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STUDY OF THE INFLUENCE OF NON-STARCH POLYSACCHARIDES RYE GRAINS AND TRITICALE ON TECHNOLOGICAL INDICATORS OF ALCOHOL WORT AND RIPE MASH

The work is devoted to the study of the influence of non-starch polysaccharides of rye grain of the Alcor variety and triticale of the Antos variety on the technological indicators of semi-products of alcohol production – wort and mature mash. It was shown that the rye grain and triticale of the 2018 harvest had a higher technological potential for producing edible ethyl alcohol and a low content of non-starchy polysaccharides with their predominance in rye grain. It has been established for ensure high technological parameters of alcoholic wort and mash, rye processing with a low initial content of non-starch polysaccharides is necessary, triticale processing is effective, despite the level of non-starch polysaccharides in the grain.

Keywords. *Rye, triticale, non-starch polysaccharides, must, mash.*

Relevance of research topic. In the alcohol industry of the Republic of Belarus, currently processed mainly rye grain and triticale [10]. This is due to a number of objective reasons: along with a low market value that ensures the profitability of alcohol production in general, these crops are characterized by a high starch content, which makes it possible to obtain a stable yield and the organoleptic profile of food ethyl alcohol, which is traditional for domestic enterprises.

At the same time, triticale and rye also have agrobiological advantages: these crops are winter-hardy, resistant to a number of diseases, adapted to cultivation on soils with low natural fertility and provide high productivity. Compared to triticale, rye is more resistant to adverse weather conditions, less demanding on its predecessors, weakly affected by root rot, and annually provides high yields on most soil types [6, 7].

However, in recent years, the volume of rye processing in the production of alcohol has decreased significantly compared with the processing of triticale grains. This is due to the specificity of the chemical composition of rye grain, in particular, the presence in its composition of a high content of non-starchy polysaccharides in comparison with triticale grain.

Non-starchy polysaccharides (hereinafter – NSP) grains are represented by cellulose, hemicellulose, pentosans, gum substances, mucus and pectin substances. Some of them, for example, rye mucus, the main part of which consists of pentosans, easily swell and dissolve in water, and the presence of branched arabinoxylans in these substances promotes the formation of stable complexes with protein substances, which is the reason for the increased viscosity of rye mixtures and wort. With a high viscosity of kneading, starch swelling processes are hindered, and amylolytic enzymes are difficult to access. Under such conditions, enzymatic hydrolysis of starch proceeds inefficiently and is associated with an overspending of enzyme preparations [8, 9]. In addition, the high viscosity of the batches reduces the mobility of the mass, which creates an additional load on the pumping equipment and energy consumption.

It is known that the content of NSP both in rye and in triticale can vary significantly depending on the climatic characteristics of the growing year, the quality of cultivated soil, region, storage time, grain variety and other factors. So the content of hemicelluloses in rye grain can be from 8. 0 to 15.0%, including the content of pentosans can reach up to 6.0 – 8.0%, in triticale the content of hemicelluloses can vary from 7.0 to 11.0%, including the number of pentosans can be 3.0 – 6.0% [10].

Formulation of the problem. This study is due to the fragmentation of scientific data on the content of non-starchy polysaccharides in rye and triticale grains and the lack of an assessment of the degree of their influence on technological processes occurring in the production of ethanol from grain. The research objectives included the study of the content of NSP in rye grain of the Alkora variety and Antos triticale of the 2018–2019 variety. Cultivation of Belarusian breeding and a study of the effect of NSP on the technological parameters of alcohol wort and mature mash obtained in the process of obtaining food ethyl alcohol from this grain raw material.

Analysis of recent researches and publications. The analysis of recent publications shows that numerous studies have been devoted to studying the content of non-starchy polysaccharides in grain, in particular pentosans, and assessing the degree of their influence on technological processes in the production of edible ethyl alcohol, in particular, special attention is paid to studying the processing of low-pentosan rye [1].

