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MILLED CORN PRODUCTS IN WORTS PRODUCTION

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Key words: wort, malt, fine maize grits, maize grits

The object of this study was to assess the effect of malt substitution with maize products and kind of malt on the properties of laboratory worts. The experimental materials in the study were laboratory worts obtained from barley malts of the Pilzen type (produced by two Polish malthouses) and milled corn products: maize grits (500-1250 μm) and fine maize grits (250-750 μm). The unmalted raw material was subjected to gelatinization and added in proportions of 20, 30 and 40%. The reference materials were worts manufactured from malt without unmalted ingredients addition. Significance of worts features diversification was determined statistically. It was proved that malt substitution with milled maize products can improve properties of laboratory worts obtained from malts of lower quality, like increasing extract content and mash extractivity. The worts produced with 20, 30, and 40% of milled corn products addition show lower contents of soluble nitrogen, free amino nitrogen and lower degree of apparent final attenuation, but they can be easier filtrated and are characterised by lighter colour, in comparison to worts obtained without unmalted ingredients.

INTRODUCTION

In the brewing industry maize, wheat and rice are most commonly used as unmalted raw materials [Debyser *et al.*, 1998; Glatthar *et al.*, 2002]. Unmalted raw materials are the source of carbohydrates which undergo decomposition by malt enzymes in the mashing process to glucose, maltose, maltotriose and other glucose polymers in the amount and proportions similar to those obtained in worts made from malt.

Among unmalted raw materials maize components are the most reliable in processing. However maize grits and fine grits, used as malt substitute, require gelatinization. This process facilitates enzymatic alteration mainly of starch, while the efficiency of obtaining non-carbohydrates from unmalted raw materials is low [Hug & Pfenninger, 1976a, b, c].

The aim of the work was to determine alterations in properties for worts obtained by mashing the malts of different quality with the addition of 20%, 30% and 40% of maize grain milled products, in the form of grits or fine grits.

MATERIALS AND METHODS

The material for investigation were the malts of Pilzen type produced in two malthouses, as well as maize grits of 500-1250 μm granulation and fine maize grits of 250-750 μm granulation. Before mashing, maize grits and fine grits were subjected to gelatinization (raw material to water rate – 1:5, temperature – 90°C, time – 10 min).

The following parameters were determined: dry matter, starch and protein content in malts and in unmalted raw materials, mash saccharification time, the time of worts flow and their mass; extractivity of malts and mashes with 20, 30 and 40% contribution of maize grits of fine grits; viscosity, colour and the degree of apparent final attenuation; total content of nitrogen compounds and α-amino nitrogen in worts, as well as Kolbach index of malts and similarly, there was calculated the share of nitrogen compounds extracted from mashes obtained with the contribution of corn milled products. The assessment of malts and congress worts obtained from pure malts and the ones with unmalted raw materials was conducted according to EBC requirements [Analytica – EBC, 1998], except for starch content in raw materials, which followed the method by Evers-Grossfeld [Leszczyński, 1975]. The results of assays underwent statistical analysis using *Statistica* program.

RESULTS AND DISCUSSION

Considering starch content, maize grits and fine grits were characterised by a similar starch contribution and they also featured similar protein content. Malts featured similar starch and low protein content (Table 1).

The time of mashes saccharification and worts flow depended both on malt, the kind of unmalted raw material (maize grits or fine grits), as well as on the amount of unmalted raw material (20, 30 or 40%). The results were collated in Table 2.

The indicator of malt enzymatic activity is its saccharification time. It is determined on the basis of staining reaction with iodine in a mash producing laboratory worts. For high quality malts this parameter should not exceed 20 min.

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The time of mash saccharification at 20% and 30% dose of unmalted raw materials was within the norm, while the application of 40% dose of unmalted raw materials exceeded the norm.

The time of laboratory worts flow is an indispensable time to completely filter the mash. It should not be longer than 120 min. Filtration is described as “normal” if it is completed within 60 min and if it lasts longer, it is referred to as “slow”. The flow time for worts obtained with high contribution of unmalted raw materials in the form of barley or wheat grain milled products does not often meet the norm, due to difficult worts filtration [Kunze, 1999]. The time of flow for Malt II remained within norm range, while the one from Malt I was slow. Application of unmalted raw materials of 20, 30 and 40% dose contributed to shortening worts flow time to about 30 min. More satisfactory improvement of filtration was recorded for maize grits of 500-1250 μm granulation, than for the fine maize grits of 250-750 μm granulation.

