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GROWTH STIMULATORS IN MALT PRODUCTION TECHNOLOGIES

This study focuses on the use of the growth stimulator "Energen" in barley malt production to accelerate biochemical processes. The experiment was conducted on "Vorsinsky 2" barley treated with "Energen" at a concentration of 0.6 g/dm³. The results demonstrated an increase in amylolytic activity from 345.9 to 432.2 units/g and proteolytic activity from 68.9 to 94.6 units/g. This facilitated the improved hydrolysis of carbohydrates and proteins and increased malt extractivity to 83.2 %.

The application of the preparation reduced the saccharification duration of laboratory wort from 18 to 15 minutes. The high enzymatic activity enables the use of malt with hard-to-dissolve raw materials and eliminates the need for corrective measures. The method is also recommended for barley with a high protein content, as the accumulated enzymes ensure proteolysis to regulatory values.

Thus, the stimulation of biochemical processes with "Energen" improves the technological and quality indicators of malt, optimizing its production process.

Keywords: barley, malt, enzymatic activity, extractivity, biocatalysis, growth stimulators.

Introduction

Barley is the primary raw material in brewing production. However, it is rarely used in its native form, only in specific types of beer, and mainly to reduce product costs. In most cases, it is utilized in the form of malt. During the malting process, the chemical composition of barley changes, new enzymes are formed, and existing ones are activated, subsequently participating in enzymatic processes at various production stages.

The main process occurring in the grain during the malting stages is its biochemical transformation, which results in the breakdown of high-molecular

compounds into lower-molecular-weight compounds, including the hydrolysis of carbohydrates and proteins. Traditionally, when barley of good or excellent quality is used, these processes proceed naturally, resulting in barley malt with high quality and technological properties. However, when raw materials with satisfactory or reduced quality indicators are used, the enzymatic activity in the final malt will be lower than required. This will lead to deviations in subsequent brewing processes, ultimately affecting beer yield and quality.

To address the problem of producing malt with the required characteristics from low-quality raw materials, biotechnological methods are employed. These include the use of stimulatory preparations of organic and inorganic nature, as well as enzyme preparations with specific or combined actions. This approach allows for adjusting the enzymatic activity of malt [1–5], intensifying biochemical processes [6; 7], reducing the concentration of undesirable compounds that affect the organoleptic properties of beverages [8], increasing malt extractability, reducing the duration of the malting process, and overall improving malt quality [9].

The objective of this study was to investigate the impact of chemical treatment on barley during malting on the qualitative and technological characteristics of barley malt.

Materials and Methods

The objects of the study were brewing barley of the "Vorsinsky 2" variety, bred in the Altai Krai region of the Russian Federation, whose agronomic and technological properties are presented in Table 1; barley malt obtained with the application of the "Energen" preparation; and barley malt obtained without treatment (control variant). The study materials included the "Energen" complex preparation (a mixture of potassium salts of humic acids, silicic acid, and sulfur), widely used in agriculture [10].

The research methods consisted of standard methods for quality control of raw materials, intermediate products, and finished products in fermentation industries, as well as mathematical and statistical methods for data processing.

Table 1 – Agronomic and Technological Properties of Barley

Indicator	Value for "Vorsinsky 2" Barley
Intended Use	Brewing, high-quality grade
Vegetation Period (days)	77–90 (medium-ripening)
Yield (t/ha)	3.26
Lodging Resistance	High
Drought Tolerance	Medium
Grain Characteristics	Healthy, consistent color and odor

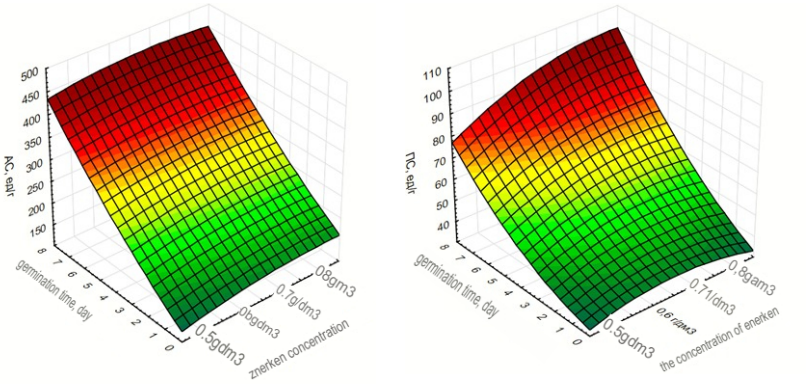
Moisture Content (%)	5.4±0.1
Starch Content (%)	59.1±1.3
Protein Content (%)	11.9±0.4
Extractivity (%)	74.1±1.4
Amylolytic Activity (units/g)	114.1±2.2
Proteolytic Activity (units/g)	34.2±0.6

Results and Discussion

The raw material proposed for the study was selected considering its high agronomic properties, particularly yield and resistance to adverse climatic factors, which allows for the potential of consistent supply to brewing enterprises. Key technological indicators of barley suitability for production include starch content, protein content, and extractivity. Starch content is standardized due to its technological purpose as a source of fermentable sugars, requiring a minimum content of 55 %. Strict requirements are imposed on protein content, as it, on the one hand, ensures foam formation in beverages, and on the other hand, may disrupt the colloidal stability of beer, leading to reduced quality and biological stability. Therefore, the protein content must be between 9–12 %. Barley extractivity determines the ability of essential macro- and micronutrients to transition into a dissolved state. The variety of barley presented in Table 1 fully meets the requirements for brewing barley and can thus be used in malt production, which will subsequently serve as a raw material for beer production.