Presenting main material. At the first stage of the work, the quality indicators of rye grain of the Alcor variety and triticale grain of the Antos variety 2018–2019 were studied cultivation for compliance with the requirements of state standards and the requirements for alcohol production. To do this, we studied the indicators regulated by the standards: the state of the grain, color, smell, humidity, nature, the content of weed and grain impurities, as well as grain contamination by pests.

In addition, technological parameters of grain were investigated: the content of starch, reducing sugars, protein, amine nitrogen and acidity. Grain quality indicators were determined in accordance with generally accepted methods [5].

The analysis of the obtained data showed that the rye grain of the Alkor variety in accordance with the studied quality indicators met the requirements of the standard GOST 16990 «Rye. Technical conditions» and Antos triticale grains met the requirements of GOST 34023 «Triticale. Technical conditions» [2, 3]. So, the organoleptic characteristics of rye grain of the Alkor variety and the Antos triticale variety (state, color, smell) were characteristic of a normal grain in a healthy, unheated state. According to the moisture content, the studied grain was classified as «dry», it was not infected by pests and had a low content of impurities, both weed and grain.

The results of studies of Alcor rye grain showed that 2018 grain cultivation was characterized by a higher nature (680 g/l) compared to 2019 grain (660 g/l), and the Antos triticale grain of 2018 was characterized by a higher nature (685 g/l) compared to the Antos triticale grain of 2019 cultivation (670 g/l). In accordance with the established values of the indicators and the requirements of the standards, the rye grain and triticale of the 2018 harvest were assigned to the 2nd class, the rye grain and triticale of the 2019 crop were assigned to the 3rd class.

For alcohol production, the most important indicator of grain is the starch content, the average content of which in rye grain can be 46.0–54.0%. The studied rye grain of the Alcor variety was characterized by a starch content of 51.5 and 50.2% (respectively, for grain grown in 2018 and 2019). The 2018 triticale grain of the cultivation had a starch content of 60.62%, the 2019 grain was characterized by a starch content of 56.7%.

In terms of the content of reducing sugars, the rye grain of 2018 exceeded the grain of 2019 (0. 82 and 0,69 g/100cm^3). In triticale grain, a large number of reducing sugars was characterized by the grain of 2018 grown (0. 91 g/100cm^3) compared to the grain of the harvest of 2019 (0. 74 g/100cm^3).

The total protein content in rye grain in 2019 significantly exceeded its content in grain in 2018 and exceeded the data of state variety tests by 12. 0%. In addition, the rye grain of 2019 was also characterized by a higher content of amine nitrogen, significantly exceeding (1.6 times) its content in the grain of 2018 cultivation.

The triticale grains of 2018 and 2019 cultivation formed an increased protein content with a predominance of cultivation in grain 2019 (13.8%). A higher content of amine nitrogen was also found in the triticale grain of the Antos crop in 2019 (9.8 mg/100cm^3). The titratable acidity of rye grains of the Alcor and Triticale varieties of Antos was at a level slightly exceeding the values corresponding to the resting stage. Thus, the studied rye grain of the Alkor variety and the Antos triticale of the 2018 harvest had a higher technological potential for further processes for the production of edible ethyl alcohol.

At the next stage of work, studies were carried out to determine the content of non-starchy polysaccharides in rye grain of the Alkora variety and the Antos triticale of the Belarusian crop selection in 2018 – 2019. In this case, the total content of hemicelluloses, the total content of pentosans and the content of water-soluble pentosans were studied [4]. The research results are presented in Figure 1.

It was established that the content of hemicelluloses in the rye grain of the Alcor variety of 2018 did not differ significantly from the grain of the 2019 crop, and the content of pentosans varied significantly. So, Alkor rye grain grown in 2019 contained more hemicelluloses (6.7%) and pentosans (33.7% total and 27.0% water-soluble) compared to Alcor rye grain from the 2018 crop.

