Expanding the assortment of fermented beverages at small enterprises

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Abstract. The authors considered the possibility of expanding the assortment of fermented beverages in small beer production enterprises. As a new type of product, the production of kvass with plant extracts is proposed: pot marjoram, clary sage, lemongrass, Schisandra chinensis. Investigations of their physicochemical properties, aroma and antioxidant activity were carried out. It was noted that the highest content of antioxidants in the extracts of pot marjoram and Schisandra chinensis was 18.34 and 12.36 mg/dm³. Fermentation of kvass wort was carried out with yeast Sacharomyces cerevisiae of strains ICV D 254, EC-1118, 71B-1122, V 116 at a temperature of 28 °C within 9 hours. The result of the analysis of solids wort’s and acidity dynamics during the fermentation process is a recommendation the EC-1118 strain. Four kvass recipes with different functional orientations have been developed. During the research, the method of mathematical planning and statistical processing of the results was used. When optimizing the parameters, the influence of the fermentation temperature, the dosage of plant extracts and the dosage of yeast on the acidity of the wort is considered. It has been established that the dosage of plant extract has the greatest effect on the acidity of kvass.

1. Introduction
At present, in Russia a significant part of the products of the beer and soft drinks industry is produced at medium and small enterprises. In conditions of fierce competition with large manufacturers, including transnational companies, well-timed reaction to market changes and consumer preferences is especially important. Import substitution of foodstuff remains relevant [1].

The advantages of small enterprises include the ability to more easily vary not only technological modes, but also the hardware design and formulations of manufactured drinks. In conditions of stabilizing the growth of beer production, and in some years even reducing consumption, it is urgent to introduce the production of new types of fermentation drinks for the enterprise, such as kvass, cider and others [2,3].

From an economic point of view, kvass is a very attractive product due to its shorter production cycle than beer and its low cost. Despite the pronounced seasonality, its production volumes continue to grow [4]. A feature of kvass is its perception by consumers as a traditional Russian drink [5,6], and the possibility of consumption by the population of all ages due to the low alcohol content [7]. To ensure competitiveness, the drink should not only have an attractive appearance, taste, but also contain useful components [8]. As a result of the natural fermentation process, organic acids, amino acids, vitamins and other biologically active substances accumulate in the product [9].
A promising area for expanding the assortment of fermented beverages, including kvass, is the use of domestic raw materials containing micro and macro elements, flavonoids, antioxidants [10, 11]. The introduction of various combinations of plant extracts can contribute to the creation of unique drinks that have a prophylactic effect on the human body and are recommended for various groups of the population. The production of kvass using plant extracts has the following positive aspects: the integrated use of domestic plant materials; introduction of low-waste technology in the processing of raw materials; increase the functional properties of the drink; expansion of the assortment; the ability to create drinks targeted at a specific population [12]. The fruits and leaves of Schisandra chinensis have a tonic, anti-inflammatory, adaptogenic, anti-cancer effect on the body, and have a significant supply of antioxidants [13]. In the aerial part of pot marjoram, a high content of polyphenolic compounds [14], thymol was noted. Drinks based on it have an anti-inflammatory, antitumor effect and the ability to neutralize the effect of free radicals and are also recommended for people suffering from neurodegenerative disorders [15]. Clary sage extracts contain vitamins, folic acid, organic acids, flavonoids. There is a developed production technology of a functional drink such as tea based on sage [16]. There is evidence of the use of lemongrass to produce food products, including drinks. In some countries, such as Brazil, lemongrass tea is traditional [17].

The microorganisms used in the fermentation have a significant effect on the properties of the finished fermentation drink. Research [18] showed that, depending on the yeast race, various by-products that form the taste and aroma of the drink accumulate, such as higher alcohols, aldehydes, ketones, organic acids, etc. The developed methods for instrumental determination of volatile components [19] facilitate the introduction of knowledge-intensive production technologies.

Hardware-technological schemes of modern mini-breweries allow you to produce kvass according to classical technology using kvass wort concentrate. The development of technologies and formulations of kvass with plant extracts will allow producing new competitive types of products at enterprises, increasing the stability of the enterprise.

