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Selection of the Mashing Mode in the Preparation of Beer Wort with Use of Triticale Malt

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Abstract: Currently, the problem of expanding the range of beer and reducing the cost of production is relevant. The article discusses the influence of different amounts of triticale malt on the mashing process. Empirically, the percentage of the grist and the mashing modes of barley and triticale malts were selected, in the ratio of light barley malt: triticale malt 90:10, 80:20, 70:30. With an increase in the amount of triticale malt in the grist, the time of saccharification of the mash and the wort extract increases. However, the use of more than 20% of triticale malt in the mash leads to a significant increase in the viscosity of laboratory wort, especially with the infusion mashing method which entails an increase in the duration of the filtration.

Key words: Triticale, fermentation industry, malt, beer, reducing, increase

INTRODUCTION

Today the brewing industry occupies an important place in the processing industry and is one of the investment-attractive sectors of the economy. Brewing companies produce a fairly wide range of beer and beer drinks, each of which finds its consumer.

But this industry is still not provided in sufficient quantities by its own quality raw materials, in particular, brewing barley. The processing of non-brewed barley with a high protein content (above 12%) and low starch content and extractives for beer is unprofitable from an economic point of view and is undesirable from the point of view of quality (Chomanov *et al*., 1998).

The most important directions in solving this problem should be recognized as the improvement and development of new resource-saving technologies of malt and beer using non-traditional types of raw materials (Kosminsky *et al*., 1988).

As is known, at present barley, wheat, rye as well as malt obtained from these crops are being processed to a greater degree. In addition, along with traditional types of cereals, grains such as triticale, amaranth, sorghum, buckwheat, oats, etc. are used which until recently were mainly used for feed purposes. Among the listed alternative crops, it should be noted triticale as the most promising type of grain raw materials.

Triticale (Latin triticosecale, from Latin "triticum" wheat and lat. "secale"-rye) a new botanical species, created by man. By combining the chromosome complexes of two different botanical genera-wheat and rye, man managed to synthesize a new agricultural crop for the first time in the history of agriculture. Triticale attracts special attention to a number of important parameters such as yield, Winter hardiness, nutritional value of the product, etc. (Paschenko *et al*., 2005).

Previously not existing in nature, artificially created cereal-triticale is a culture that does not have intermediate properties between rye and wheat which has its own characteristics.

According to the general chemical composition, the triticale grain is a typical fruit of cereals, characterized by a high content of carbohydrates and protein, varying in a very wide range. Depending on the variety, climatic and agrotechnical conditions of growth and other factors in the triticale grain contains (% of DM): starch-62.13-66.70%, protein-9.75-14.80%, gum-1.72-3.48%, hemicelluloses-5.45-7.28%, fat 2.1-2.5% ash elements-1.7-2.2%. Along with this, it also includes lipids, minerals, organic acids, enzymes, vitamins and pigments (Meledina, 2003).

The carbohydrate amylase complex of triticale grain is represented by higher polysaccharides (starch, dextrins, hemicellulose, mucus) polysaccharides of the first order (disaccharides, trisaccharides) small amounts of simple sugars (glucose, fructose) and amylolytic enzymes (α and β-amylase) (Pens-Bautista and Bates, 1982). These enzymes are characterized by specificity of action with

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respect to the structural components of starch as well as sensitivity to environmental conditions. According to the literature data, the amylolytic activity of triticale depends both on the variety and the physiological state of the grains (Kosminsky, 2002).

Starch triticale contains a somewhat smaller amount of amylose (23.7%) than its parent forms: wheat (28.9-30.1%); Rye-(up to 30.1%) which indicates its higher molecular weight (Pena-Bautista and Bates, 1982).

Protein-protease complex triticale includes protein substances, proteolytic enzymes, activators and inhibitors of proteolysis. According to the literature data, the triticale protein is characterized by a well-balanced amino acid composition. For essential amino acids, triticale proteins are more valuable than wheat proteins and have better digestibility (Kosminsky, 2001).