When studying the content of non-starchy polysaccharides in the triticale grain of the Antos variety, a pattern characteristic of rye grain was noted. Thus, the grain of the 2019 harvest contained 22.0% more hemicelluloses and 13.0% more than total pentosans, as well as 1. 4 times more water-soluble pentosans compared to their content in the Antos triticale grain that grown in 2018.

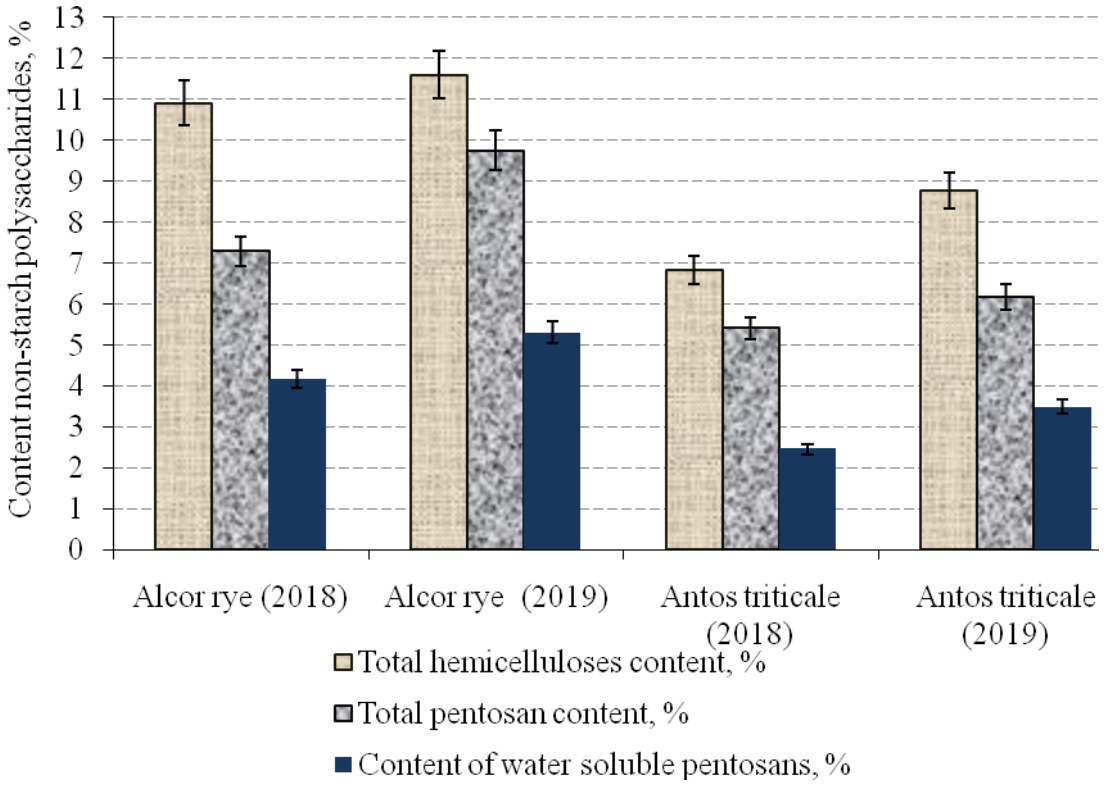

Figure 1. Content of non-starchy polysaccharides in rye grain of the Alkora variety and Antos triticale of the 2018–2019 Antos variety growing

The comparative analysis of the content of NSP in rye and triticale showed that rye grain in the 2019 crop contained 1.7 times more hemicelluloses, 1. 8 times more total pentosans and 2.2 times more water-soluble pentosans than triticale grains, grown in 2018.

