace, Margret) except for the use of organic acids complex, which was introduced at the stage of soaking in the last retted water at a concentration of $10^{-9}$ mol/dm$^3$. Vorsinsky barley was kept with the preparation for six hours, then water was drained and the grain was sent for germination. Changes, in particular, the biochemical changes occurring in barley at the soaking stage, manifested themselves in an increase in the enzymatic activity of barley. The dynamics of proteolytic activity, as the most interesting one, in the last six hours of soaking of barley treated with an organic stimulant in comparison with untreated grains (control version) is shown in Figure 1.

![Figure 1. Dynamics of the accumulation of proteolytic activity of Vorsinsky barley during soaking](image)

The processing of barley with an organic stimulant allows us to accelerate the biochemical transformations, and to accumulate the enzymatic potential of the grain, which is especially important at the stage of assessing the suitability of barley for malting. The grain did not have good quality and technological characteristics and caused some concerns about its use in the production of high-quality
malt product. The obtained barley malt of Vorsinsky variety using a mixture of organic acids of Krebs cycle after all technological stages of malting is not inferior to malt produced from barley of Beatrice, Grace and Margret varieties in its physical, chemical and organoleptic characteristics, which is confirmed by the data in Table 2.

Table 2. Cooked malt quality indicators

| Name                      | Beatrice  | Vorsinsky | Grace  | Margaret |
|---------------------------|-----------|-----------|--------|----------|
| Mass fraction of moisture, % | 4.2±0.2a  | 4.20±0.2a | 4.10±0.2a | 4.20±0.2a |
| Mass fraction of extract in malt dry matter, % | 81.00±0.2a | 80.20±0.2a | 80.90±0.2a | 80.40±0.2a |
| Mass fraction of protein, % | 10.4±0.1a | 10.9±0.1a | 10.3±0.1a | 10.1±0.1a |
| Amylolytic activity, u/g | 350.4±0.5a | 348.2±0.5a | 345.1±0.5a | 355.4±0.5a |
| Proteolytic activity, u/g | 65.1±0.2a | 67.2±0.2a | 64.7±0.2a | 62.8±0.2a |
| Lab wort:                |           |           |        |          |
| Colour, col.unit         | 0.18±0.02a | 0.18±0.02a | 0.18±0.02a | 0.19±0.02a |
| Acidity, ac. unit        | 1.0±0.1a  | 1.1±0.1a  | 1.0±0.1a  | 1.0±0.1a  |

a p<0.05

The received results of research testify to the possibility of obtaining malt on the basis of the offered grades with quality indicators corresponding to requirements of the normative and technical document on the given product.

4. Conclusion

Thus, we can make a general conclusion that the studied samples of malting barley varieties, selected and grown in different regions by their quality and technological indicators, fully meet the requirements for malting barley. They do not need special methods of their preparation and processing, except for the variety Vorsinsky, the malting process of which can be corrected by applying the complex of organic acids at the stage of soaking. This is primarily due to unstable weather conditions in the region where this barley variety is grown. The results obtained testify to the possibility of creation of the malting barley domestic raw material base to ensure food security of the country.

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