According to the statistics of recent years, published by FAO, the main producers of triticale grain are Poland, Germany, France, Belarus. Triticale is superior to barley by the total amount of extract, enzymatic activity and protein dissolution. These parameters suggest its use as raw material for the production of brewing malt (Zarnkow *et al*., 2009). There are a number of experimental studies on the features of the use of triticale in the production of beer and alcohol for food and technical purposes (Gruji and Pej, 2007).

In recent years new varieties of triticale have been obtained in the Republic of Kazakhstan, distinguished by high technological properties which are included in the State Register (SI "State Commission for the Variety Testing of Agricultural Crops" of the Ministry of Agriculture of the Republic of Kazakhstan, 2014). The quality indices of the previously studied triticale varieties which are regionalized in the Republic of Kazakhstan, indicate that the "Balausa 8" variety has the highest technological characteristics, it has a high extract content (83.34%) and an allowable protein content (10.8%) (Bayazitova *et al*,, 2017)

The purpose of these studies is to determine the optimal percentage of triticale malt from the mass of the grist and choose the method of mashing.

MATERIALS AND METHODS

For research, malt was used from the triticale grain of the "Balausa 8" variety and barley malt of the "Tekeli" variety. Both types of malt were experimentally developed and submitted for research by the Kazakh Research Institute of Agriculture and Plant Cultivation LLP (harvest of 2016, Almaty, Kazakhstan).

The quality of the initial grain raw material, laboratory wort was evaluated according to the EBC and/or MEBAC methods (European Brewery Convention, 1998; Methodological collection of the Central European Brewing Analysis Commission, 1997)

Experimental: When preparing a mash with the use of triticale malt, the known methods for its preparation are considered (Kunze, 1994). The grist was prepared in the barley malt/triticale malt ratio of 90:10, 80:20 and 70:30, respectively. Mashing was carried out by infusion and single-decoction methods as in the production of beer using classical technology. The hydromodule 1:4 was used. Sugared mash, depending on the method of mashing was heated to 73-77°C for 5 min and then cooled and filtered.

RESULTS AND DISCUSSION

The results of the analysis of the malts used in the work on the physico-chemical quality indices are given in Table 1. The data obtained testify to the good quality of used malts (European Brewery Convention, 1998). The amount of protein in the triticale (10.8%) and barley (11%) malt is normal (European Brewery Convention, 1998). Quality indices of triticale malt exceed barley malt by extract content, Kolbach number, activity of amylolytic and proteolytic enzymes by 4.6, 25.3, 7.8 and 18%, respectively. Malt from triticale showed a better saccharification time than malt from barley but the relative viscosity of laboratory triticale malt is much higher than that of barley malt but is within the permissible limits of the norm.

At the next stage of the research, the percentage of grist of barley and triticale malt and the mashing mode were selected. Samples of beer wort with different contents of triticale malt in the mash are prepared under laboratory conditions.

Table 1: Physico-chemical indices of the quality of triticale and barley malts

Index	Triticale maltof the "Balausa 8" variety	Barley malt
Protein content, %, (n = 3)	10.8±0.12	11±0.070
Extract content, % by DM* (n = 3)	83.34±0.13	79.61±0.16
Saccharification, min (n = 3)	11±0.15	18±0.17
Kolbach index, % (n = 1)	54.92	43.82
Activity of amylolytic enzymes: α-amylase, unit/g (n = 1)	16.37	10.91
β-amylase, unit/g (n = 1)	211.54	196.17
Activity of proteolytic enzyme, unit/g (n = 1)	1.442	1.212
Relative viscosity of laboratory wort, mPa*s, 8.6%, (n = 3)	2.0387±0.07	1.6094±0.08

*DM-Dry Matter

Table 2: Results of saccharification, filtration of mash and extraction of extract in dependence of the method of mashing

