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МРНТИ 65.43.31 https://doi.org/10.48184/2304-568X-2025-1-114-123

DEVELOPMENT OF BEER TECHNOLOGY USING UNMALTED DOMESTIC RAW MATERIALS

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Currently, brewing is a leading industry in the beverage industry. The expansion of the product range, the use of new technologies, and modern equipment allows us to remain competitive in the market. For Kazakhstan, brewing is a new, modernized industry. The creation of new flavors and the use of non-traditional raw materials creates opportunities for obtaining beverages with enhanced biological properties. This study examines the possibility of using an unconventional grain crop of sorghum, in the form of non-malted raw materials of domestic breeding in beer production technology. The use of new types of grain crops makes it possible to obtain new beer profiles, as well as improve the functional properties due to individual components in the grain. The purpose of the study is to study the properties of sorghum grain of the domestic selection of the Kazakhstan- 16 variety and to develop beer technology based on it. A single-brewed mashing method has been selected, which is associated with the increased temperature of the sorghum grain gelatinization. The physicochemical properties, vitamin composition and antioxidant activity of the developed type of beer have been studied. The research was carried out at the NANO BREWERY TYPE 50 L4 microbrewery. The developed technology will make it possible to expand the range of products and produce beer with enhanced biological properties.

Keywords: brewing, beer, non-traditional raw materials, technology, sorghum, antioxidant activity.

ОТАНДЫҚ СЕЛЕКЦИЯНЫҢ УЫТТАЛМАҒАН ШИКІЗАТТЫ ПАЙДАЛАНА ОТЫРЫП СЫРА ТЕХНОЛОГИЯСЫН ЖАСАУ

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Қазіргі уақытта сыра қайнату сусындар өнеркәсібінің жетекші саласы болып табылады. Ассортиментті кеңейту, жаңа технологиялар мен заманауи жабдықтарды пайдалану нарықта бәсекеге қабілетті болып қалуға мүмкіндік береді. Қазақстан үшін сыра қайнату өндірісі жаңа, модернизацияланған сала болып табылады. Жаңа түрлерді жасау және дәстүрлі емес шикізатты пайдалану биологиялық қасиеттері жақсартылған сусындарды алу мүмкіндігін тудырады. Бұл зерттеу сыра өндірісінің технологиясында отандық селекцияның уытталмаған шикізат ретінде астықты дақылдардың дәстүрлі емес түрлерін пайдалану мүмкіндігін зерттелді. Астықты дақылдардың жаңа түрлерін қолдану жаңа сыра профильдерін алуға, сондай-ақ астық құрамындағы жекелеген компоненттер есебінен функционалдық қасиеттерді арттыруға мүмкіндік береді. Зерттеудің мақсаты отандық селекциялық «Казахстанская - 16» сортының құмай дәнінің қасиеттерін зерттеу және олардың негізінде сыра технологиясын жасау. Құмай дәнін клейстеризация температурасының жоғары болуына байланысты бір қайнатпалы әдісі таңдалды. Дайындалған сыраның физика-химиялық қасиеттері, дәрумендік құрамы және антиоксиданттық белсенділігі зерттелді. Зерттеулер NANO BREWERY type 50 L4 шағын сыра қайнату зауытында жүргізілді. Дайындалған технология шығарылатын өнім ассортиментін кеңейтуге және биологиялық қасиеттері жоғары сыра өндіруге мүмкіндік береді.

Негізгі сөздер: сыра қайнату өндірісі, сыра, дәстүрлі емес шикізат, технология, құмай, антиоксиданттық белсенділік.

