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TOP AND BOTTOM FERMENTATION BEER BREWED WITH COMMERCIAL BUCKWHEAT MALT

PIWO GÓRNEJ I DOLNEJ FERMENTACJI WARZONE Z WYKORZYSTANIEM KOMERCYJNEGO SŁODU GRYCZANEGO

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Summary: The investigations of buckwheat malting and its usage for brewing were driven by the rising market demand for gluten–free beer. This has been extensively studied, leading to the conclusion that it is impossible to brew beer from 100% buckwheat malt without additional support from the added enzymes. The main problem was the resulting viscosity which has caused the rejection of this valuable raw material. Such an approach has led to the unjustified marginalization of this type of malt in brewing. As buckwheat malt also contributes to antioxidant activity when used in food formulation, it was reasonable to study its potential application in brewing. This study evaluates the top and bottom fermentation process conducted on 20% of commercially available buckwheat malt contribution. Such a contribution delivers the viscosity of wort within the acceptable range which does not cause further filtration problems. Sensory analysis revealed the high acceptability of the resulting beer, pointing simultaneously to the insufficient guidelines for assessments of such a novel beer.

Keywords: buckwheat malt, Castle Malting, top fermentation, bottom fermentation, beer.

Streszczenie: Słodowanie gryki i zastosowanie słodu gryczanego w warzeniu piwa wynika z rosnącego na rynku popytu na piwo bezglutenowe. Zostało to wyczerpująco przebadane i stwierdzono, że nie jest, jak dotąd, możliwe wyprodukowanie piwa ze 100% słodu gryczanego bez dodatku enzymów. Głównym problemem była lepkość, która spowodowała odrzucenie tego cennego surowca. Takie podejście doprowadziło do nieuzasadnionej marginalizacji tego typu słodu w piwowarstwie. Ponieważ słód gryczany przyczynia się także do wzrostu aktywności przeciwutleniającej w produktach spożywczych, do których jest dodawany, zasadne jest szersze zbadanie jego zastosowania w produkcji piwa. W pracy przedstawiono wyniki oceny wpływu dodatku 20% komercyjnego słodu gryczanego na proces górnej i dolnej fermentacji. Taki udział procentowy zapewnia lepkość brzeczki w dopuszczalnym technologią zakresie, co nie powoduje dalszych problemów z filtracją. Analiza sensoryczna wykazała wysoką akceptowalność otrzymanego piwa, wskazując jednocześnie na brak dedykowanych wytycznych dotyczących jego oceny.

Słowa kluczowe: słód gryczany, sława górska, fermentacja górna, fermentacja dolna, piwo.

1. Introduction

A lot of investigations have been conducted during last ten years on buckwheat malt elaboration [Wijngaard 2006, 2005a, 2005b; Nic Piaharais 2005], inspired by the novel malts needed for gluten–free beer brewing. In brief, it was noted that brewing with 100% buckwheat malt is impossible due to high viscosity and insufficient enzymatic activity in such viscous conditions. Because of this, brewing with 100% buckwheat malt was only possible supported by the addition of enzymes [Dezelak et al. 2014; Nic Phiarais et al. 2010]. Unfortunately from the economical point of view the introduction of such beer on the market is highly difficult although gluten–free beer market represents quite a big part of global beer market [Harasym, Podeszwa 2015].

However, buckwheat is a very rich source of organic compounds and minerals [Harasym 2009] and its usage in brewing is undeservingly abandoned [Giménez-Bastida et al. 2015]. A recent study revealed that buckwheat malt significantly contributes to antioxidant activity when added to the mashing mixture [Podeszwa, Rutkowska 2015; Rutkowska, Podeszwa 2015].

The viscosity of wort seems to be main restricting factor when thinking about buckwheat malt usage. The RSM analysis of congress wort characteristics obtained from commercial buckwheat malt Chateau Buckwheat revealed that 20% of this malt's contribution allows to manufacture the congress wort with a viscosity of 1.65 mPas [Podeszwa et al, 2016, manuscript submitted]. Some authors suggested that wort viscosity within 1–2 mPas from malts other than barley malt does not cause any problems during mash filtration [Klose et al. 2011; Zarnkow et al. 2005].