Additionally, the specified enzymatic activity indicates a low level of activity of the primary enzymes – amylases and proteases – highlighting the necessity for the accumulation of hydrolytic enzymes in the grain. This can be intensified through the implementation of stimulating actions.

The production of barley malt was carried out using traditional technology: steeping using the air-water method, germination in a “box malting” system, drying, and removal of sprouts. To enhance enzyme formation during the steeping stage, the complex preparation “Energen” was used. The concentration of the stimulator was determined experimentally using mathematical processing of the obtained data. The results of the study and their analysis are shown in Figure 1 (x_1 – concentration of the preparation, x_2 – steeping duration), which allowed the determination of the optimal dosage of the preparation – 0.6 g/dm³ of steeping water.



a b

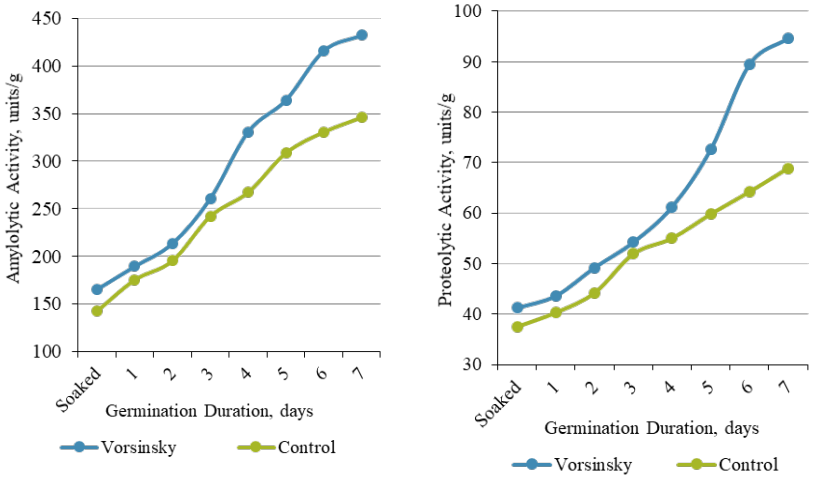
Figure 1 – Changes in amylolytic activity (a) and proteolytic activity (b) of barley during germination depending on the dosage of the “Energen” preparation and the steeping duration

Regression equations for amylolytic (AC) and proteolytic (PC) activity of barley:

$$AC = -35\,159{,}7849+653{,}7479x+101{,}4993y-3{,}025xx-0{,}6811xy+1{,}0687yy$$

$$PC = -16\,771{,}7839+315{,}695x-72{,}7874y-1{,}4821xx+0{,}715xy+0{,}4458yy$$

During the germination process, the activity of amylolytic and proteolytic enzymes in barley was monitored once a day throughout the entire stage. The results of the dynamics of amylase and protease activity are presented in Figure 2.



а б

Figure 2 – Dynamics of amylolytic (a) and proteolytic (b) activity of barley enzymes during germination; *Soaked – soaked barley

The presented data demonstrate that stimulating the grain during steeping activates enzyme formation in the grain and contributes to the production of barley malt with high enzymatic activity [11]. By the end of germination, the level of amylases in the grain treated with the “Energen” preparation reached 432.2 units/g, compared to 345.9 units/g in the control variant. This level of amylolytic enzymes enables hydrolytic processes during the mashing stage to proceed without the need for corrective measures, including the use of enzyme preparations or unconventional methods for preparing grain wort, thereby eliminating additional economic costs [12]. Alternatively, this malt can be incorporated into beer production technologies when unmalted, hard-to-dissolve raw materials are used.

An evaluation of the accumulation of proteolytic enzymes showed a similar positive trend. By the end of germination, protease activity was 94.6 and 68.9 units/g in treated and untreated grain, respectively. The high level of proteolytic enzymes supports deeper hydrolysis of proteins and polypeptides present in the grain, leading to the formation of amino acids that play a technological role in production and enrich the final beverage with essential components. Furthermore, applying the proposed method of biochemical grain dissolution using the “Energen” preparation in malt production allows for the use of barley with a higher

protein content, as the proteolysis will be ensured by the high levels of proteolytic enzymes accumulated during germination [13].

The application of chemical stimulation during the malting process improves other quality indicators of barley malt regulated by standards, as evidenced by the data in Table 2.