РАЗРАБОТКА ТЕХНОЛОГИИ ПИВА С ПРИМЕНЕНИЕМ НЕСОЛОЖЕННОГО СЫРЬЯ ОТЕЧЕСТВЕННОЙ СЕЛЕКЦИИ

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В настоящее время пивоварение является лидирующей отраслью в производстве напитков. Расширение ассортимента, применение новых технологий, современного оборудования позволяет оставаться конкурентоспособным на рынке. Для Казахстана пивоваренное производство является новой, модернизированной отраслью. Создание новых вкусов, применение нетрадиционного сырья создает возможности для получения напитков с повышенными биологическими свойствами. В данном исследовании изучена возможность применения нетрадиционной зерновой культуры сорго, в виде несоложенного сырья отечественной селекции в технологии производства пива. Применение новых видов зерновых культур дает возможность получить новые профили пива, а также повысить функциональные свойства за счет отдельных компонентов в зерне. Целью исследования является изучение свойств зерна сорго отечественной селекции сорта «Казахстанская - 16» и разработка технологии пива на ее основе. Подобран одноотварочный способ затирания, связанный с повышенной температурой клейстеризации зерна сорго. Изучены физико-химические свойства, витаминный состав и антиоксидантная активность разработанного вида пива. Исследования проведены на мини- пивоваренном заводе NANO BREWERY TYPE 50 L4. Разработанная технология позволит расширить ассортимент выпускаемой продукции и производить пиво с повышенными биологическими свойствами.

Ключевые слова: пивоваренное производство, пиво, нетрадиционное сырье, технология, сорго, антиоксидантная активность.

Introduction

The agricultural and industrial complex is an interconnected system of rural and industrial sectors. This, in turn, is closely related to agricultural production, as well as the transportation, storage, processing of agricultural products, and their delivery to consumers [1].

The brewing industry is a separate sector of the economy. Because various related industries are connected with it. Today, it is one of the dynamically developing markets of the non-commodity sector of the economy, it is an innovative, modernized and modern industry [2].

Beer, being a natural product of natural fermentation, does not lose its position and has its own consumer in the market. Currently, there is an increasing interest in the production of beer with increased nutritional properties. Of particular interest is the use of non-traditional grain raw materials, which make it possible to obtain high quality indicators and expand the range of products.

Despite the fact that the beer market in the world is developing dynamically, the task of expanding the range of beer and reducing its cost remains relevant. Resource-saving technologies allow us to solve this issue. Malt is the main traditional raw material component in classical beer brewing technology, but its full use is not always possible for producers in a difficult economic situation. An effective solution to this problem is the use of unsalted raw materials of plant origin.

The use of unsalted raw materials in brewing makes it possible to achieve the following positive effects from its targeted use: reducing the cost of using barley; increasing the extractivity of wort; increasing the productivity of the brewhouse when using grain crops with greater extractivity; increasing the colloidal and flavor stability of beer; creating new beers.

Unsalted raw materials are sugar-containing or starch-containing products, the enzymatic activity of which is practically zero. This type of raw material includes cereals (barley, rice, corn, wheat, rye, oats, sorghum, millet, triticale, buckwheat), non-cereals: solid (granulated sugar, vegetables, fruits) and liquid materials (glucose-maltose syrups, sugar syrups, malt extracts, syrups from cereals) [3,4].

The traditional types of unsalted raw materials used all over the world include grains of barley, rice, and corn. The remaining types of grain crops are considered unconventional due to their characteristics and cultivation in different climatic conditions [5].

Crops such as sorghum and triticale are of interest to Kazakhstan brewing, as they began to be cultivated in the republic relatively recently and the study of their properties and effects on beer is an urgent area of research.

The sorghum grain crop is a unique cereal plant, both in terms of its biological characteristics and economic characteristics [6]. In Kazakhstan, they were obtained for the first time in the laboratory of breeding and seed production of the Scientific and Production Center for Agriculture and Crop Production (former KazNIIZ by Williams) under the guidance of Doctor of Agricultural Sciences V.M. Makarov, promising cultivars of forage sorghum and breeding material of early-ripening food sorghum varieties Kazakhstan 16 and Kazakhstan 20 [7].

The purpose of the presented scientific research is to study the possibility of using sorghum grain of domestic breeding to produce a new type of beer with enhanced functional properties.

To achieve this goal, the following tasks were solved:

- justification of the use of non-traditional grain raw materials, sorghum grains, and domestic breeding in beer production technology;
- development of beer technology using sorghum grain and study of its physico-chemical characteristics.

Materials and research methods

The objects of the study were sorghum grains of the Kazakhstan-16 variety, developed and presented for research by "Kazakh Scientific Research Institute of Agriculture and Crop Production" LLP (Almaty region, Kazakhstan), used as unsalted raw materials. Light Pilsen barley malt, bitter granulated hops (α-acid 14.2%) and aromatic (α-acid 4.3%), yeast of the Saflager S-23 strain were also used for brewing wort preparation.

