Evaluation of the effectiveness of enzyme preparations to improve the quality characteristics of brewing barley malt

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Abstract. The feasibility and effectiveness of using a multienzyme composition to improve the quality characteristics of brewing barley malt was assessed. It included the enzyme preparations ViscoSEB HTX, SEBPro XL and SEBrew AT Plus. Enzyme treatment was carried out at the steeping stage, using a solution of a mixture of the above enzyme preparations as the last steeping water. The quality of freshly sprouted malt was assessed by determining the moisture content and amylolytic capacity. It was found that the use of the multienzyme composition ensured the values of the controlled characteristics of the experimental variant at the control level or higher. The greatest increase under the experimental conditions was recorded for the amylolytic capacity - by 23% compared to the control. It was found that the extractivity of freshly sprouted malt in the experimental variant increased by 4%. It was determined that the percentage of sprouted grains and the content of amino nitrogen in the experimental and control samples were almost equal. Based on the presented data, a conclusion was made about the prospects of using the multienzyme composition of the specified composition to improve the quality indicators of barley brewing malt and the advisability of continuing research in the chosen direction.

1 Introduction

The quality of brewing malt as the main grain raw material largely determines both the choice of technological modes for its processing and the quality of the finished product. The desire of malthouse technologists to reduce the duration of key stages in the production of brewing malt necessitates the use of additional technological methods that ensure the required quality of the product. One of such methods may be the use of enzyme preparations. The development of such an approach began at least 40 years ago [1]. Research in this area has continued throughout this period [2-3]. Significant technological [4] and economic efficiency of using exogenous biocatalysts [5], primarily of microbial origin, the possibility of reducing raw material consumption and, consequently, reducing

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emissions at the brewing enterprise have been proven. It is proposed to use both mixtures of two or more enzyme preparations [6], and one, including a complex type of action [7-8].

Over the past few decades, enzyme preparations from leading Western manufacturing companies have been widely used in the malting and especially brewing industries in the Russian Federation. They have proven themselves to be effective and cost-effective auxiliary means for eliminating production difficulties or intensifying technological processes. However, in the current situation, they have become difficult to access and/or too expensive. This made it advisable to search for similar preparations produced in Asia, in particular, in India and China. The objective of our research was to evaluate the efficiency of using a number of such enzyme preparations in the production of light brewing barley malt. The purpose of their use was to improve the quality of this type of raw material for brewing. The article presents the results of an experiment conducted in laboratory conditions. The technological characteristics of freshly sprouted light barley malt obtained using a multienzyme composition (MEC) are determined in comparison with similar indicators of a control sample of malt obtained without the use of third-party enzyme preparations.

2 Materials and methods

For malting, malting barley of the 2023 harvest grown in the Russian Federation was used.

Barley was steeped using the air-water method according to the following regime: 3 hours (water break) - 6 hours (air break) - 3 hours (water break) - 7 hours (air break) - 4 hours (water break). In the experimental version, a solution of three tested enzyme preparations was used as the third (last) steeping water.

In the described experiment, the enzyme preparations ViscoSEB HTX, SEBPro XL and SEBrew AT Plus (manufacturer - Advanced Enzymes, India) were used at a dosage of 2.2 kg / t of barley each.

ViscoSEB HTX contains active cellulase and xylanase.

SEBPro XL is a plant-based protease.

SEBrew AT Plus includes α-amylase, glucoamylase and pullulanase of fungal origin.

Germination was carried out in an automatic germinator Suba Seeds Vitaseed (Italy), the design and operating principle of which are similar to a drum malthouse without a flat sieve.

Due to the high germination capacity of the barley used in the experiment and the rapid formation of sprouts of excessive length, the germination process was carried out for 3 days at a temperature of 21-23 ° C.

In the control and experimental samples of freshly sprouted malt the following were determined:

- Moisture by drying to constant weight; this indicator was also determined in the original and soaked barley.
- Percentage of sprouted grains - by counting.
- Extractivity - by a standard method generally accepted in the Russian Federation.
- Amylolytic capacity - by the Windisch-Kolbach method.

In the extracts obtained when determining the extractivity of the experimental and control variants, the content of amine nitrogen was also determined by the number of carboxyl groups in water-alcohol solutions.

All indicators (except for the number of sprouted barley grains) were determined in three replicates; the article provides average values.

3 Results and Discussion

At the previous stages of our study, the results of using a number of enzyme preparations of microbial origin of varying specificity from several manufacturers, both European and Asian, were determined. The best results were obtained with the combined use of SEBPro XL and SEBrew AT Plus. The first of them has proteolytic activity, the second contains α-amylase, glucoamylase and pullulanase. Minor improvements in a number of controlled characteristics of freshly sprouted malt were achieved, exceeding the error of determination. However, in our opinion, they were insufficient from the technological and economic points of view. Probably, this is due to the limited penetration of protein molecules of the target enzymes of the preparations through the external structures of germinating barley. Due to this, it was decided to introduce the ViscoSEB HTX enzyme preparation of cytolytic type of action into the composition of the MEC.

