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TECHNOLOGICAL PROPERTIES OF WORTS OBTAINED FROM MALTS OF NAKED BARLEY GRAIN

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Abstract. The purpose of the research was to determine the effect of diversified nitrogen fertilization (0, 25 and 50 kg·ha^{-1}) on selected properties of grains, malts and brewing worts. Brewing value of barley grain was determined by Molina-Cano method. It was stated that the higher doses of nitrogen caused an increase of yield, as a result of stronger productive tillering of plants. Significant growth of grain yield was obtained by the increasing of nitrogen fertilization from 25 to 50 kg·ha^{-1}. Malts from naked barley grain were produced in the same way as malts of the Pilzen type. According to Molina-Cano method, the naked barley grain of Rastik cultivar was qualified as brewing, because of high malt extractivity. Laboratory worts were characterized by a high extract content, but not suitable viscosity, total attenuation and low soluble nitrogen content.

Key words: naked barley, nitrogen fertilization, malt, wort

INTRODUCTION

Polish malthouses produce mainly the Pilzen type malts and small quantities of special malts (caramel and black malts) from naked, mostly spring, brewing barley forms, while brewing industry in the world uses malts obtained from winter barley forms, wheat grains and sorgo, as well [Kunze 1999].

Since 1999, when naked spring barley form of Rastik cultivar was registered in the State Cultivar Register, the possibilities of the use of grain in feed industry, groats processing, bakery, malt industry and as a non-malting raw material have been investigated [Liszewski and Szybiga 2002, Spychaj et al. 2002, Błażewicz and Liszewski 2003].

The objective of this work was to define the influence of diversified nitrogen fertilization on the yield results and properties of naked barley grain of Rastik cultivar as well as properties of brewer's malts and brewer's worts obtained from it.

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MATERIALS AND METHODS

The experiment was carried out in 2002 in the experimental field of Department of Crop Production of Wrocław University of Environmental and Life Sciences, in Agricultural Experimental Station in Pawłowice. The field experiment was set up by the method of random blocks as two-factor, in four repetitions. Diversified nitrogen fertilization in kg·ha^{-1} was the first factor. The following doses were applied: 0, 25, 50, 75 (50 + 25), 100 (50 + 50), 100 (75 + 25), 125 (100 + 25). Two spring barley cultivars, Rastik (naked) and Rataj (hulled) were the second factor. Nitrogen fertilization was performed before sowing, while in the case of divided doses, their second part was applied during the stage of shooting barley. Nitrogen was applied as 34% ammonium nitrate. Soil cultivation for spring barley did not differ from the rules of proper agricultural practice.

Barley grain was sown on April 2, 2002 with the use of a plot seeder in the number of 3 million grains per 1 ha (Rataj cultivar) and 4 million grains per 1 ha (Rastik cultivar). In the period of tillering of barley, herbicides such as Granstar 75 WG (8 g·ha^{-1}) and Compete 240 EC (0.06 l·ha^{-1}) were applied. In order to protect against fungus diseases, preparation Tilt Plus 400 EC in the dose of 1 l·ha^{-1} was used. At the beginning of barley's earing, there was also a retardant Cerone 480SL (0.75 l·ha^{-1}) applied. Barley was harvested in its full maturity on July 22, 2002.

Significance of diversification of the grains yield and features of their structure was determined statistically by means of the analysis of variance considering t-Student's test, with the confidence coefficient of 0.05.

Quality parameters of the grains were determined by defining the equalization and germination energy by Schönfeld method and calculation of grains yield with the grains of thickness over 2.5 mm. To obtain 7-day Pilzen type malts, malting of the grains was carried out in laboratory conditions applied in the Department of Food Storage and Technology of Wrocław University of Environmental and Life Sciences. These conditions were described in detail in a study published in 2003 [Błażewicz and Liszewski 2003]. In the obtained malts the following were determined: diastatic power by Windisch-Kolbach method and the protein content by Kjeldahl method. Also the extract content and Kolbach number were calculated. In the laboratory worts were determined: flowing time, volume, colour, viscosity by means of Höppler viscosimeter, extract by pycnometric method, the nitrogen content by Kjeldahl method, the degree of final attenuation [Analytica – EBC 1998]. Determination was performed in three repetitions.