Fine maize grits, or even maize grits can be used as an additive improving filtration of worts made of poor quality malts. The higher contribution of unmalted raw materials the better worts filtration becomes a fact. This is, undoubtedly, an advantage of maize grain milled products, they differ from barley, wheat or triticale grain milled products.

On the basis of Table 3 data it is possible to state that laboratory worts obtained from malts of Pilzen type produced in different malthouses did significantly differ, in almost all properties. The worts obtained from Malt I generally featured more advantageous technological properties than the worts produced from Malt II.

The application of unmalted barley, wheat or triticale

TABLE 1. Total content of starch and protein in maize grits, fine grits and malts of Pilzen type.

Raw materials	Starch (% d.m.)	Total protein (% d.m.)
Fine maize grits of 250-750 μm granulation	84.4	8.3
Maize grits of 500-1250 μm granulation	85.4	8.3
Malt I	63.9	9.1
Malt II	63.6	9.4

TABLE 2. The time of saccharification and flow of worts from pure-malt and composition of malt and maize grain milled products.

Alternative	Time of saccharification (min)	Time of flow (min)	Alternative	Time of saccharification (min)	Time of flow (min)
Malt I	10	90	Malt II	10	45
20% Fine maize grits + Malt I	10	45	20% Fine maize grits + Malt II	5	60
30% Fine maize grits + Malt I	20	45	30% Fine maize grits + Malt II	15	45
40% Fine maize grits + Malt I	30	30	40% Fine maize grits + Malt II	27	30
20% Maize grits + Malt I	10	30	20% Maize grits + Malt II	15	45
30% Maize grits + Malt I	20	27	30% Maize grits + Malt II	20	30
40% Maize grits + Malt I	25	20	40% Maize grits + Malt II	35	30

TABLE 3. Worts properties depending on the kind and contribution of raw materials used.

Differentiating factor	Parameter	Mash extractivity (% d.m.)	Worts colour (EBCindex)	Total soluble nitrogen content (mg/L)	Kolbach index and * (%)	Free amino nitrogen content (mg/L)	Apparent final attenuation (%)	Worts viscosity (mPa.s)
Kind of unmalted addition applied	Malt without additives	83.1 ^{a}	3.08 ^{c}	941 ^{c}	42.5 ^{c}	215 ^{b}	49.6 ^{a}	1.48 ^{b}
	Fine maize grits	83.8 ^{a}	2.75 ^{b}	620 ^{a}	32.6 ^{a}	149 ^{a}	48.1 ^{b}	1.38 ^{a}
	Maize grits	83.9 ^{a}	2.48 ^{a}	631 ^{b}	33.2 ^{b}	148 ^{a}	50.1 ^{a}	1.37 ^{a}
	LSD	*1.22*	*0.17*	*5.24*	*0.30*	*9.30*	*0.91*	*0.017*
Unmalted raw material contribution	0%	83.1 ^{a}	3.08 ^{c}	941 ^{d}	42.5 ^{d}	215 ^{d}	49.6 ^{bc}	1.48 ^{d}
	20%	83.5 ^{a}	2.86 ^{a}	703 ^{c}	36.2 ^{c}	162 ^{c}	50.2 ^{c}	1.40 ^{c}
	30%	84.0 ^{a}	2.68 ^{a}	633 ^{b}	33.2 ^{b}	148 ^{b}	48.1 ^{a}	1.38 ^{b}
	40%	84.0 ^{a}	2.30 ^{b}	541 ^{a}	29.2 ^{a}	136 ^{a}	49.0 ^{ab}	1.34 ^{a}
	LSD	*1.30*	*0.18*	*5.55*	*0.32*	*9.86*	*0.97*	*0.018*
Kind of Pilzen type malt	Malt I	85.1 ^{b}	2.29 ^{a}	691 ^{b}	36.3 ^{b}	150 ^{a}	49.7 ^{b}	1.42 ^{b}
	Malt II	82.4 ^{a}	3.07 ^{b}	650 ^{a}	32.2 ^{a}	166 ^{b}	48.7 ^{a}	1.36 ^{a}
	LSD	*0.88*	*0.12*	*3.75*	*0.22*	*6.67*	*0.65*	*0.012*

* – the percentage share of nitrogen compounds in worts obtained with the use of mixture of malt and corn milled products; a, b, c, d – homogenous groups (α=0.05); LSD – last significant differences (p=0.05)

grain usually decreases worts mass due to more difficult filtration of mashes richer in β-glucans or pentosanes than of worts made exclusively of malt [Anderson *et al*., 1989; Kunze, 1999; Błażewicz, 2002].