Scientific research was conducted at the Scientific Research Institute "Food Safety" of the Almaty Technological University. Beer samples were brewed at the educational and scientific center for fermentation products of the Almaty Technological University at the NANO BREWERY TYPE 50 L4 microbrewery.

The main physico-chemical parameters were measured on a biomer of alcohol-containing products "Kolos". Water-soluble antioxidants according to GOST R 54037-2010. The content of water-soluble B vitamins according to GOST 31483-2012 [8,9].

Literature review

Beer is one of the oldest and most popular alcoholic beverages [10, 11]. Currently, there are about a thousand different varieties of beer, the recipes of which vary from country to country, and sometimes even from city to city. Beer consumption around the world remains at a high level and continues to grow due to the variety of beer varieties and new innovative flavors and recipes of its production. Craft beer is becoming popular in many parts of the world. In light of the growing interest in a healthy lifestyle, the demand for non-alcoholic beer is also increasing [12].

Lager and IPA are traditionally preferred in Asia, and overall consumption continues to rise. The population is eager to try new flavors and innovative variations of beer, which stimulates interest in craft beers with a variety of flavors and flavors.

Currently, the brewing industry in Kazakhstan is one of the leaders in the beverage industry. Expanding the range and increasing the functional properties of the drink is one of the conditions for competitiveness in the market of Kazakhstan and beyond [13]. Beer production and sales in Kazakhstan have increased significantly in recent years. The majority of the population prefers classic light beer of medium strength, which is characterized by a low alcohol content and bitterness. This segment accounts for almost 92% of the total beer market. In the period from January to October 2024, 598.2 million liters of beer were produced, which is 6.2% more than in the previous year [14]. The main beer production in 2024 in the regional context is concentrated in Almaty and the Almaty region.

Today, in addition to traditional barley and soft wheat, triticale, quinoa, buckwheat, tritordeum, sorghum, and others are used in beer production [15,16]. These cereals are used as unsalted raw materials in order to increase the extractivity of the wort, expand the product range, obtain certain organoleptic characteristics and reduce the cost of the final product. Moreover, some of them have other functional properties, which increases the nutritional value of the drink. The authors of [17] have developed beer samples with antioxidant properties due to the content of phenols and flavonoids obtained from quinoa. An innovation of the research is the development of a technology for the production of sour non-alcoholic beer (non-alcoholic Sour Ale) using juice from the fruits of the red-colored dogwood variety (Cornus mas L.). It has been proven that in addition to interesting organoleptic qualities, such as sour taste or aroma, this beer has other valuable properties, such as strong antioxidant potential, and also contains iridoids, which are found in these types of fruits.

Replacing expensive brewing malt with unsalted carbohydrate-containing raw materials is one of the most important and urgent tasks of the brewing industry. For beer production, it is important to select the raw materials that make it possible to obtain a semi-finished product with a high final degree of fermentation and increased organoleptic characteristics of the finished drink.

It is known that in the production of traditional beer, the higher the extractivity of the raw material, the faster the available enzymes hydrolyze starch to simple sugars. Consequently, the yield of fermentable carbohydrates increases, which has a positive effect on the process of basic fermentation and an increase in the yield of ethyl alcohol. The mashing process is also accompanied by starch gelatinization when heated. Gelatinized starch is more easily exposed to the action of amylolytic enzymes, thereby conducting the starch hydrolysis process more deeply, which also helps to increase the yield of extractive substances in the wort [18].

In this regard, according to the monitoring of scientific literature, sorghum grain may become the most promising type of non-traditional grain raw materials that can be used in beer production.

Grain sorghum is a unique cereal crop of interest to the agriculture of our republic. Showing its drought-resistant properties, it can be cultivated in southern regions with a hot climate, yielding good yields. It is not capricious to changes in weather conditions, soil composition, and processing methods [19].

Research suggests that sorghum grain is not inferior in starch content to barley or corn, which has a positive effect on the yield of extractive substances. In beer production, an important condition is deep hydrolysis of starch compounds, with maximum yield of unfermented sugars. Since sorghum grain has a large number of small starch grains (less than 1 micron), and they fit snugly together, elevated temperatures must be used during mashing (78-85 ° C) for their gelatinization and liquefaction. In this regard, a certain mashing mode has been selected, in which it is necessary to completely hydrolyze the starch grains of sorghum.