In this work, instead of statistic analysis of many technological features of grains, malts and worts, Molina-Cano method of evaluation malting suitability of grains, generally used in plants breeding, was applied [Molina-Cano 1987]. In this work, data concerning hulled barley grains of Rataj cultivar were not included. Malts features and laboratory worts obtained from grains of this typically feed barley cultivar were (as expected) below standards for brewing barley grains (Table 6).

RESULTS AND DISCUSSION

Characteristics of vegetation season

April 2002 was characterized by a bit higher average monthly temperature respectively to the average perennial temperature (of 0.7°C). However, the lack of rain in the first decade of April caused a delay in sprouting, which started 18 days after sowing (Table 1). Obtained sprouting was of 75.6% for Rastik and of 97% for Rataj of established standards for sowing. In May, the observed temperature was by 3.8°C higher than the average perennial, and the sum of the rainfall in that month was lower by 17.9 mm than the average perennial rainfall. It was not conducive to the tillering of barley, which lasted only for 11 days. In the first decade of June abundant rainfall was observed that exceeded the average monthly sum of rainfall within the perennial period. The average air temperature in June was by 1.7°C higher than the average perennial. These conditions were conducive for barley to shooting. In July, the average air temperature exceeded the average perennial temperature by 2.2°C and the rainfall was of only 35.8% of the average perennial sum. Such warm and dry weather was conducive to the maturing of grains, and also caused a rapid vegetation of the plants.

Table 1. Weather conditions in 2002 (for the Agricultural Experimental Station in Pawłowice near Wrocław)
Tabela 1. Warunki meteorologiczne w 2002 roku według obserwacji stacji meteorologicznej w Pawłowicach k. Wrocławia

Months – Miesiąc	March Marzec	April Kwiecień	May Maj	June Czerwiec	July Lipiec	August Sierpień
Temperature, °C – Temperatura, °C						
Decade – Dekada						
I	5.3	4.7	18.3	16.1	20.7	21.2
II	7.2	10.3	16.5	20.4	20.7	20.4
III	4.3	11.9	27.4	19.0	20.2	21.2
Means for months – Średnie miesięczne	5.5	9.0	174	18.5	20.5	20.9
Means for years 1961-2000 Średnie za lata 1961-2000	3.4	8.3	13.6	16.8	18.3	17.6
Rainfalls, mm – Opady, mm						
Decade – Dekada						
I	5.3	0.0	20.3	66.7	23.2	0.1
II	7.5	26.7	10.0	7.1	3.0	89.5
III	2.7	6.2	9.2	8.6	0.6	13.5
Means for months – Średnie miesięczne	15.5	32.9	39.5	82.4	26.8	103.1
Means for years 1961-2000 Średnie za lata 1961-2000	32.5	34.8	57.4	65.8	74.8	69.4

Table 2. The structure of spring barley yield (2002)
Tabela 2. Struktura plonu jęczmienia jarego (2002)

Nitrogen fertilization Nawożenie azotem kg·ha^{-1}	Cultivar Odmiana	Number of productive ears per 1 m^2 Liczba kłosów produktywnych z 1 m^2	Number of grains per ear Liczba ziarniaków w kłosie	Weight of grains per ear Masa ziarna z kłosa g	Grain yield Plon ziarna t·ha^{-1}
0	Rastik	353	22	1.02	3.77
	Rataj	548	22	1.01	4.73
25	Rastik	428	22	1.06	4.33
	Rataj	472	23	1.14	4.78
50	Rastik	432	23	1.11	4.77
	Rataj	528	23	1.11	5.42
75 (50 + 25)	Rastik	397	22	1.14	4.96
	Rataj	570	22	1.05	5.88
100 (50 + 50)	Rastik	559	23	1.14	4.88
	Rataj	572	23	1.10	6.06
100 (75 + 25)	Rastik	502	23	1.10	4.63
	Rataj	538	22	1.17	6.21
125 (75 + 25)	Rastik	506	23	1.09	4.71
	Rataj	605	23	1.19	5.83
LSD – NIR (α = 0.05) for interaction cultivars × fertilization dla współdziałania odmiany × nawożenie		86.0	n.s.*	n.s.	n.s.
Means for variables – Średnie dla czynników					
0		451	22	1.01	4.25
25		450	23	1.10	4.56
50		480	23	1.11	5.09
75 (50+25)		484	22	1.09	5.42
100 (50+50)		565	23	1.12	5.47
100 (75+25)		520	22	1.14	5.42
125 (100+25)		555	23	1.14	5.27
LSD – NIR (α = 0.05)		60.8	n.s.	0.071	0.492
Rastik		454	23	1.09	4.58
Rataj		547	23	1.11	5.56
LSD – NIR (α = 0.05)		92.5	n.s.	n.s.	0.261

