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Contents

Influence of low-gluten grain crops on beer properties

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Abstract

Introduction. The prospects of using buckwheat and buckwheat malt for the production of low-gluten beer are shown.

Materials and methods. Beer wort and beer were made from crushed white buckwheat and buckwheat malt in the ratio of 85, 90, 95 percent barley malt and 15, 10, 5 percent (crushed buckwheat and buckwheat malt). To determine the content of amine nitrogen iodometric method was used, to determine the content of reducing substances the method of Wilshteter-Schudl was used, the protein content was determined by the method of Keldal, the starch content was determined by the method of Evers.

Results and discussion. Gluten is absent in such cereals as buckwheat and rice, and in other cereals the amount of gluten is: corn 80 ppm, barley 151 ppm, wheat 162 ppm. Therefore, for the preparation of low-gluten beer, crushed white buckwheat, buckwheat malt and barley malt are recommended.

The sample with the replacement of 5% barley malt on buckwheat has the highest content of reducing substances, namely 91.0 g per 100 g of extract and amine nitrogen 167.1 mg per 100 g of extract, the content of ethyl alcohol in the finished beer 3.5% by weight at mass fraction of the actual extract of 4.83% by mass.

When replacing barley malt with crushed white buckwheat, it was better to replace it with 5% barley malt. The content of reducing substances was 86.9 g per 100 g of extract, and the content of amine nitrogen was 154.9 mg per 100 g of extract. The obtained beer of this sample has the best result in terms of alcohol content of 2.9% by weight and in terms of mass fraction of real extract – 5.53% by weight.

As the amount of crushed buckwheat and buckwheat malt increases, the amount of reducing substances and amine nitrogen decreases due to the insufficient amount of hydrolytic enzymes in barley malt, under the action of which the above substances are formed. Thus, in the sample with the replacement of 5% barley malt by buckwheat, the content of reducing substances was 92 g per 100 g of extract, and the content of amine nitrogen was 168 mg per 100 g of extract. Whereas in the sample with a substitution of 15% barley malt, these figures are 82 g per 100 g of extract and 91 g per 100 g of extract, respectively.

Conclusions. The best crop for the production of low-gluten beer is crushed white buckwheat and buckwheat malt in a ratio of 95:5.

Introduction

Studies of the following cereals were made: barley, wheat, rye, corn, buckwheat in order to select grains with minimum gluten content for the production of low-gluten beer. The content of gluten in crops such as barley, wheat, corn, buckwheat is different [2].

Therefore, studies aimed at determining the minimum amount of gluten in cereals are of particular importance [16, 17]. Wheat (gliadin), rye (secaline) and barley (hordein) prolamines are toxic to the intestinal mucosa of patients with celiac disease [8, 17] due to the high content of glutamine (30%) [4] and proline (15%) [5, 6], while prolamins of rice, buckwheat, corn are not toxic due to the lower content of these amino acids [7].

Significant scientific and applied interests are the possibility of using gluten-free raw materials for the preparation of low-gluten beer [1, 3].

In study [2] it is recommended to use up to 30% of extruded buckwheat flakes for brewing wort. The use of such an amount of unmalted raw materials necessarily requires the use of a complex of hydrolytic enzymes [15], which is undesirable in the preparation of low-gluten beer. When using barley malt, this amount of extruded buckwheat flakes will not be able to saccharify the mash, so the optimal amount of buckwheat flakes remains unknown [5], which requires additional research.

Technological, physicochemical, biochemical properties of different varieties of buckwheat were studied and the choice of its optimal amount for brewing was substantiated [20]. Beer wort was prepared in an infused manner with a dry matter content of 8%, the main indicators: reducing substances and amine nitrogen decreased with increasing amount of buckwheat. It would be necessary to investigate in more detail the process of mashing and the amount of unmalted raw materials.