The use of grain sorghum of domestic breeding is of particular interest for brewing as a source of extractive substances and functional properties.

Results and discussions

At the first stage of the study, the main physico-chemical quality indicators of some grain crops used in brewing in the form of unsalted raw materials were studied and a comparative analysis was carried out with the quality indicators of grain sorghum of the Kazakhstan-16 variety (picture 1).

According to the data presented in picture 1, sorghum grain is in no way inferior in its main characteristics to traditional grain crops used in beer production. Sorghum has a moderate starch content, which is not inferior to traditional types of unsalted raw materials, at a high gelatinization temperature (78-85 ° C), which is higher than for other cereals (on average it is 60-72 ° C).

In connection with the above, when developing beer technology, a single-brewed mashing method was selected, which promotes deeper hydrolysis of starch grains and increases the yield of extractives.

At the next stage of the study, beer production technologies using domestic sorghum were developed, taking into account the structural features of this grain crop (picture 2).

The traditional brewing technology involves the production of beer wort from extract-containing raw materials, its further hopping and fermentation with brewer's yeast. Next, the resulting green beer must go through the stages of aging and maturation, colloidal stabilization and bottling. Beer production in the framework of this study was carried out according to a typical technological scheme. The content of unsalted raw materials in the fill was 20%, which is optimal for obtaining beer with the specified characteristics.

The main technological stages of the prototype production were: crushing and mashing of grain products, mash filtration, hopping and cooling of wort, calculation and task of yeast culture, fermentation and fermentation of beer, filtration and bottling.

As part of this study, a single-boil mashing method was used, which involves separating one part of the mash, boiling it and returning it to the mash vat in order to increase the temperature of the entire mash.

From the point of view of the technological description of the mashing process, the following modes were observed: grain raw materials were crushed on a crusher, after which the mash boiler was filled with water (temperature 45 ° C), with the ratio of the selected hydraulic module and grain raw materials. Crushed sorghum was poured into broth I with constant stirring to prevent sticking due to gelatinization of starch grains.

Further, when the jam temperature increased by 1 ° C in 1 minute, the first temperature pause was reached - 62 ° C, the pause was maintained for 15 minutes, then the temperature was increased to 72 ° C and the pause was maintained at this temperature for 15 minutes. This was followed by a pause at 85 ° C for 20 minutes, followed by a temperature pause at 98 ° C for 15 minutes for the final gelatinization of sorghum starch.

At the same time, crushed barley malt was combined with water at a temperature of 52 ° C in another mash boiler. When combining the first and second decoctions, the mash temperature rose to 63 ° C and a 20-minute pause was maintained. This was followed by a pause at 65 ° C for 15 minutes, at 68 ° C for 20 minutes. The maltose pause (at 72 ° C) lasted 30 minutes, followed by a quality check of saccharification with an iodine sample. The total mashing time was 15 minutes (2 hours and 30 minutes). The mashing schedule is shown in the technological scheme of beer production in Figure 2.

After that, the sugared mash was sent for filtration to separate the wort from the pellet and clarify. As the first wort was obtained, filtration continued until the washing water was collected, and both fractions were then combined to obtain the most highly extractable wort with the least losses.

Further, according to the technological scheme of the study, the wort was boiled with hops and the wort was fermented. The technological characteristics of the boiling process are shown in Table 1.

The bitterness was calculated by determining the required amount of bitterness for the volume of wort obtained after filtration. The resulting volume of wort after filtration was 52 liters (including washing water), the desired amount of bitterness in hopped wort was 16-18 EBC.

After hopping (temperature 98 ° C), the wort underwent a cooling stage to a temperature of 18 ° C by passing through a heat exchanger and cooled with ice water. Upon reaching this value, the wort was directly seeded with dry yeast. Since top-fermentation yeast was selected, the temperature and duration of the main fermentation were 18 ° C and 7 days, fermentation was carried out in a cylindrical-conical tank. To control the quality of fermentation, beer extractivity and alcohol content were measured on a daily basis. Based on the indicators of the sugar meter, the degree of fermentation was calculated, upon reaching the target value of 78%, the main fermentation stopped

and the beer was transferred to the post-fermentation stage.