* n.s. – non-insignificant difference; n = 4.
* n.s. – różnica nieistotna; n = 4.

The effect of nitrogen fertilization on the barley yield

The efficiency of nitrogen fertilization depends mainly on the rainfall, soil abundance in nutritious components and on cultivar features. These factors can affect the yield structure regardless of the applied nitrogen dose [Słaboński 1985]. In Polish literature there is a lack of studies concerning nitrogen fertilization of the first registered naked spring barley cultivar. Noworolnik and Leszczyńska [2002] in their pots experiment showed that naked barley of Rastik cultivar does not differ in its reaction to nitrogen fertilization from cultivars which belong to a typical form (naked and two-rowed). Dividing the investigated cultivars into groups of weaker and stronger reactions to nitrogen, they included Rastik cultivar into the first group. Positive influence of nitrogen fertilization on barley grain yield is most often the result of a better productive tillering of plants and thus increasing the number of ears per area unit [Błażewicz and Liszewski 2003, Noworolnik et al. 2004].

Data in Table 2 show the influence of nitrogen fertilization on productive tillering of plants, the number of grains in an ear and their mass. These are the components on which, to a great extent, grain yield depends [Słaboński 1985]. Nitrogen fertilization significantly influenced an increase of productive tillering of barley, regardless of its cultivar. Significantly lower number of ears per 1 m^2 was produced by plants of naked cultivar (Rastik). Increasing fertilization up to 100 kg (50 + 50) $kg \cdot ha^{-1}$ significantly influenced the increase of the number of ears per 1 m^2. Higher doses of nitrogen did not cause a significant diversification of this feature. The number and mass of the grain in an ear did not depend either on the doses of nitrogen or on cultivar features. The average mass of the grain per ear was 1.10 g.

In the experiment, nitrogen fertilization in doses from 25 to 125 $kg \cdot ha^{-1}$ was applied. Doses of over 50 $kg \cdot ha^{-1}$ were divided in order to decrease the danger of the plant lodging [Słaboński 1985]. The presented data show that application of nitrogen fertilization in the dose of 50 $kg \cdot ha^{-1}$ compared with 25 $kg \cdot ha^{-1}$, caused a significant increase of the yield by 0.53 $t \cdot ha^{-1}$ (11.6%). Higher doses of nitrogen did not influence the barley yield.

Technological features of malts and worts obtained from naked barley

Table 3 shows basic agricultural and malting grain features. Due to naked barley reaction to high doses of nitrogen fertilizer i.e. the decrease of the grain yields of grains with their thickness of over 2.5 mm, it was resolved that in the further part of this study, only these variants of the experiment that concern fertilizing levels of 25 and 50 $kg \cdot ha^{-1}$ will be reported. Increasing nitrogen doses, in the range of 75-125 $kg \cdot ha^{-1}$, contributes neither to the increasing of the grain yield of grains of over 2.5 mm nor to improving the technological features of the grain and malt.