The use of light buckwheat malt for the production of gluten-free beverages: bread kvass, low-alcohol beverages, gluten-free beer has been studied [19]. For example, the made gluten-free beer, for the preparation of which this raw material was used, had the following physicochemical parameters: dry matter content – 11%, alcohol content by volume – 4%, active pH – 4, color – 18.5 units. EBC, amine nitrogen – 185 mg /dm3, titratable acidity – 0.9 mol/dm3 NaOH. To determine the content of reducing substances that play a significant role in the process of brewing young and finished beer additional research is needed.

For the preparation of low-gluten beer, it is advisable to use buckwheat, as it has optimal physicochemical properties, does not contain gluten and has a unique amino acid composition, which is much better than barley [10, 11].

Therefore, for the preparation of wort, and subsequently low-gluten beer as an auxiliary raw material crushed white buckwheat and buckwheat malt was selected [1, 2].

The purpose of research is to establish the effect of white buckwheat or buckwheat malt on physicochemical and organoleptic parameters for the production of low-gluten beer.

Materials and methods

Materials

Barley malt, buckwheat malt, and crushed white buckwheat were used to prepare beer wort. The mash is prepared in an insistent way [15].

Malt wort was obtained by mashing at various temperature pauses ranging from 45 °C to 78 °C, followed by filtration, boiling with and hopping, followed by clarification and cooling [12].

The finished beer wort was fermented and rambled in the classical way. The finished beer was filtered and physicochemical parameters were determined in it [15].

Pure malt wort made from light barley malt was selected as a control sample.

Methods

Determination of extractivity in grain raw materials. Extractivities in grain raw materials were performed by the congress method [12].

The essence of the method is to convert to a solution of extractive substances of malt under the action of its personal enzymes, provided that they are close to optimal, followed by separation of the solution and determine its concentration on the Anton Paar analyzer [13].

Determination of starch content in grain raw materials. Determination of starch was carried out by the Evers method. To determine the starch content, a portion of the ground raw material was dissolved at low boil with 1% hydrochloric acid solution. The resulting clear solution was polarized on a polarimeter using a tube length of 200 mm [15].

Determination of protein content in grain raw materials. Protein determination was performed by the Keldal method. The essence of the method is that the product sample is decomposed (burned) with sulfuric acid in the presence of a catalyst, and then obtained after decomposition, bound in the form of ammonium sulfate, nitrogen is determined by titration [14].

The nitrogen content (A) as a percentage of the dry matter of barley is calculated by the formula:

$$\mathrm{A} = \frac{(a-b)\cdot 0.0014\cdot 100\cdot 100}{H\cdot(100-w)},$$

where a is the amount of sulfuric acid solution taken (0.1 mol/dm3), cm3;
b – is the amount of sodium hydroxide (0.1 mol/dm3), which is spent on back titration, cm3;
w – moisture content of flour,%;
H – portion of flour, g.

Determination of moisture in grain raw materials. Determination of humidity was performed by drying to constant weight at a temperature of 130°C [12].

$$W = \frac{m_1 - m_2}{m_1 - m_0}\times 100\%$$

W – product moisture,%;
m_0 – mass of cups without sample g;
m_1 – mass of sample cups before drying, g;
m_2 – mass of the sample cups after drying, g.

Determination of physicochemical parameters of beer wort. Determination of physicochemical parameters of beer wort (mass fraction of dry matter, titratable acidity, active acidity, bitterness, color, transparency), as mentioned above, was determined using Anton Paar analyzer [13].

Determination of reducing substances in the wort. Determination of reducing substances in the wort was determined by the method of Wilshteter-Schudl, based on the oxidation of aldose by iodine [15].

Determination of amine nitrogen content in wort. The content of amine nitrogen in the wort was determined by iodometric method (according to Pop and Stevens) [12].

The method is based on the ability of amino acids to form soluble complex compounds with copper [12]. Excess copper is filtered off, acetic acid is added to the filtrate, which cleaves copper from the complex compound to form copper acetate, and then potassium iodide is added. When the latter interacts with copper acetic acid, free iodine is released, the amount of which is proportional to the amount of copper, and hence the amount of amine nitrogen [12]. Free iodine is titrated with a solution of sodium thiosulfate in the calculation [12].