As soon as the desired degree of fermentation was achieved, the green beer was transferred to fermentation, where it was aged at a temperature of 2 ° C for 7 days. At the end of fermentation, there was an obvious lightening of the wort and an improvement in the taste profile. Next, the finished beer was clarified and its physico-chemical properties were determined (Table 2).

Beer made using classical technology was used for control. For this, malt filling with a 1:4 hydraulic module was used, mashing was carried out using classical technology with 3 pauses, the main fermentation was carried out using low-fermentation yeast at a temperature of 8-12 ° C, for 7 days, and fermentation at a temperature of 0-2 ° C, for 7 days, then sent to 3-stage filtration. The physico-chemical parameters of the prototype were within the normal range for classic light beer. The color index is higher than for the control sample as a result of the introduction of sorghum grain, but it is within the acceptable range for light beer.

The nutritional value of the drink is due to the presence of vitamins and amino acids in its composition. Its nutritional value and antioxidant activity were determined in the developed drink (Table 3).

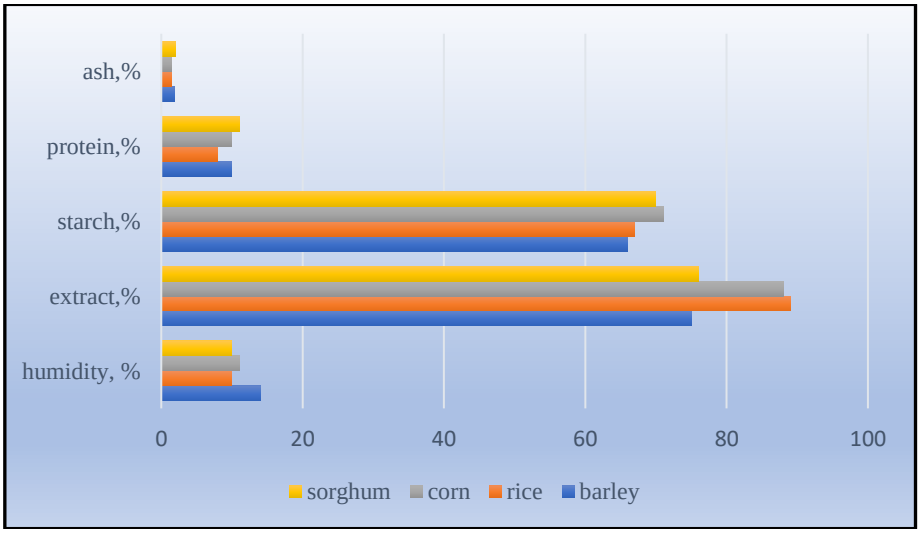
According to the data shown in Table 3, a small amount of B vitamins was identified in the developed beer, which were transferred from grain raw materials to beer. Nutritionists believe that B vitamins have a positive effect on the nervous system and can reduce stress levels. This drink is a natural product of natural fermentation, which makes it possible to replenish the body's water balance (19% of the daily value).

Of particular interest is the antioxidant activity of the developed beer, this indicator is one of the additional criteria for the quality of beverages.