Due to the fact that it was not possible to find recommendations from the manufacturer or suppliers of the enzyme preparations used in open sources regarding their rational dosages, it was decided to use the preparations in quantities approximately 4 times greater than those recommended for their analogues. It was decided to consider the issue of optimal dosages later, if the fundamental expediency of using the enzyme preparations under consideration at the stage of barley germination is proven.

The values of the determined characteristics of freshly sprouted barley of the experimental and control variants are presented below.

First of all, the humidity of the experimental and control samples of freshly sprouted malt was determined. This indicator is important from the technological and economic points of view, and is also necessary for calculating the values of other controlled indicators of brewing malt. The humidity of the control variant was 42.88%, while an abnormally high value of 51.27% was recorded in the experimental one. In our opinion, the reason for this may be an increase in the permeability of the germinating barley grain shells due to the effect of cytolytic enzymes from the ViscoSEB HTX preparation on their components. This probably led to an increase in the intensity of the internal anatomical parts of the grain with the external environment, intensification of the diffusion of water molecules and a set of higher humidity by the soaked barley. It was established (Table 1) that the use of MEC did not affect the percentage of sprouted grains: the difference in the experimental and control indicators did not exceed the error of determination.

It should be noted that in both samples the germination was slightly lower than typical values, which is probably due to the short period of grain germination. According to regulatory documents adopted in the Russian Federation, the germination capacity (determined within 5 days) of brewing barley should be at least 90-95% depending on the class of barley.

Table 1. Proportion of sprouted grains.

Option	Number of grains	Number of sprouted grains	Percentage of sprouted grains
Control	1973	1762	89.30
Experience	1929	1747	90.57

Germination energy (determined over 3 days) should be no more than 2% less. Taking this into account, it can be concluded that under the experimental conditions, barley had physiological characteristics that met the requirements of the current standard.

A different situation was recorded with respect to such an important indicator as amylolytic capacity (Table 2).

Table 2. Amylolytic capacity (AC) of freshly germinated malt.

Variant	AC, Windisch-Kolbach unit
Control	324,5
Experiment	400,2
Typical values for pale raw malt	300-400

The revealed advantage of the experimental sample in amylolytic capacity over the control seems to us to be quite significant, which allows us to assume the prospects of using the MEC of the used composition. In addition, it seems advisable to continue the research in order to determine the rational ratio of individual enzyme preparations in the MEC composition and the dosage of the latter.

The values of another technologically important characteristic from the brewer's point of view of the control and experimental samples of freshly sprouted malt - its extractivity - are presented in Table 3.

Table 3. Extractivity of freshly sprouted malt.

Variant	Extractivity on dry matter, %
Control	63.73
Experiment	66.34
Typical values for good quality malt	76-79

It should be noted that both variants had extractability significantly inferior to the values characteristic of good quality light malt. The main reasons for this, in our opinion, could be:

- Insufficient degree of grinding of the samples taken for analysis, since freshly sprouted malt with high humidity was ground with a pestle in a porcelain mortar before determining the extractability due to the impossibility of using a mill (crushing equipment) of one type or another.
- The duration of germination, significantly shorter compared to that characteristic of the classical technology of light malt (3 days instead of 7-8 days; this was due, as noted above, to the intensive formation of sprouts, which under the experimental conditions on average exceeded the length of the grain even with the selected duration of barley germination.
- Associated with the increased losses of extractive substances for the formation of vegetative organs noted in the previous paragraph.

Nevertheless, the results presented in Table 3 allow us to assume the feasibility of using the MEC of the composition used, and from the point of view of increasing the yield of technologically valuable components of brewing barley malt. This can have a positive effect on the economic efficiency of the entire production cycle.

The nutritional value of beer wort is largely determined by the content of nitrogen-containing compounds assimilated by yeast - amino acids and dipeptides (amine nitrogen). It, in turn, depends, first of all, on the content of substances of this group in the processed brewing malt. Due to this, the content of amine nitrogen in the experimental and control samples of freshly sprouted barley malt was determined. The results obtained as a result of recalculating the concentration of amine nitrogen in the extract obtained when determining the extractivity, to dry matter of freshly sprouted malt are presented in Table 4.

Table 4. Amino nitrogen content in freshly sprouted malt samples.

Option	Amino nitrogen content, mg/100 g DM of freshly sprouted malt, %
Control	441
Experience	447

The table shows that the difference in the values of this indicator lies within the limits of the determination error. At the same time, optimization of the composition of the used MEC and its dosage may lead to an increase in the content of low-molecular protein hydrolysis products necessary for yeast nutrition in the malt (and, as a consequence, in the beer wort obtained from it).