Analysis of finished beer. Physicochemical parameters in the finished beer (mass fraction of visible, actual extract, ethyl alcohol, transparency, bitterness) were determined using an Anton Paar analyzer [13].

Results and discussion

Physicochemical parameters of raw materials

In samples of different cereals their fractional composition of proteins have been studied [5], the data are given in Table 1.

Table 1

Fractional composition of buckwheat proteins and some cereals (as a percentage of total protein content)

Factions	Grain products				
	Buckwheat	Barley	Wheat	Rice	Corn
Albumins	21-24	2,8-6,4	0,5-5,2	5,8-11,2	0-10,0
Globulins	42-45	7,5-18,1	0,6-12,6	4,8-9,2	4,5-6,0
Prolamines	1,1-1,2	37,2-41,6	35,6-99	4,4-14,0	29,9-55,0
Glutelins	10-12	26,6-41,9	0-28,2	63,0-70	30,0-45,0

According to the obtained results (Table 1), buckwheat and rice are classified as gluten-free cultures and are recommended for use in dietary nutrition for patients with celiac disease [3] (other names – intestinal enteropathy, gluten intolerance, gluten atoxia). This autoimmune disease, according to the World Association of Gastroenterologists, affects about one percent of the world's population [5].

Buckwheat has the best properties for brewing, beer made from buckwheat or by replacing part of the barley malt with buckwheat in taste and color is almost no different from barley.

In the Table 2 it is shown the physicochemical parameters of the studied grain raw materials.

Table 2

Physicochemical parameters of grain raw materials

Raw	Humidity,%	Extractivity, %		Starch,%		Protein,%		Duration of filtering of a congestion, min
		Air-dry substance	Dry substance	Air-dry substance	Dry substance	Air-dry substance	Dry substance	
Barley malt	3,6	74,53	77,32	62,8	65,6	10,1	11,15	30
Buckwheat malt	4,2	61,4	66,7	66,2	68,5	12,3	12,9	45
Crushed white buckwheat	12,7	67,2	69,8	70,3	72,1	13,5	14,7	45

The dry matter extract content of light barley malt exceeds the content of buckwheat malt and crushed buckwheat and is 77.32%. But the highest protein content was found in crushed buckwheat, which is 14.7%, which is 21.8% higher than the content in barley malt and 12.4% in buckwheat.

The process of filtering the wort is much faster when using barley malt, but when using buckwheat malt or white buckwheat, the filtration process is not much longer than when using barley malt. This is due to the fact that collapsed buckwheat does not have a fruit shell, which leads to a decrease in the height of the filter layer, while slowing down the filtration rate [12, 15].

Analysis of beer wort

Physicochemical parameters of pure malt wort from light barley malt (control) with partial replacement of barley malt with crushed white buckwheat are given in Table 3.

Table 3

Physicochemical parameters of malt wort with partial replacement of barley malt with crushed white buckwheat

Mash (barley malt + crushed white buckwheat)	Content of dry substance,%	pH	Titrated acidity, mol/dm³ NaOH		Content of reducing substances, g		Content of amine nitrogen, mg	
			per 100 cm^3 of wort	per 100 g of extract	per 100 cm^3 of wort	per 100 g of extract	per 100 cm^3 of wort	per 100 g of extract
Control pure malt wort	14	5,9	2,1	5,1	10,3	71,3	22,12	152,9
95% barley malt +5% crushed white buckwheat	14	6,1	4,0	9,2	12,0	86,9	22,4	154,9
90% barley malt +10% crushed white buckwheat	14	6,1	4,1	9,5	11,0	81,4	18,2	124,4
85% barley malt +15% crushed white buckwheat	14	6,1	4,2	9,7	11,7	80,8	12,6	87,1

The best results in terms of reducing substances and amine nitrogen showed a sample of wort, which was prepared from barley malt and crushed white buckwheat in a ratio of 95:5, respectively. As the content of crushed white buckwheat increases, the content of reducing substances and amine nitrogen decreases, this is due to the fact that white buckwheat lacks enzymes and therefore reducing substances and amine nitrogen cannot be extracted into solution (pure malt wort) [7]. Therefore, in the preparation of low-gluten beer, it is proposed to use wort with partial replacement of barley malt with crushed white buckwheat in the amount of 5%.