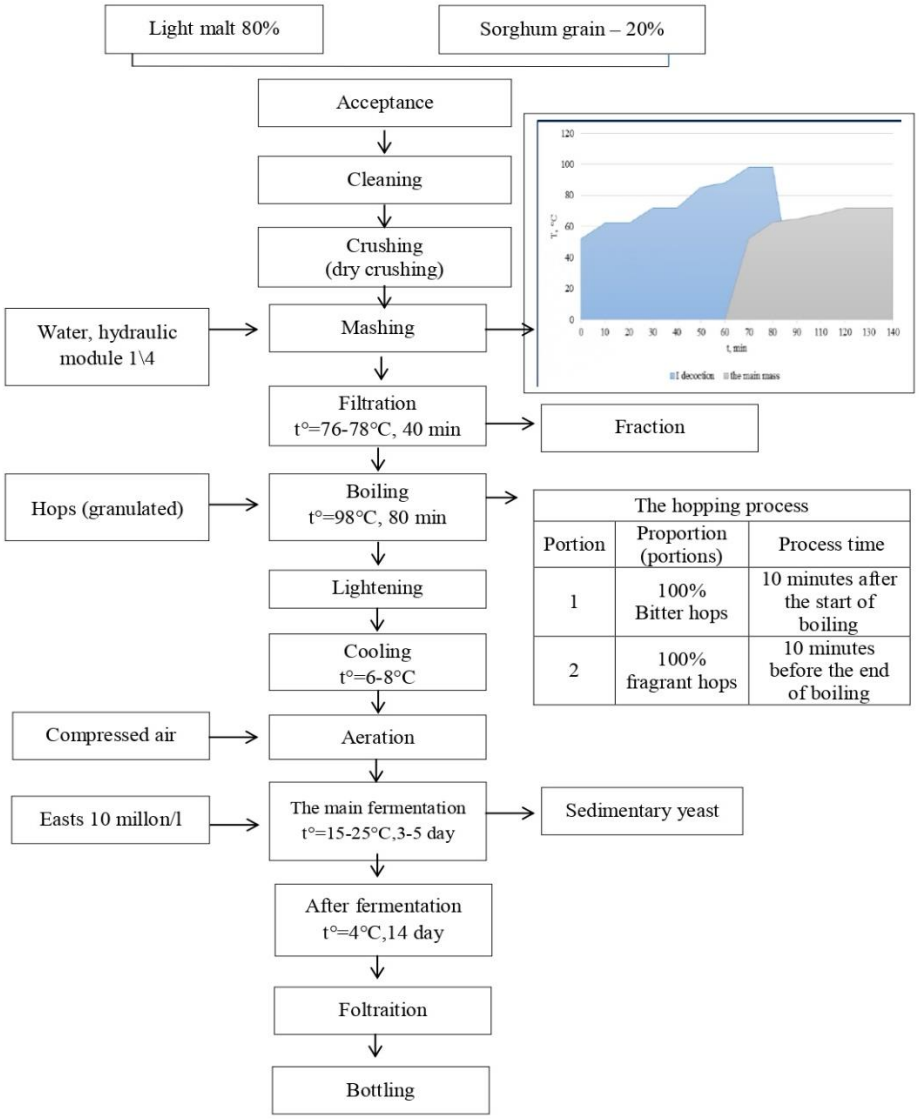
It is important to note that in addition to information about product quality, the indicator of antioxidant activity also reflects the physiological value of the product for the human body. In recent years, from the point of view of consumer properties, various groups of beverages have been increasingly considered as products with a certain physiological value and used to enrich the body with a wide range of biologically active substances. At the same time, compounds of the phenolic complex (catechins, tannins, aitocyanins, flavones, flavonols, etc.) are of particular interest, since, on the one hand, they are factors that reduce the risk of developing chronic non-communicable diseases, and on the other hand, they bind free radicals, that is, they exhibit pronounced antioxidant properties. Currently, for various groups of phenolic compounds, the need for their presence in the diet has been proven due to their participation in a number of metabolic processes, and adequate and upper acceptable levels of their daily intake have been established. It has been established that phenolic compounds have pronounced anticarcinogenic, anti-inflammatory, antiallergic, and antiviral properties.

The antioxidant activity of the developed beer is 0.7 mg/ml, which is equivalent to 0.07 mg of quercetin. Quercetin is a well-known and widespread antioxidant [20]. The predominance of the antioxidant properties of the developed beer is due to the content of hops containing polyphenolic compounds, as well as the presence of unsalted sorghum grain. Sorghum is rich in a number of phytochemicals, including tannins, phenolic acids, anthocyanins, and phytosterols, which enhance its antioxidant properties.

Thus, the use of grain sorghum in beer production can become an alternative to the traditional type of unsalted raw materials, which does not require additional investments in production. Also, the presence of antioxidant properties of sorghum grain will increase the nutritional value of the developed drink. These studies will make a definite contribution to the development of the brewing industry in the country.