One of more considerable determinants of malt usability is its extractivity. High quality malt should be characterised by extractivity not lower than 79.5%. Application of unmalted raw materials in the amounts higher than 20% of charge without the addition of enzymatic preparations usually results in decreased extractivity of mashed matter [Kunze, 1999; Błażewicz, 2002]. Yet additional introduction of both maize grits and fine grits, dosed from 20% to 40% allowed to achieve the same level of extractivity as in the case when solely malt was used. Application of high quality malt (Malt I) enables the increase in extractivity of the composition subjected to mashing.

Worts colour is the parameter informing about the type of malt used for its production. Worts colour value should amount up to 4 EBC units for Pilzen type malts [Kunze, 1999]. The use of 20-40% addition of gelatinized maize grits and fine grits resulted in lighter worts colour – the lighter the higher contribution of unmalted raw material was applied.

In mashed matter of malt and unmalted raw material main source of hydrolysis products of protein compounds is malt. Total amount of soluble nitrogen should meet the range of 650 to 1000 mg/L of pure-malt wort [Kunze, 1999]. In the brewing industry there does occur a serious problem of protein enzymatic hydrolysis products shortage when obtained worts with unmalted raw materials are added [Agu, 2002; Jurek *et al*., 2004]. Malt I, in spite of lower total content of protein (Table 1), was a better source of nitrogen compounds in worts than Malt II. The increase in maize grits and fine grits contribution always caused the shortage of total soluble nitrogen content in laboratory worts. If lower limit of nitrogen compounds is assumed 650 mg/L of wort, 20% of unmalted raw material contribution is the limit of their application.

Kolbach index informs about the amount of malt protein enzymatic hydrolysis products which can be extracted into brewing wort. Their quantity should not exceed the range of 36-44% [Kunze, 1999]. Appropriate amount of these products have an effect on yeast physiology, quantity of higher alcohols, foam quality and stability, as well as organoleptic parameters of beer. According to our prediction, as the contribution of unmalted raw material, which does not provide in mashing conditions the same amount of protein compounds hydrolysis product as in the case of malt, their contributions in worts did considerably decrease. Percentage contribution of protein hydrolysis products in the worts made of mashes with 30% and 40% content of maize milled products was lower than 36%. When maize grits and fine grits were processed, only the use of malts featuring higher than standard Kolbach index can allow obtaining worts of appropriate protein enzymatic hydrolysis products content.

Free amino nitrogen (FAN) content in worts (especially in technology of beer production in cylindrical-conical tanks) is one of the most important indicator of their quality. It points to the amount of amino acids present in wort available to brewing yeast. When unmalted raw materials are applied, allowable minimum of α-amino nitrogen content equals 150 mg/L of wort [Kunze, 1999]. The worts obtained from pure malts were characterized by low α-amino nitrogen content (Table 3), yet still kept within the range of standard. At the same time, when the contribution of maize grits and fine maize grits increased a proportional decrease was observed in free amino nitrogen content. It was also confirmed by other authors [Jurek *et al.*, 2004]. To avoid typical effect of dissolving wort components, which is technologically not allowed and effect a decrease in α-amino nitrogen content in worts obtained with the addition of unmalted raw materials, like maize grits and fine grits, the use of malt featuring higher than standard α-amino nitrogen content, as well as the use of appropriate enzymatic preparations or ready medium providing wort with suitable amino acids are necessary. The results of our own investigation are confirmed by observations of other authors who pay attention to shortages of these protein enzymatic hydrolysis products in worts obtained with high contribution of unmalted raw materials [Agu, 2002].