2. Materials and methods
The objects of research were plant raw materials grown in the experimental fields of the Voronezh Agricultural University: pot marjoram (Origanum vulgare), clary sage (Salvia sclarea), lemongrass (Cymbopogon citratus), Schisandra chinensis (Schisandra chinensis). when cooking kvass, kvass wort concentrate of industrial production was used [GOST 28538-2017], sugar [GOST 33222-2015]. For the research, yeast of the Sacharomyces cerevisiae race of strains ICV D 254, EC-1118, 71B-1122, V 116; bacterial lyophilized concentrate of viscous races of acidophilus bacillus for fermented products Pa BK-Uglich-AV, producer the Federal State Unitary Enterprise “Experimental Biofactory” of the Russian Agricultural Academy.

For use in the technology of kvass production, pre-dried and ground vegetable raw materials were extracted with water at a temperature of 90 ± 2 °C for 15 minutes at a hydraulic module of 1:10 [12].

The solids content was determined by the refractometric method [GOST R 51433-99], the mass fraction of titratable acids by titration [GOST 6687.4-86], the aroma of plant extracts was determined on a MAG-8 odor analyzer with “the electronic nose” method using eight sensors: S1 - Beeswax, S2 - Bee glue, S3 - Bee glue with Fe (III), S4 - Polyethylene glycol sebacinate (PEGSb), S5 - Polyethylene glycol phthalate (PEGF), S6 - Polyethylene glycol succinate (PEGS), S7 - Polyphenyl ether (PFE), S8 - Trioctylphosphine oxide (TOFO). Antioxidant activity was determined by the method, which is based on the amperometric method for determining the content of antioxidants, which consists in measuring the electric current arising from the oxidation of the test substance (or mixture of substances) on the surface of the working electrode at a certain potential and comparing the received signal with a standard signal (quercetin), measured under the same conditions. The calculation is made with the formula:

$$CA = CA_{arp} \times N,$$
where is agr. - the value of the content of antioxidants found from the calibration graph, mg / dm³; 
N - dilution of the analyzed sample.

3. Results and discussion

Characteristic features of kvass - its color, aroma, fullness of taste is determined basically by the 
composition of the feedstock. The inadequate content in the wort of nutrients for microorganisms 
disrupts the normal course of wort fermentation. As a result, kvass will have low acidity, low alcohol, 
carbon dioxide and aromatic substances. You can avoid this problem by using natural plant 
components in the drink. Both economically and technologically, it is advisable to use plant materials 
in the form of aqueous extracts.

A research was made of the physicochemical properties of plant extracts. The results are presented 
in table 1.

### Table 1. Physico-chemical characteristics of water extracts

| Physico-chemical indicator | Pot marjoram | Clary sage | Lemongrass | Schisandra chinensis |
|----------------------------|--------------|------------|------------|----------------------|
| Acidity (titratable), cm³  | 1.2          | 1.5        | 1.7        | 2.1                  |
| sodium hydroxide solution 1 mol / dm³ per 100 cm³ |              |            |            |                      |
| Solids content, %          | 5.2          | 3.8        | 4.2        | 4.0                  |

In accordance with the obtained data, a higher titratable acidity was noted in the extract of 
Schisandra chinensis and lemongrass, which is explained by the high content of malic, citric and 
tartaric acids in them.

The highest solids content was noted in aqueous extracts of pot marjoram (5.2%) and lemongrass 
(4.2%). Tannins, organic acids, amino acids, micro and macro elements, vitamins (ascorbic acid), 
which promote the nutrition and growth of yeast cells, as well as increase the biological value of 
ready-made kvass, actively pass into the liquid phase during extraction.

Aroma is the most important quality indicator for kvass and soft drinks. It determines the 
popularity and demand in the market of the presented product. Therefore, when developing 
technologies and recipes for fermented drinks using plant extracts, it is necessary to carry out 
instrumental analysis to assess the composition of the volatile gas phase and the persistence of aroma.

The aroma research of water extracts of plants were carried out on an odor analyzer, the results are 
presented in table 2.