Basic condition to obtain a good malt is the processing of a homogenous mass containing grains of similar thickness, where changes during the malting process can occur with a defined intensity. Equalization, i.e. the share of grains of thickness of over 2.5 mm, should not be lower than 85%. Equalization of naked barley grain of Rastik cultivar, regardless of the nitrogen fertilization level, maintained at the level of 70.5%. However, a typical feature of naked cultivars is their lower equalization, often at the level of 67%. It was stated that high doses of nitrogen do not conduce to obtain the yield of equal grains, they only enable the plants to have a better vegetation by increasing the

Table 3. The effect of nitrogen fertilization on selected brewing features of spring barley grain of Rastik cultivar
Tabela 3. Wpływ nawożenia azotem na wybrane cechy ziarna jęczmienia jarego odmiany 'Rastik'

N doses Dawka azotu $kg \cdot ha^{-1}$	Equalization Wyrównanie %	Yield of grain of thickness over 2.5 mm Plon ziarna o grubości ponad 2,5 mm $t \cdot ha^{-1}$	Thousand grains weight g d.m. Masa 1000 ziaren g s.m.	Germination energy after 120 hours Energia kiełkowania po 120 godz. %
0	70.5	2.66	41.5	89.60
25	70.5	3.05	41.5	90.73
50	70.5	3.36	42.7	94.13

number of sprouts and ears. They also cause yield increase but grain in its mass can remain tiny, whereas in malting practice, content of well-developed grain in the cereal mass is important. The yield of grains with thickness of over 2.5 mm was increasing along with the increase of nitrogen fertilization and it was the highest after application of the dose of 50 $kg \cdot ha^{-1}$ (3.36 t of grains per 1 ha).

The mass of 1000 of grains of brewing barley, which depends on the size of grains and on their filling with starch, should be of at least 35 g of dry matter. It determines processing properties of the grain and affects the extract content of the malt obtained from it [Kunze 1999]. The mass of 1000 of grains of naked barley of Rastik cultivar was increasing along with more intense nitrogen fertilization and ranged from 41.5 to 42.7 g of dry matter.

Brewing barley grain should be characterized by germination energy not lower than 95% [Kunze 1999]. The result of lower grain vitality is most often worsening of the malt extractivity and of its diastatic power, prolongation of mash saccharification time and decreasing of the degree of the final worts attenuation [Pecio 2002]. Germination energy of Rastik cultivar grain was at the level of 89.6-94.1%. These values are beyond limits determined for brewing barley. Naked barley grain is, however, often characterized by reduced germination energy. During the threshing process, when chaff is being separated, damage or embryo removal from the seed may occur. Konieczna et al. [2002] in their research confirm a lower resistance of naked barley grain to mechanical injuries during the harvest time.

Evaluation of 7-day barley malts obtained in laboratory conditions from naked Rastik cultivar was performed by determination of: the protein content, diastatic power, Kolbach index, the extract content and mash saccharification time. Laboratory malts features were compared with standards determined for the Pilzen type barley malts.

The protein content in a brewing barley grain should be in the range from 9 to 11.5%. Exceeding those values worsens, among others, wort flowing time, the extract content and colloidal stability of beer. The protein content in grains is to a high degree modified by environmental conditions and the treatment applied by the farmer, and even in the best brewing cultivars it is difficult to maintain the protein content within desirable limits [Bathgate 1987, Bertholdsson 1999, Clancy et al. 1991].

Due to the specificity of the raw material, i.e. naked barley grain, which during removing of the roots and uncovered germinal sprouts may lose more nitrogen components than hulled grain. The protein content in the malt was reported as a more valuable indicator of its malting suitability than the protein content in the grain. As the data in

Table 4 show, the protein content in the malt obtained from barley grain of Rastik cultivar ranged from 10.6 to 11.8% of dry matter.