Physicochemical parameters of malt wort with partial replacement of barley malt with buckwheat malt are given in Table 4.

Table 4

Physicochemical parameters of malt wort with partial replacement of barley malt with buckwheat malt

Mash (barley malt + buckwheat malt)	Content of dry substance,%	pH	Titrated acidity, mol/dm^3 NaOH		Content of reducing substances, g		Content of amine nitrogen, mg	
			per 100 cm^3 of wort	per 100 g of extract	per 100 cm^3 of wort	per 100 g of extract	per 100 cm^3 of wort	per 100 g of extract
Control pure malt wort	14	5,9	2,1	5,1	10,3	71,3	22,1	152,9
95% barley malt +5% buckwheat malt	14	5,9	4,5	11,9	13,2	91,0	24,2	167,1
90% barley malt +10% buckwheat malt	14	6,0	4,8	11,2	12,7	87,5	19,5	139,2
85% barley malt +15% buckwheat malt	14	5,9	4,1	9,5	11,9	82,1	13,4	92,4

The best results in terms of reducing substances and amine nitrogen content showed a sample of wort, which was prepared from barley and buckwheat malt in the ratio of 95:5%, respectively. You can also see a pattern that increasing the amount of buckwheat malt decreases the amount of reducing substances and amine nitrogen, this is due to the fact that buckwheat malt has a small amount of amylolytic and proteolytic enzymes [18, 19], so biologically active substances cannot be hydrolyzed and then extracted in solution [18, 19].

But in the production of low-gluten beer, enzyme preparations are not desirable to use, as they can harm people with celiac disease [9,16].

Comparing the two types of wort (Figure 1, 2), namely the wort made from light barley malt and crushed white buckwheat and barley malt and buckwheat malt, it was concluded that for brewing wort made from barley and buckwheat malt is better. This wort has the best physicochemical parameters, and buckwheat malt has enzymatic activity [12, 15], which allows you to hydrolyze more biologically active substances. This will further prepare low-gluten beer for prophylactic purposes [12, 15] with the best Physicochemical and organoleptic characteristics.

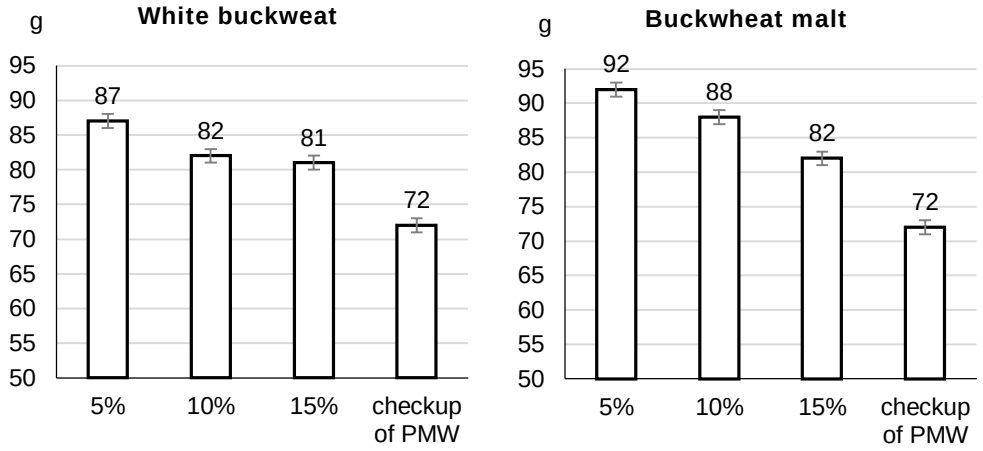

Figure 1. Content of reducing substances in malt wort from various buckwheat raw materials