Picture 1. Physico-chemical properties of some grain crops used in brewing



The hopping process		
Portion	Proportion (portions)	Process time
1	100% Bitter hops	10 minutes after the start of boiling
2	100% fragrant hops	10 minutes before the end of boiling

Picture 2. Technological scheme of the developed beer production

Table 1. Technological parameters of boiling wort with hops

Duration of boiling	60 min
Boiling with bitter hops	50 min
Boiling with aromatic hops	10 min
Evaporation rate	75%

Table 2. Physico-chemical indicators of beer quality

Indicator	Control	Experience
Extractivity of the initial wort, %	12	12
Valid extract, %	3,8	3,2
Visible extract, %	2,8	2,6
Alcohol content, % volume	4,3	4,7
The actual degree of fermentation, %	70	74,1
pH	4,2	5,1
The color of beer, EBC	8,2	11,5

Table 3. The content of vitamins and antioxidant activity in the developed beer

Indicator	The average norm for an adult	The prototype
Vitamins of group B, mg/100 ml		
B1,	0,15	0,01
B 2	0,18	0,05
B3	2,0	0,8
B4	250	40
B5	100	9
B6	40	8
Antioxidant activity, mg/ml		
water-soluble antioxidants	0,27	0, 7

Conclusion

Based on the conducted experimental studies, the following conclusions can be drawn:

1. For the production of beer using non-traditional grain raw materials, a type of unsalted grain sorghum of the Kazakhstan -16 variety of domestic breeding has been selected. The introduction of this grain crop is justified by the presence of an optimal starch content (70.0-81.0%), necessary for an increased yield of extractives.

2. A technological scheme for beer production has been developed, taking into account the characteristics of grain sorghum. Thus, a single-brewed mashing method has been selected, which makes it possible to increase the yield of extractive substances.

3. The physico-chemical quality indicators have been determined, which are not inferior in their values to the classic light beer produced in production conditions.

4. The content of vitamins in the composition and antioxidant activity in beer were studied. Water-soluble vitamins in small amounts have been identified in the finished beer, which also determines its nutritional value. The antioxidant activity of beer was 0.7 mg/ml, which is a high indicator of beer stabilization and is justified by the presence of these properties in grain sorghum.

Gratitude, conflict of interest (financing)

These studies were conducted within the framework of research and development (R&D) funded by Efes Kazakhstan JSC.

We would also like to thank “Efes Kazakhstan JSC” for the sponsorship financing for the acquisition of the “NANO BREWERY TYPE 50 L4” microbrewery. This contribution makes it possible to conduct numerous studies in the brewing industry.

There is no conflict of interest.

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ӘОЖ 68.39.15 https://doi.org/10.48184/2304-568X-2025-1-123-130

ДӘСТҮРЛІ ЕМЕС МАЙЛЫ ДАҚЫЛДАРДЫҢ ЖАНАМА ӨНІМДЕРІН ҚҰРАМА ЖЕМ ӨНДІРІСІНДЕ ҚОЛДАНУ

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Жем-шөп өндіру ауыл шаруашылығының негізгі салаларының бірі, бұл құрама жем өндірісінің өсуі және осы мал шаруашылығының қарқынды дамуына әсер етеді және мал өнімдерінің бәсекеге қабілеттілігін жоғарлатып, малдың азықтық мәселесін шешеді. Өйткені мал шаруашылығымен айнлысатын қожалықтарда мал азығына жұмсалатын шығының көп бөлігі осы мал азығына кетеді. Сол себепті егістікте жарамсыз қалған майлы дақылдардың дәстүрлі емес қалдықтарын пайдалану орынды болып саналады. Осы майлы дақылдарды жем азығына пайдалану арқылы біраз экологиялық, экономикалық және технологиялық мәселелерді шешуге болады, оның ең маңыздысы – қауіпсіз кешенді технологияларды жасау. Ауыл шаруашылық жануарларына арналған құрама жем өндірісін жақсарту үшін дәстүрлі емес майлы дақылдардың егістіктегі қалдықтарын пайдалану арқылы сауынды сиырлардың орташа тәуліктік сауынының жоғарлатып және азықтық шығындардың төмендеуіне ықпал ететіні маңызды. Осы берілген мақалада егістіктерден жиналған күнбағыс қалдықтарынан алынған жемдік ұнның физикалық-механикалық көрсеткіштері, химиялық, аминқышқылдық құрамы мен микробиологиялық көрсеткіштері анықталған. Зерттеулер нәтижелері бойынша егістктегі дәстүрлі емес майлы дақылдардың