Table 4. Effect of nitrogen fertilization on selected properties of malts obtained from spring barley grain of Rastik cultivar
Tabela 4. Wpływ nawożenia azotem na wybrane cechy słodów uzyskanych z ziarna jęczmienia jarego odmiany ‘Rastik’

N doses Dawka azotu $kg \cdot ha^{-1}$	Total protein % d.m. Białko ogółem % s.m.	Kolbach index Liczba Kolbacha %	Diastatic power u. W-K Siła diastatyczna j. W-K	Saccharification time Czas scukrzania min	Malt extractivity % d.m. Ekstraktywność słodu % s.m.
0	10.6	36.3	170	< 15	89.0
25	10.8	34.5	140	< 15	85.8
50	11.8	32.2	240	< 15	84.8

Kolbach index is the measure of proteolytic modification during grain sprouting and mashing of the malt, affecting in 10% the value of ‘Q’ indicator in Molina-Cano evaluation and should be at least of 36.3% [Molina-Cano 1987]. It ensures a proper amount of products of protein enzymatic hydrolyze in a wort, which influences yeast physiology, foam durability, the content of higher alcohols, and thus the best-quality taste of beer. Too low Kolbach index in malts obtained from barley grain of Rastik cultivar is probably the result of their low proteolytic activity. The values of Kolbach index ranged from 32.2% (variant with the dose of 50 $kg \cdot ha^{-1}$) to 36.3% (variant without nitrogen fertilization) suggest that due to the lack of hulling, the process of water absorption by the grain and activation of different enzymes groups proceed probably in an a different way than in hulled grain (Table 4).

Diastatic power is an indicator of total activity α- and β-amylases of malt. In malts of the Pilzen type it usually ranges from 240 to 260 W-K units [Kunze 1999]. Lower amylolytic activity of malt may cause prolongation of mash saccharification time and reduce the final degree of worts attenuation. Diastatic power of malts obtained from naked barley grain of Rastik cultivar depended on the total protein content and germination energy of grain and it ranged from 140 to 240 W-K units. It was observed that the use of naked barley grain of Rastik cultivar with a standard value protein content to the malting process, enables to obtain a malt of amylolytic activity below 240 W-K units, while obtaining higher activity of these enzymes demands the use of grain of the protein content exceeding 12% [Błażewicz and Liszewski 2003].

Saccharification time is also an indicator of enzymatic activity of malts. For good quality malts, saccharification time should not be longer than 20 minutes. The results shown in Table 4 indicate that saccharification time of mashes obtained from a malt produced from grain of Rastik cultivar was below 15 minutes.

One of the important malt quality features is its extract content because it is the base to determine the suitability of barley cultivars for the brewing malts production. According to Molina-Cano evaluation, up to 45% of brewer’s value points of grains depend on the extract content, which is also important from the economic point of view because the copper yield is determined by it. A good quality malt should be characterized by the extract content not lower than 79.5%. Requirements concerning the maximum protein content in hulled barley grain are rigorous, because the increase by 1% of the total protein content in a malt most often causes the decrease of extract content by about 0.6%. In the investigated material, it was also observed that along with the increase of the protein content, the extract content in a malt decreases, but to a higher extent than in the case of typical Pilzen type malts. Analysis of the data in Table 3 shows that both the utilizable yield and germination energy of naked barley grain of Rastik cultivar reached maximum values in the variant of the experiment with the nitrogen dose of 50 $kg \cdot ha^{-1}$. This level of fertilization caused both the increase of the total protein content and the decrease of the malt extractivity, which none the less was up to 84.8% (Table 4). This tendency confirms earlier investigations, which report that the extractivity of malts obtained from naked barley grain is much higher than the one obtained from hulled barley grain [Błażewicz 1993].

Table 5. Effect of nitrogen fertilization on selected properties of worts obtained from malts produced from spring barley grain of Rastik cultivar
Tabela 5. Wpływ nawożenia azotem na wybrane cechy brzeczek uzyskanych ze słodów wyprodukowanych z ziarna jęczmienia jarego odmiany 'Rastik'

N doses Dawka azotu $kg \cdot ha^{-1}$	Flow time Czas spływu min	Wort volume Objętość brzeczki cm^3	Wort colour u. EBC Barwa brzeczki j. EBC	Wort viscosity Lepkość brzeczki $mPa \cdot s$	Content of extract Ekstrakt brzeczki %	Total soluble nitrogen content Zawartość związków azotowych ogółem $g \cdot 100\ g^{-1}$	Free amino nitrogen content Zawartość azotu alfa-aminowego $mg \cdot dm^{-3}$	Apparent final attenuation Stopień ostatecznego odfermentowania %
0	> 120	155	5.7	1.69	9.4	0.065	191	73.8
25	> 120	192	5.4	1.63	9.2	0.063	155	77.2
50	> 120	197	6.4	1.64	9.1	0.065	254	77.4

Laboratory worts were analysed taking into consideration basic brewing parameters. The results were compared with standard values for congress worts obtained from the malts produced from hulled brewing barley grain, defining at the same time the influence of the level of nitrogen fertilization of the plants on particular worts features.