In the structure of rye hemicelluloses, pentosans occupied on average 67 – 84%, in the structure of hemicelluloses triticale pentosans occupied 71 – 79%. Water-soluble rye pentosans accounted for 54 – 57% of the total content of pentosans, water-soluble triticale pentosans in the structure of total pentosans accounted for 45 – 56%.

At the next stage of the work, the effect of the content of NSP on the physicochemical parameters of alcoholic wort samples obtained from rye grain of the Alkora variety and Antos triticale was studied. Wort was obtained according to a low-temperature mechanical-enzymatic scheme, enzyme preparations in standard dosages were used at the kneading stage: amylolytic – Likvaflo and cellulolytic – Viskaferm, glucose amylase enzyme preparation Sakhsime Plus 2X was used at the saccharification stage.

It was found that the high content of non-starchy polysaccharides in the source grain has a significant impact on the quality indicators of alcohol wort. So, in a wort sample obtained from rye of the Alkor variety (2019) with a high initial content of NSP, the content of solids, reducing sugars, soluble carbohydrates was at a level significantly lower than the quality indicators of wort from rye grain in 2018, despite a slight difference in grain by starch content. Thus, the solids content in the 2019 rye wort sample was 8. 2% lower, the reducing sugars content – 28.8%, the soluble carbohydrates – 13.9% compared to the same indicators for the rye wort sample 2018.

The quality indicators of triticale wort were less affected by the content of NSP in the initial grain, which was probably due to their lower content compared to the content of rye in the grain. Thus, the difference between the dry matter content in the samples of triticale wort from the harvest of 2018 and 2019 was 3.6%, between the content of reducing sugars – 9.9%, soluble carbohydrates – 6.3% with a predominance of grain wort 2018 year.

At the final stage of the work, dry alcohol yeast was wired into the obtained samples of rye and triticale wort and fermented for 72 hours at a temperature of 30 ± 2 °C. In the obtained samples of mature brews, the main physicochemical parameters were determined.

It was found that in a mature rye mash of grain with a high initial content of NSP (harvest of 2019), the ethyl alcohol content was 8. 0% vol. which is 11.1% less compared to the sample of mash from grain in 2018 such indicators as the content of visible and actual dry substances, the content of unfermented carbohydrates, mature rye mash from 2019 also significantly lower than the indicators of ripe mash from rye grain of the 2018 Alkora variety grown.

An analysis of the physicochemical quality indices of mature triticale mash brews showed that a grain mash sample with a higher initial content of NSP (2019 crop) contained 9.0% vol of ethanol, which is 6.3% less than the ethanol content in sample from triticale 2018. In addition, the content of visible solids in a mature mash from triticale 2019 was 1.6%, from triticale 2018 – 1. 2%, the content of actual solids in the studied mash was 3.8 % and 3.2%, respectively, the content of unfermented carbohydrates with content 0.49 g/100cm^3 and 0.46 g/100cm^3 respectively.

Conclusion. Thus, it was found that the lower the initial content of NSP in the processed grain, the higher the quality indicators of the resulting alcoholic wort and mature mash. Moreover, the most pronounced effect of NSP on the parameters of wort and mature mash is typical for samples of intermediates obtained from rye grain. On the main indicators of triticale wort and mash breaks, the initial content of NSP in the grain has a not so significant effect as compared to rye samples. Thus, the indicators of wort and mash obtained from triticale grains of the Antos variety of the harvest of 2018 and 2019 were characterized by a smaller difference between the actual values of the studied indicators.

Thus, the results of the studies show that the content of non-starchy polysaccharides in the processed grain acts as a factor in ensuring the quality of the resulting alcohol products. For the stable operation of the distillery, high technology and guaranteed performance of the resulting intermediates and the yield of alcohol, processing of rye exclusively with a low content of non-starch polysaccharides is necessary. Processing triticale is effective, despite the level of non-starchy polysaccharides in the grain. However, p-rovided that the content of triticale NSP is lower in grain, it is possible to obtain mash with higher quality indicators and alcohol yield.

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