The apparent final attenuation characterizes maximum consumption of fermenting sugars by brewing yeast introduced into wort. Application of 20, 30 and 40% contribution of maize grits and fine grits (of high starch content – Table 1) introduced starch, hydrolyzed by malt amylases without any help from enzymatic preparations, into the mash. Comparison of apparent final attenuation of pure-malt worts and that of added maize grits and fine grits proves that 30% and 40% contribution of unmalted raw materials did decrease that parameter. The other authors also point to a low degree of apparent final attenuation of worts obtained with the addition of maize products [Jurek *et al*., 2004], which justifies the use of exogenous amylases in the form of appropriate enzymatic preparations in the course of their preparation.

Low viscosity of brewing worts facilitates beer clarification and filtration. Worts viscosity depends on the activity of cytolytic and amylolytic grain and malts enzymes, as well as on non-starch polysaccharides in the mash. Its value should meet the range of 1.51-1.63 mPa.s. Unmalted raw materials like barley, wheat or triticale grain generally increase worts viscosity, leading to difficulties in filtration, mainly because of high-molecular β-glucans and pentosanes in overplus, which are hydrolyzed in the course of malt mashing with those raw materials only to a low degree [Kunze, 1999; Błażewicz, 2002]. The use of maize milled products did considerably decrease worts viscosity, which proves the lack of typical components making worts filtration difficult in this products. Majority of breweries routinely apply preparations containing non-starch polysaccharides hydrolases in the course of unmalted raw materials introduction as the means decreasing viscosity and increasing, to a certain degree, extract yield [Anderson *et al*., 1989; Błażewicz, 2002]. The results of this investigation prove that when applying maize grits and fine grits in the technology of obtaining brewing worts there is no need to introduce preparations facilitating worts filtration.

CONCLUSIONS

The malt substitution with milled maize products can improve the properties of laboratory worts obtained from malts of lower quality, like increasing extract content and mash extractivity.

The worts produced with 20, 30, and 40% of milled corn products addition show lower contents of soluble nitrogen, free amino nitrogen and lower degree of apparent final attenuation, but they can be easier filtrated and are characterised by lighter colour, in comparison to worts obtained without unmalted ingredients.

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PRODUKTY PRZEMIAŁU ZIARNA KUKURYDZY W TECHNOLOGII OTRZYMYWANIA BRZECZEK

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Celem pracy było określenie cech brzeczek laboratoryjnych otrzymanych w wyniku zacierania słodów o zróżnicowanej jakości z dodatkiem produktów przemiału ziarna kukurydzy w formie kaszki lub grysu. Materiał badawczy stanowiły brzeczki otrzymane ze słodów typu pilzneńskiego (wyprodukowanych w dwóch słodowniach), a także kaszki kukurydzianej o granulacji 250-750 μm oraz grysu o granulacji 500-1250 μm. Materiał niesłodowany, w ilości 20, 30 lub 40% zasypu, kleikowano w temperaturze 90°C przez 10 minut, stosując proporcję surowca do wody 1:5. Po ochłodzeniu, skleikowaną masę łączono ze słodem i zacierano metodą kongresową. Materiał porównawczy stanowiły brzeczki otrzymane z samego słodu bez dodatku produktów kukurydzianych. Słody, surowce niesłodowane oraz brzeczki laboratoryjne poddano ocenie. Oznaczono zawartość białka ogólnego i skrobi (tab. 1) oraz czas scukrzania zacieru (tab. 2). Obliczono ekstraktywność oraz wartość liczby Kolbacha słodu lub procentowy udział związków azotowych w brzeczkach otrzymanych z kompozycji produktów przemiału ziarna kukurydzy i słodu (tab. 3). W brzeczkach określono: barwę, czas spływu, lepkość, zawartość związków azotowych i azotu alfa-aminowego oraz stopień ostatecznego odfermentowania (tab. 2 i 3). Stwierdzono, że substytucja słodu produktami kukurydzianymi może poprawiać cechy brzeczek uzyskanych ze słodów gorszej jakości, powodując między innymi zwiększenie zawartości ekstraktu brzeczek i ekstraktywności zacierów. W porównaniu do brzeczek z samego słodu, brzeczki uzyskane z 20-40% udziałem grysu lub kaszki kukurydzianej, charakteryzowały się mniejszą zawartością produktów hydrolizy enzymatycznej białek i azotu α-aminowego oraz niższym stopniem ostatecznego odfermentowania, ale również jaśniejszą barwą i krótszym czasem filtracji.