Flow time of laboratory (congress) worts should not be longer than 120 minutes. Worts obtained from malts of barley grains of Rastik cultivar were mostly characterized by flow time typical for worts of difficult filtration (Table 5). In all variants, regardless of fertilization, a wort was not filtrated in a time shorter than 120 minutes. The dependence between the level of fertilization or the protein content in malt, and the speed of filtering was not observed. Similar problems are reported by authors who determine the suitability of triticale grains for brewing purposes [Błażewicz 1993, Creydt et al. 1999]. Prolongation of the filtration time can be caused by the lack of hull or increased content of non-starch polysaccharides in grains of this new cultivar. Volume of malt worts of Rastik cultivar grain did not exceed 200 ml in a time of 120 minutes (155-197 ml).

Wort colour is determined mainly by the chemical composition of malt but it also depends on the process of malt drying as well as on the quality of barley in a particular vegetation season. In comparison with the wort colour of the Pilzen type malt which is mostly of ca. 4 EBC units, worts of hulled barley malts were characterized by a darker colour, in the range from 5.4 to 6.4 EBC units.

Wort viscosity should be within the range from 1.51 to 1.63 mPa·s [Kunze 1999]. Worts obtained from malts produced from naked barley grain of Rastik cultivar, apart from difficult filtration resulting in prolonged worts flowing time, were also characterized by higher viscosity (1.63-1.69 mPa·s). On the basis of the research that has been carried out till present, poor filtration of these worts cannot be univocally established.

The extract content in barley worts produced from naked barley grain is usually of 7.5 to 9%. Very high extract content in worts obtained from malts of Rastik cultivar grain from 9.1 to 9.4%, is the result of the lack of hulling process of grains, which are characterized by a higher content of extractable components.

According to Kunze [1999], the content of total soluble nitrogen should be within the limits of 0.065-0.075 $g \cdot 100\ g^{-1}$ of wort. It is the feature that determines, among others: colloidal durability of beer, turbidity formation and foam properties. The number and size of protein compounds in worts are connected with the process of malting and mashing. In laboratory worts obtained from malts of barley grains of Rastik cultivar, the content of protein enzymatic hydrolyse products was of 0.063 to 0.065 $g \cdot 100\ g^{-1}$ of wort.

The content of α-amino nitrogen in worts provides information about the quantity of low-molecular products of malt protein enzymatic hydrolyse which are used by brewing yeast during fermentation. If this value is lower than 200 $mg \cdot dm^{-3}$ of wort, disorders of yeast operating, delay of fermentation and maturing of beer may occur [Kunze 1999]. Content of α-amino nitrogen in worts obtained from malts of naked barley grains of Rastik cultivar was of 155 to 254 $mg \cdot dm^{-3}$ of wort. Despite a relatively high protein content in malts and a high extract content in components of endosperm, the α-amino nitrogen content in worts and Kolbach index value were lower than expected (Tables 4 and 5), which probably results from too low proteolytic enzymes activity of these malts.

The apparent final attenuation degree may be defined as the wort ability to ferment under the influence of brewing yeast. According to Molina-Cano, the degree should be of minimum 78.8%. A low degree of apparent final attenuation of worts obtained from hull-less malts, ranged from 77.2 to 77.8%, indicates too low content of fermenting sugars in these worts, resulting probably from low amylolytic enzymes activity of malts (Tables 4 and 5).

Table 6 shows the results of the quality classification of barley grain of Rastik cultivar, according to Molina-Cano. Total evaluation of barley grain malting quality, which was influenced mostly by the extract content, allows to include Rastik cultivar into brewing cultivars of medium quality.