### Table 2. Sensor responses S1-S8 (Hz) and the area of the “visual imprint” of the sensor signals in the 
gas phase above the samples, S, Hz.s

| Name                               | S1  | S2  | S3  | S4  | S5  | S6  | S7  | S8  | S, Hz.s |
|------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|---------|
| Water                              | 2   | 11  | 21  | 19  | 28  | 36  | 1   | 6   | 756.3   |
| Pot marjoram extract               | 4   | 12  | 17  | 23  | 30  | 40  | 4   | 8   | 977.6   |
| Clary sage extract                 | 4   | 12  | 18  | 23  | 20  | 37  | 5   | 8   | 901.6   |
| Lemongrass extract                 | 4   | 12  | 16  | 24  | 20  | 38  | 5   | 8   | 905.6   |
| Schisandra chinensis extract       | 4   | 13  | 20  | 18  | 29  | 40  | 4   | 10  | 917.1   |

Different contents of volatile organic compounds were established in the equilibrium gas phase 
above the samples. Samples contain a close number of unsaturated hydrocarbons, terpenes, ketones,
The content of aromatic, including phenolic compounds, and esters varies significantly in samples.

The aroma intensity is determined by the characteristic $S$, Hz·s. The value of the indicator is the largest for the extract of pot marjoram and the smallest for the extract of clary sage. Compared to the background of the water, the increase in aroma is 19.7% - for a sample of the aqueous extract of clary sage; 19.2% - for a sample of an aqueous extract of Schisandra chinensis, 21.3% for a sample of an aqueous extract of lemongrass and 29.3% - for a sample of an aqueous extract of pot marjoram. According to the content of the main classes of organic compounds, all samples significantly differ in the proportion in the mixture of individual volatile components. In accordance with the data obtained, the qualitative composition of the volatile fractions of all samples in terms of the ratio of substances with large molar mass is close (aromatic) and differs in the content of saturated cyclic hydrocarbons and unsaturated linear and cyclic hydrocarbons.

An indicator of the aroma stability can be considered the ratio of sensor signals. When calculating the ratios of the indicators of the PEGSb (S4) / PEGS (S6) sensors, it was found that the parameter value for the oregano extract is 0.57, clary sage - 0.57, lemongrass - 0.43, Schisandra chinensis - 0.63. In water, the signal ratio was 0.53. Therefore, aqueous extracts of Schisandra chinensis and lemongrass are characterized by a more persistent aroma and can be recommended as the main component in the preparation of compositions in the formulation of fermented drinks.

An important criterion for the selection of components in the development of beverage formulations is the possibility of a positive effect on the human body, including slowing down the aging process and eliminating free radicals. We have investigated the content of antioxidants in aqueous extracts of plants by the amperometric method. Based on the analysis of the obtained amperograms, it was found that the value of the area (nA·s), as well as the height of the peaks, have the greatest influence on the total antioxidant content. For calculation, the average values for the experiment are taken. Calculations are carried out, the total content of antioxidants in the studied samples is established. The results are presented in table 3.

### Table 3. The content of antioxidants

| Name               | The content of antioxidants, mg / dm³ |
|--------------------|---------------------------------------|
| Pot marjoram       | 18.34                                 |
| Clary sage         | 7.50                                  |
| Lemongrass         | 8.64                                  |
| Schisandra chinensis | 12.36                               |

In accordance with the data obtained, all samples contain antioxidants. The greatest amount was noted in extracts of common oregano and Schisandra chinensis and amounted to 18.34 and 12.36 mg / dm³ respectively. Based on the data obtained, it can be concluded that it is advisable to use the studied plant extracts in beverage technology.

Fermentation processes of carbohydrate-containing raw materials are the most important biochemical processes in the production of many types of food products. The regimes and conditions of the fermentation of the substrate can vary significantly depending on the microorganisms used. The fermentation process is also fundamental in the production of kvass. At the same time, the quality of the finished product is influenced by various factors, including the chemical composition of the raw materials, the duration and temperature of the fermentation, the characteristics of the yeast used.