	Single-decoction method of mashing				Infusion method of mashing			
Index (n = 3)	No. 1	No. 2	No. 3	Control	No. 1	No. 2	No. 3	Control
Duration of saccharification (min)	18±0.08	16±0.14	14±0.06	21±0.08	19±0.11	17±0.09	15±0.13	21±0.05
Duration of filtration (min)	84±0.17	91±0.12	101±0.08	79±0.13	91±0.08	102±0.15	118±0.07	86±0.06
Yield of the extract:on dry matter (%)	78.56±0.08	78.58±0.22	79.78±0.18	80.64±0.15	78.12±0.13	79.31±0.09	80.33±0.16	81.12±0.17
in % to control	100.58	102.12	103.22	100.0	100.95	102.25	103.25	100.0

Table 3: Physico-chemical indices of laboratory wort samples depending on the method of mashing

	Single-decoction method				Infusion method			
Index	No. 1	No. 2	No. 3	Control	No. 1	No. 2	No. 3	Control
Reducing substances (%) maltose (n = 1)	68.23	67.46	66.83	68.68	66.96	66.32	65.16	67.34
Relative viscosity (mPa*s) 8.6%e (n = 3)	1.6269±0.08	1.6662±0.07	1.6878±0.09	1.5814±0.11	1.6449±0.15	1.7255±0.05	1.7579±0.07	1.6089±0.13
pH (n = 3)	5.94±0.03	5.95±0.05	5.97±0.04	5.93±0.07	5.92±0.03	5.94±0.06	5.95±0.07	5.92±0.04
Acidity, cm^3 1 mol/dm^3 NaOH per 100 cm^3 wort (n = 3)	1.25±0.10	1.23±0.09	1.18±0.08	1.27±0.03	1.26±0.05	1.24±0.07	1.19±0.07	1.28±0.06
Color, cm^3 0.1 mol/dm^3 of iodine solution per 100 cm^3 of water (n = 3)	0.26±0.03	0.30±0.05	0.33±0.06	0.24±0.04	0.25±0.03	0.29±0.07	0.34±0.02	0.24±0.06
Final degree of fermentation (%) (n = 1)	78.24	77.72	77.23	78.85	78.06	77.48	77.12	78.33
Nitrogen, mg per 100 cm^3 of wort: total (n = 1)	56.31	60.52	63.09	53.96	56.19	60.41	62.93	54.12
Amino (n = 1)	22.93	27.66	30.78	19.48	22.01	26.21	30.11	19.13

- Sample No. 1-mash, wort with 10% of triticale malt added from the grist of grain products
- Sample No. 2-mash, wort with 20% of triticale malt added from the grist of grain products
- Sample No. 3-mash, wort with 30% of triticale malt added from the grist of grain products
- As a control, mash and laboratory wort from 100% barley malt were used

The effectiveness of the mashing process was assessed by the duration of saccharification, filtration of mash, the yield of the extract and the physico-chemical indices of the wort. The average experimental data are presented in Table 2 and 3.

The data in Table 2 shows that as the share of triticale malt in the mash increases, the duration of saccharification and yield of the extract improves which is associated with a high extractivity index of triticale malt (83.34% for DM) and a low saccharification duration (11 min).

According to the data in Table 3, it follows that with an increase in the amount of triticale malt in the mash in samples of laboratory wort prepared both by the infusion and the single- decoction method, the content of reducing substances and the final degree of fermentation is reduced and the content of total and amine nitrogen and the wort color index increase.

Graphic dependencies are more indicative of the relationship between the extractivity and duration of saccharification from a different amount of triticale malt when mashing (Fig. 1 and 2).

It can be seen from Fig. 1 and 2 that with an increase in the share of triticale malt in the mash up to 30%, the extractivity increases and the duration of filtration is reduced. The optimum value is reached when using 20% of triticale malt with a duration of saccharification of 16, 17 min and an extract yield of 79.78, 80.33% for single-decoction and infusion methods of mashing, respectively. The experimental dependences are described by a linear equation with a sufficiently high accuracy (for the yield of the extract $R^2 = 0.985$, $R^2 = 0.996$ and for the duration of saccharification $R^2 = 0.998$, $R^2 = 1$ for single-decoction and infusion methods, respectively).