In the case of hulled brewing barley cultivar grain, exceeding standard value of protein content significantly worsens the extract content of malts. During naked barley grain processing, the lack of hull improves the extract content of malts and probably changes the mechanism of water absorption. Thus, enzymatic changes of naked barley endosperm during the malting process can be different. It seems, however, that a high extract content of malts of naked barley grain of Rastik cultivar has no connection with the other malt and worts features which influence the total evaluation according to Molina-Cano. Comparing the obtained data with the parameters of malts produced from grain of vegetation season of 2001 [Błażewicz and Liszewski 2003], it can be observed that the diversified protein content in a grain significantly affects malts and worts features and final evaluation of malting suitability of grain according to Molina-Cano. More detailed conclusions concerning technological value of naked barley grain demand further investigation of the material grown in the next vegetation seasons.

Table 6. Effect of nitrogen fertilization on the brewing value of barley grains of Rastik variety determined by Molina-Cano method
Tabela 6. Wpływ nawożenia azotem na wartość browarną ziarna jęczmienia odmian 'Rastik' określoną metodą Molina-Cano

N doses Dawka azotu kg·ha^{-1}	Malt extractivity Ekstraktyw-ność słodu %	Wort viscosity Lepkość brzeczki mPa·s	Apparent final attenuation Stopień ostatecznego odfermento-wania %	Kolbach index Liczba Kolbacha %	Diastatic power u. W-K Siła diastatyczna j. WK	Quality index Q Wskaźnik Q	Quality group Grupa jakości
	q index wskaźnik q	q index wskaźnik q	q index wskaźnik q	q index wskaźnik q	q index wskaźnik q		
0	4.05	0.75	0.15	0.1	0.05	5.10	B
25	4.05	1.00	0.15	0.1	0.05	5.35	B
50	4.05	1.00	0.15	0.1	0.20	5.50	B

CONCLUSIONS

1. Increasing fertilization from 25 to 50 kg N·ha^{-1} caused statistically significant increase of grain yield as a result of higher productive tillering.
2. From the technological point of view, malts obtained from barley grain of Rastik cultivar, fertilized with nitrogen in the dose of 50 kg·ha^{-1}, were characterized by the best parameters.
3. Malts obtained from naked barley grain of Rastik cultivar were characterized by a high protein content and low Kolbach index, while worts were characterized by a high extract content but more difficult filtration, worse apparent final degree of attenuation and low content of protein enzymatic hydrolyzate products.
4. In evaluation according to Molina-Cano, barley grain of feed Rastik cultivar was classified into a group of brewing cultivars of medium quality, mainly due to a high malts extractivity.

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CECHY TECHNOLOGICZNE BRZECZEK OTRZYMANYCH ZE SŁODÓW Z ZIARNA JĘCZMIENIA NAGIEGO

Streszczenie. Określono wpływ zróżnicowanego nawożenia azotem (0, 25 i 50 kg·ha^{-1}) na właściwości ziarna, słodów i brzeczek piwowarskich. Przydatność słodowniczą ziarna jęczmienia oceniono metodą Molina-Cano. Stwierdzono, że większe dawki azotu przyczyniają się do wzrostu plonu ziarna jęczmienia na skutek silniejszego krzewienia produkcyjnego roślin. Statystycznie istotny przyrost plonu uzyskano, zwiększając nawożenie azotem z 25 do 50 kg·ha^{-1}. Słodowanie nieoplewionego ziarna jęczmienia przeprowadzono w warunkach takich samych, jak przy otrzymywaniu słodu typu pilzneńskiego. W ocenie według Molina-Cano ziarno jęczmienia nagiego odmiany ‘Rastik’ zakwalifikowano jako browarne, głównie ze względu na dużą ekstraktywność słodu. Uzyskane brzeczki laboratoryjne charakteryzowały się dużą zawartością ekstraktu, ale utrudnioną filtracją, gorszym ostatecznym stopniem odfermentowania i małą zawartością produktów hydrolizy enzymatycznej białek.

Słowa kluczowe: jęczmień nagi, nawożenie azotem, słód, brzeczka

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