For the research, yeast of the Saccharomyces cerevisiae race of strains ICV D 254, EC-1118, 71B-1122, V 116 was selected. The effect of various yeast strains on the wort parameters during fermentation was determined.

Yeast in a dosage of 0.4 g / l was added to the wort samples and the changes in the solids content and titratable acidity were monitored during fermentation.
Option 1 - ICV D 254; option 2 – EC-1118; option 3 – 71B-1122; option 4 – V 116.

The change in the solids content in kvass during fermentation is shown in Figure 2.

The change in the acidity of kvass during fermentation with yeast of different strains is presented in Figure 1.

![Figure 1. The dry matter content in kvass during fermentation.](image1)

![Figure 2. Change in titratable acidity during fermentation.](image2)

In accordance with the results presented in Figure 1, the yeast EC-1118 and ICV D 254 ferment leaven wort more intensively than others. After 9 hours, the solids content decreased by 1.1% and 1.2%, respectively. However, the increase in acidity in the kvass sample with yeast EC-1118 (Figure 2) occurs more intensively: from 0.68 to 1.28 units. Therefore, yeast strain EC-1118 can be recommended for use in kvass technology.
Based on the results and information from literary sources, kvass formulations are compiled with different functional orientations (table 4). At the same time, the components whose dosages are the same according to the formulation options are not included in the table.

**Table 4. Dosages of plant extracts per 100 gave kvass**

| Component / Metric | Recipe 1 | Recipe 2 | Recipe 3 | Recipe 4 |
|--------------------|----------|----------|----------|----------|
| Pot marjoram extract, l | 60       | 20       | -        | -        |
| Clary sage extract, l | 20       | -        | 20       | 60       |
| Lemongrass extract, l | -        | 60       | -        | -        |
| Schisandra chinensis extract, l | - | - | 60 | 20 |

| Functional focus | Recipe 1 | Recipe 2 | Recipe 3 | Recipe 4 |
|------------------|----------|----------|----------|----------|
| Elimination of free radicals, anti-inflammatory effect, enrichment with vitamins, organic acids, prevention of nervous system disorders | - | - | 60 | 20 |
| Tonic effect, elimination of free radicals, flavonoid enrichment | - | - | - | - |
| Adaptogenic, tonic, anti-inflammatory effect, elimination of free radicals | - | - | - | - |
| Anti-inflammatory effect, enrichment with vitamins, organic acids | - | - | - | - |

In all variants of the formulation, the dosage of kvass must concentrate is 29.4 kg, sugar - 45 kg, bacterial concentrate - 0.83 kg, yeast - 0.4 kg per 100 decaliters of kvass.

The optimization of the main technological parameters was carried out using the method of mathematical planning of the experiment. Processing of results - in the program Statistica. As variable variables, the fermentation temperature, the dosage of yeast, and the dosage of the plant extract (according to recipe 1) were considered. Dependent variable - acidity, units as a result, the regression equation \( Y = 1.89 + 0.07X_1 + 0.18X_2 + 0.74X_3 + 0.06X_3^2 \) is obtained.

A plot of the acidity of the wort on the dosage of yeast and the dosage of the plant extract is shown in Figure 3.

**Figure 3.** The dependence of titratable acidity on the dosage of the extract and the dosage of yeast
In the considered interval, acidity has a positive dependence on the considered factors. However, with increasing values of the factors, the angle of inclination of the surface to the horizontal plane decreases, therefore, the degree of influence on the dependent variable is less. Based on the analysis of the coefficients of the regression equation and the graph presented in Figure 3, it can be concluded that the effect of the dosage of the plant extract on acidity is greater than the dosage of yeast and the temperature of the wort fermentation. The obtained data allows you to directionally change the technological parameters of the wort, simulate the process in the considered range of values and can be used in the production of kvass.

Thus, the authors proposed expanding the assortment of fermented drinks by releasing kvass with plant extracts. Studies have shown the feasibility of using extracts of oregano, clary sage, lemongrass and Schisandra chinensis to obtain kvass in small enterprises with various organoleptic properties and functional orientation.

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