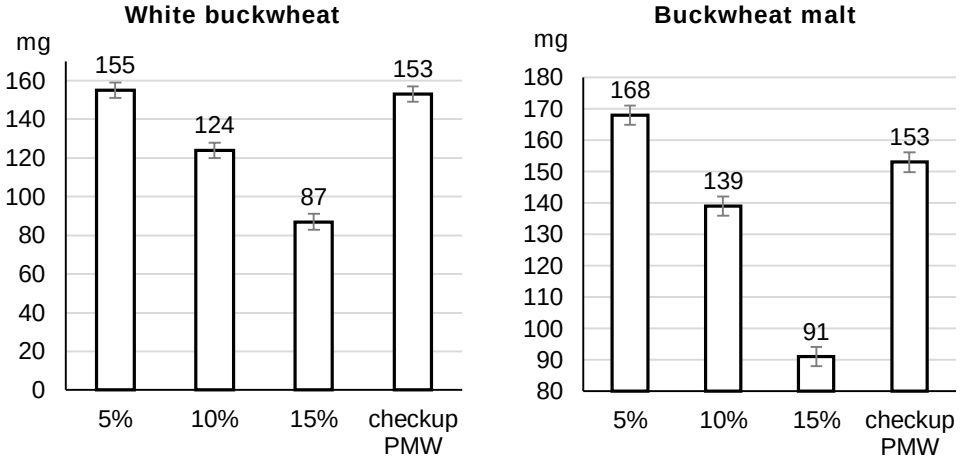

Figure 2. Content of amine nitrogen in malt wort from various buckwheat raw materials

Analysis of finished beer

The finished beer, prepared with partial replacement of barley malt with crushed white buckwheat and with partial replacement with buckwheat malt, had physicochemical parameters, which are presented in Tables 5 and 6.

As the content of crushed white buckwheat increases, the amount of alcohol changes and the mass fraction of the actual extract decreases. This is due to the fact [19] that during the main fermentation with increasing amine nitrogen, the volume fraction of alcohol increases.

Table 5

Physicochemical parameters of finished beer with partial replacement of barley malt on crushed white buckwheat

Beer samples	Content of dry substance in initial wort, %	Color, cm^3 0.1 mmol of iodine solution per 100 cm^3 of wort	pH	Titrated acidity, mol / dm^3		Content of ethyl alcohol,% wt	Mass fraction of the actual extract,% wt
				per 100 cm^3 of beer	per 100 g of extract		
Pure malt beer	14	1,55	4,3	2,3	5,7	2,8	5,51
95% barley malt + 5% crushed white buckwheat	14	1,6	4,2	2,4	5,8	2,9	5,53
90% barley malt + 10% crushed white buckwheat	14	1,7	4,3	2,5	5,9	3,1	5,46
85% barley malt + 15% crushed white buckwheat	14	1,75	4,2	2,3	5,6	3,4	5,41

Table 6

Physicochemical parameters of finished beer with partial replacement of barley malt with buckwheat malt

Beer samples	Content of dry substance in initial wort, %	Color, cm^3 0.1 mmol of iodine solution per 100 cm^3 of wort	pH	Titrated acidity, mol / dm^3 NaOH		Content of ethyl alcohol,% wt	Mass fraction of the actual extract,% wt
				per 100 cm^3 of beer	per 100 g of extract		
Pure malt beer	14	1,55	4,25	2,3	5,74	2,9	5,51
95% barley malt + 5% buckwheat malt	14	1,75	4,29	2,65	6,1	3,5	4,83
90% barley malt + 10% buckwheat malt	14	1,80	4,35	2,60	5,98	3,7	4,91
85% barley malt + 15% buckwheat malt	14	1,82	4,26	2,75	6,23	3,8	5,58

With an increase in the content of buckwheat malt increases the amount of alcohol and increases the mass fraction of the actual extract (Figure 3,4). The best results showed a sample made from 95% barley malt and 5% buckwheat malt, as it had optimal results in alcohol content and the best results in mass fraction of real extract, because the smaller the mass fraction of real extract, the better the yeast fermented the wort [12, 15].