Table 2 – Quality Indicators of Barley Malt

Category	Indicator	Treated with "Energen"	Untreated
General Characteristics	Appearance, Color, Taste, Aroma	Typical of light barley malt, compliant with standard requirements	Typical of light barley malt, compliant with standard requirements
Moisture Content (%)	-	4.9±0.1	4.8±0.1
Protein and Starch	Protein Content (%)	10.6±0.2	11.3±0.2
	Extractivity (%) (fine grind)	83.2±1.4	80.2±1.4
Laboratory Wort	Transparency	Transparent	Transparent
	Saccharification Duration (min)	15±0.5	18±0.5
	Acidity (units)	0.90±0.01	0.90±0.01
	Color (units)	0.18±0.01	0.17±0.01
Enzymatic Activity	Amylolytic Activity (units/g)	359.4±10.6	311.4±9.6
	Proteolytic Activity (units/g)	71.3±2.0	54.8±1.1

The obtained data confirm an improvement in the physicochemical characteristics of malt, particularly in technologically important parameters such as extractives and the saccharification duration of laboratory wort. Additionally, our findings align with [14] regarding the lower protein content in treated malt, which does not pose any concerns for using malt derived from such raw materials in beer production. Furthermore, it essentially permits the use of barley malt with raw materials containing higher protein levels in brewing technologies.

Conclusions

Thus, stimulating biochemical processes in barley malt production through the use of the "Energen" complex preparation allows for intensifying the process of enzyme formation and activation in the grain, improving the quality parameters of malt as the primary raw material for fermentation beverage production, optimizing technological stages, and ensuring the production of a final product with high-quality indicators. It is recommended to apply this preparation during grain steeping at a concentration of 0.6 g/dm³ of steeping water and to steep the grain with this preparation for 6 hours.

The proposed method can be recommended for the production of barley malt based on standard-quality raw materials, as well as raw materials with increased protein content. The resulting proteolytic enzymes will reduce protein levels to regulated values. The resulting malt is recommended for use in the production of beer and kvass.

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СОЛОД ӨНДІРУ ТЕХНОЛОГИЯСЫНДАҒЫ ӨСУ СТИМУЛЯТОРЛАРЫ

Бұл зерттеу биохимиялық процестерді жеделдету мақсатында «Энерген» өсу стимуляторын арпа солодын өндіруде қолдануға арналған. Эксперимент 0,6 г/дм³ концентрациясында «Энерген» препаратымен өңделген «Ворсинский 2» сортының арпасында жүргізілді. Нәтижелер бойынша амилолитикалық белсенділік 345,9-дан 432,2 бірлік/г-ға, ал протеолитикалық белсенділік 68,9-дан 94,6 бірлік/г-ға дейін артты. Бұл көмірсулар мен ақуыздардың гидролизінің жақсаруына және солодтың экстрактивтілігінің 83,2 %-ға дейін өсуіне ықпал етті.

Препаратты қолдану сусланың зертханалық осахарлану уақытын 18 минуттан 15 минутқа дейін қысқартуға мүмкіндік берді. Жоғары ферментативті белсенділік солодты қиын еритін шикізатпен пайдалануға мүмкіндік береді және түзету шараларын қажет етпейді. Әдіс сондай-ақ ақуыз мөлшері жоғары арпа үшін ұсынылады, себебі жинақталған ферменттер протеолизді нормативті мәндерге дейін қамтамасыз етеді.

Осылайша, «Энерген» препаратының көмегімен биохимиялық процестерді жеделдету солодтың технологиялық және сапалық көрсеткіштерін жақсартады және оның өндіріс процесін оңтайландырады.

Кілтті сөздер: арпа, солод, ферментативті белсенділік, экстрактивтілік, биокатализация, өсу стимуляторлары.

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СТИМУЛЯТОРЫ РОСТА В ТЕХНОЛОГИЯХ СОЛОДОРАЩЕНИЯ

Исследование посвящено применению стимулятора роста «Энерген» в производстве ячменного солода для интенсификации биохимических процессов. Эксперимент был проведен на ячмене сорта «Ворсинский 2», обработанном препаратом «Энерген» в концентрации

0,6 г/дм³. Результаты показали увеличение амилолитической активности с 345,9 до 432,2 ед./г и протеолитической — с 68,9 до 94,6 ед./г. Это способствовало улучшению гидролиза углеводов и белков, а также увеличению экстрактивности солода до 83,2 %.

Применение препарата позволило сократить продолжительность осахаривания лабораторного сусла с 18 до 15 минут. Высокая ферментативная активность обеспечивает возможность использования солода с труднорастворимым сырьем и снижает необходимость корректирующих мероприятий. Метод также рекомендован для ячменя с повышенным содержанием белка, так как накопившиеся ферменты обеспечивают протеолиз до нормативных значений.

Таким образом, стимуляция биохимических процессов с помощью «Энергена» улучшает технологические и качественные показатели солода, оптимизируя процесс его производства.

Ключевые слова: ячмень, солод, ферментативная активность, экстрактивность, биокатализация, стимуляторы роста.

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