The tables show the values of the controlled indicators in absolute terms. For greater clarity, it was decided to present them on a summary graph (Figure 1), expressing them as a percentage in relation to the values of similar indicators in the control variant, which were taken as 100%.

Obviously, different controlled indicators of freshly sprouted malt under the experimental conditions depended to varying degrees on the preliminary (at the soaking stage) treatment of barley with a multienzyme composition.

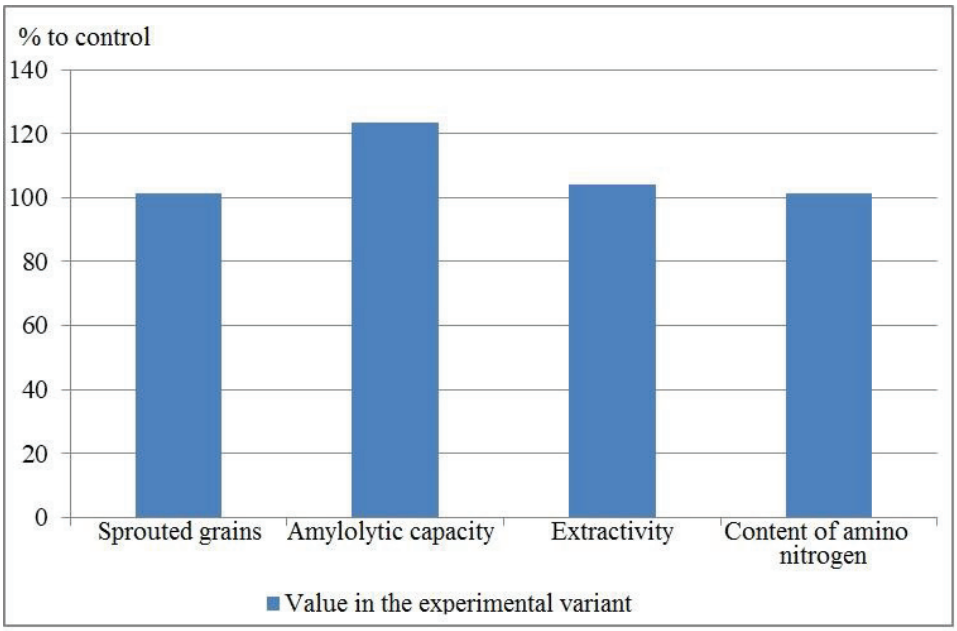

Fig. 1. The effect of the use of a multienzyme composition on the characteristics of freshly sprouted barley malt.

The enzyme treatment had virtually no effect on the percentage of sprouted grains and the content of amino nitrogen (in terms of dry matter of malt). In our opinion, it was virtually impossible to significantly improve the first indicator, since in the control variant its value was close to the maximum possible. The increase in extractivity in the experimental variant (about 3%) is quite significant, but it is necessary to confirm the activating effect of MEC in other experiments, in which the extractivity of freshly sprouted malt in the control variant will reach normal values approaching 80%. Only in this case - with a pronounced positive effect - will it be possible to reasonably state the technologically and economically significant positive effect of enzyme treatment on this characteristic of malt.

The most obvious expediency of using MEC in obtaining brewing malt is to increase its diastatic power (amylolytic capacity). In the experimental variant, the value of this indicator increased by more than 20% compared to the control. Probably, for large-capacity breweries this is not fundamentally important, since they can increase the depth of hydrolysis of starch of grain raw materials by increasing the amylolytic activity in the mash

due to scientifically or experimentally substantiated use of appropriate enzyme preparations directly at the mashing stage. However, for small-capacity breweries, where for various reasons the rational use of enzyme preparations may cause difficulties, the use of barley malt with high amylolytic capacity may be expedient. Undoubtedly, this statement is true only at comparable prices for "regular" malt and its analogue with increased AC.

4 Conclusion

The study conducted on a laboratory scale, in our opinion, allows us to conclude that it is fundamentally feasible to use enzyme preparations from Southeast Asian manufacturers as an alternative to products from today's leading companies previously tested in Russian brewing and malting industries. It was found that the use of a multienzyme composition consisting of the enzyme preparations ViscoSEB HTX, SEBPro XL and SEBrew AT Plus (manufacturer - Advanced Enzymes, India) improved a number of technologically important indicators of freshly sprouted barley malt. The greatest increase in the experimental variant was recorded for amylolytic capacity - by 23% compared to the control. An increase in extractivity was also observed - by 4%. The percentage of sprouted grains and the content of amino nitrogen in the experimental variant were not inferior to those in the control.

Of course, the data presented require verification under conditions close to production conditions, but, in our opinion, they indicate the advisability of continuing research in the area under discussion.

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