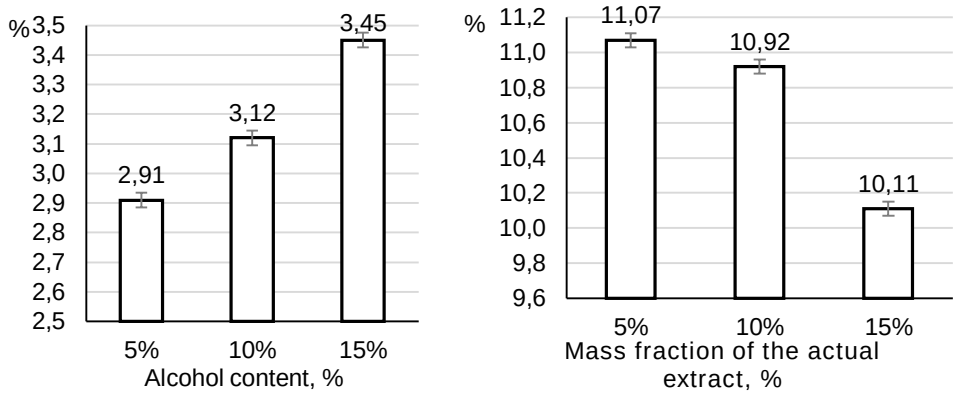

Figure 3. Effect of the amount of crushed white buckwheat on the content of ethyl alcohol and the mass fraction of the actual extract in the finished beer

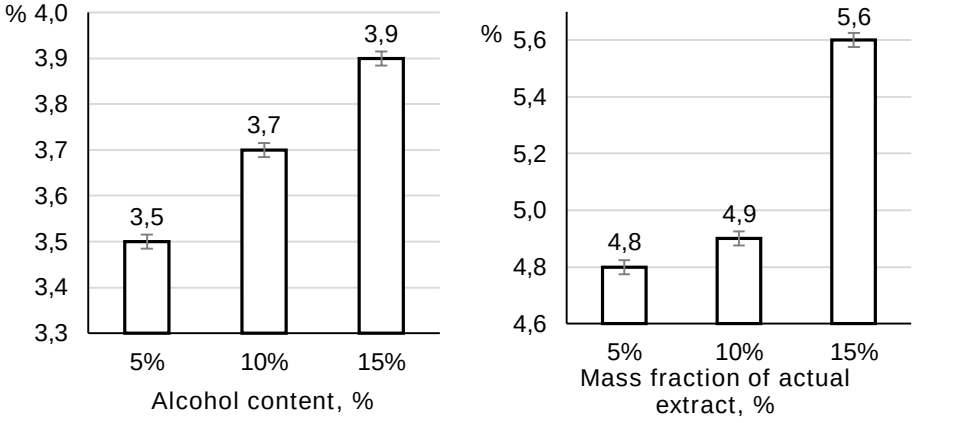

Figure 4. Effect of the amount of buckwheat malt on the content of ethyl alcohol and the mass fraction of the actual extract in the finished beer

Conclusions

The choice and quantity of unmalted raw materials – crushed white buckwheat and buckwheat malt for the production of low-gluten beer (95% barley malt and 5% buckwheat malt or crushed white buckwheat) are substantiated.

Beer brewed with a partial replacement of barley malt for buckwheat malt has better physicochemical properties than beer brewed with a partial replacement of barley malt for crushed white buckwheat.

For the production of low-gluten beer, it is recommended to use 5% buckwheat malt as a low-gluten raw material.

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