At the same time, the duration of filtration of laboratory mash increases. Filtration of mash is considered normal, if after returning the first portion (100 cm^3) to the filter, it lasts no more than 1 h (Kunze, 1994). Graphical dependencies characterizing the relationship between viscosity and duration of filtration from different amounts of triticale malt for different methods of mashing are shown in Fig. 3 and 4.

In the preparation of laboratory wort by a single-decoction method with a content of 20% triticale malt, the filtration duration of the mash reaches 91 min, i.e., about 1 h and the relative viscosity of the laboratory wort increases to 1.6662 (Table 3 and Fig. 3).

In the case of mash preparation by an infusion method, the duration of its filtration reaches 102 min and exceeds this value at a content of 30% and the viscosity of the laboratory wort increases to 1.7255 when using 20% triticale malt in the mash (Table 3,

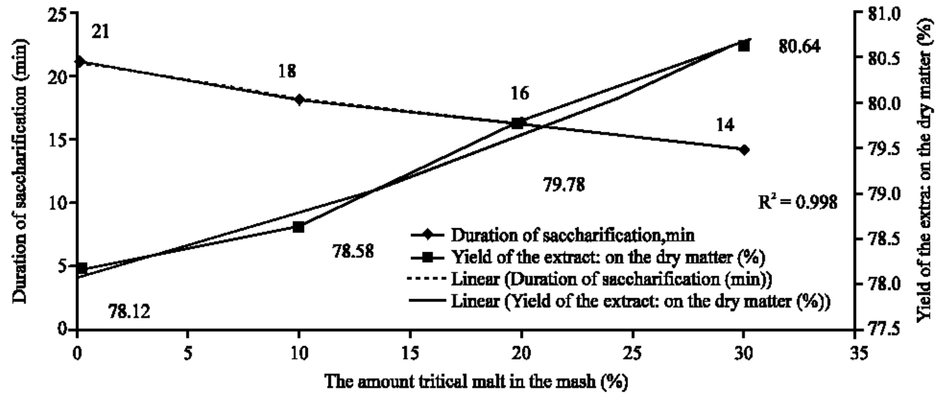

Fig. 1: The influence of the amount of triticale malt on the extractivity and duration of saccharification in a single-decoction mashing method

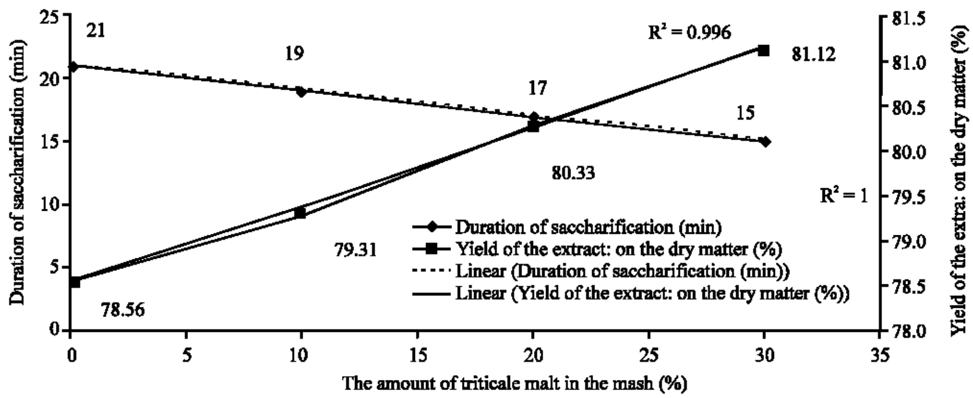

Fig. 2: The influence of the amount of triticale malt on the extractivity and duration of saccharification with the infusion method of mashing

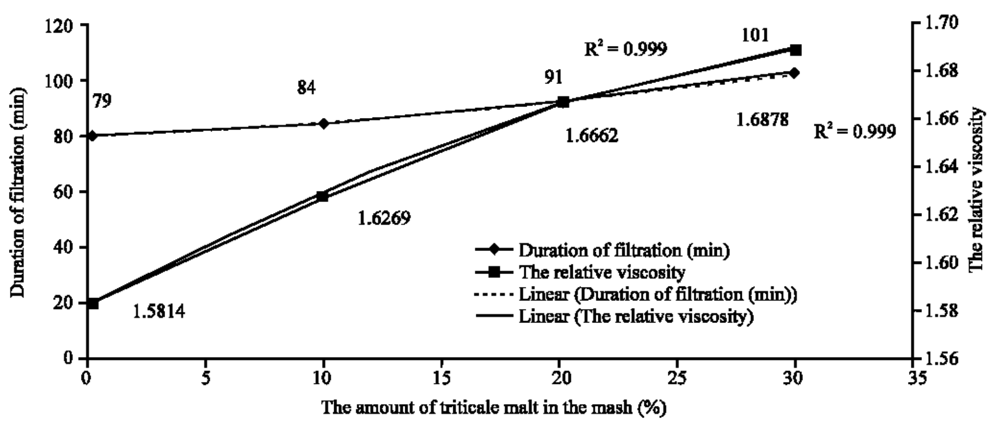

Fig. 3: The influence of the amount of triticale malt on the viscosity and duration of filtration in a single-decoction mashing method

Fig. 4). These figures exceed considerably in comparison with single-decoction method of mashing.

The experimental dependence is described by a linear equation with a high degree of reliability of approximation (for the relative viscosity R^2 = 0.999, R^2 = 0.999 and

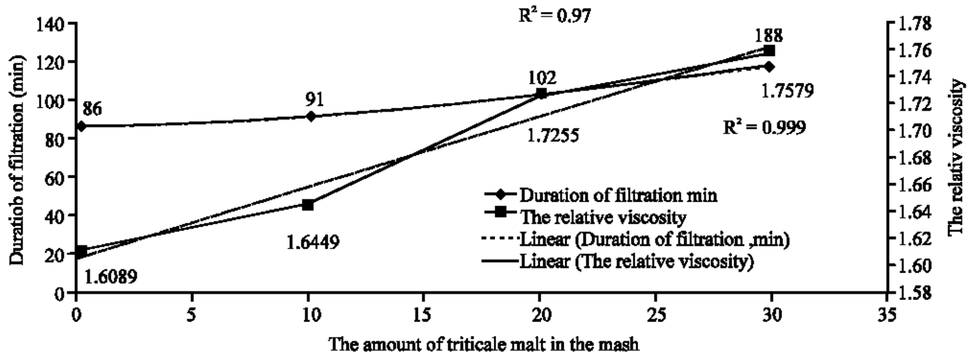

Fig. 4: The influence of the amount of triticale malt on the viscosity and duration of filtration for the infusion mashing method

for the duration of filtration R^2 = 0.999, R^2 = 0.97 for single-decoction and infusion methods, respectively).

The increase in the viscosity of laboratory wort produced using triticale malt, due to the fact that the viscosity of laboratory wort of triticale malt (2.0387) exceeds the viscosity of laboratory wort of barley malt (1.6094). And increased viscosity of laboratory wort from triticale malt, apparently is due to the fact that triticale malt contains mucous substances-pentosans, inherited from parents. The content of pentosans in triticale and wheat is the same and less than in rye.

CONCLUSION

On the basis of the conducted studies, it can be concluded that when the amount of triticale malt is increased by more than 20% for preparation of mash, indices of the duration of saccharification and yield of the extract improve. However, the use of more than 20% of triticale malt in the mash leads to a significant increase in the viscosity of laboratory wort, especially with an infusion mashing method which results in an increase in the duration of filtration of more than 1 h. The optimal dose of triticale malt added to the mash is 20%. The recommended mashing mode is single-decoction.

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