Despite these obvious problems, some malt manufacturers released buckwheat malts declaring their suitability for brewing, however without delivering any specific procedures. Therefore the purpose of this study was the evaluation of the brewing process with commercial buckwheat malt using previous results from RSM congress wort study.

2. Materials and methods

Materials

Buckwheat and barley malts

The buckwheat malt, commercial name Château Buckwheat from the Belgian Castle Malting manufacturer and barley malt Viking Pale Ale produced by VIKING MALT (Strzegom, Poland) from two–row spring barley, were studied. The malts' characteristics are available at the manufacturer's web page [www.castlemalting.com; www.vikingmalt.com]. The comparison of main malt features is shown in Table 1.

Table 1. Parameters of used malts
Tabela 1. Cechy zastosowanych słodów

Malt type		Moisture [%]	Extract (dry basis) [%]	Wort colour [EBC (Lov.)]	Total protein [%]
Chateau Buckwheat	min	0.0	65.3	4.0 (2.1)	9.0
	max	8.0	–	15.0 (6.2)	11.0
Viking Pale Ale	min	0.0	80.0	4.0	9.0
	max	8.0	–	6.0	11.5

Source: own study based on [www.castlemalting.com; www.vikingmalt.com].
Źródło: badania własne na podstawie [www.castlemalting.com; www.vikingmalt.com].

Water

The distilled water of the pH value 5.5 was used for the whole experiment.

Yeast

For the production of top fermented beer *ale* – the top fermentation yeast Fermentis Safale–04 (Fermentis, France) was used. It is characterized by an average flocculation and sedimentation level and the average final degree of attenuation. To produce a low fermentation beer *lager* – the bottom fermentation yeast Bohemian Lager M84 (Mangrove Jack's, New Zealand), characterized by high flocculation and sedimentation level and the high average final degree of attenuation was used.

Hops

The granules of hops of Hallertau Tradition varieties (Hopsteiner, Germany) for hop cooking were used. This type of hop is mainly used in lager type beers, bock, wheat and pilsner. It is characterized by an intensive aroma and the content of α–acids at 5.4%.

Analytical methods

Wort analysis

The saccharification time was assessed according to ECB 4.5.1. [Analytica EBC 2016]. Evaluation of filtration (laboratory wort run–off) was carried out in accordance with the 4.5.1. ECB Method [Analytica EBC 2016]. pH value was evaluated with pH meter (Hanna Instruments, France). The viscosity of the wort was evaluated in accordance with PN–A–79083–7 using the Höppler viscometer.

Beer analysis

Alcohol in beer was measured by distillation according to EBC 9.2.1 Method [Analytica EBC 2016]. Original, real and apparent extract were assessed in accordance with EBC 9.4. Method [Analytica EBC 2016]. pH value was measured with pH meter (Hanna Instruments, France).

Beer manufacturing

Buckwheat Château 1000 g and Pale Ale 4000 g malts were weighed and ground. Then 20 l of water was poured and heated in a laboratory heater up to 63°C. The mixture of weighed and ground malts was poured into the heated water and left at this temperature for 35 minutes. After this time the mash was heated to 72°C and left to stand for 30 minutes. Then the whole volume was heated up to 78°C and poured out into the filter. The mash was filtered several times until obtaining the clear wort. The next stage was the sparging process. The mash was filtered until the spent grains were visible and then the contents of the filter pot was partially refilled with 11 dm^3 of heated up water to 78°C in order to recover sugars remaining in the spent grain and to obtain the wort extract on the level of 14 BLG. With this method 21 dm^3 of wort was obtained.

The next stage was the one hour hops boiling process. The Hallertau Tradition (Hopsteiner, Germany) hops samples of 30, 10, and 10 g were added. After boiling the wort the first sample of 30g of hops was added, which was responsible for the bitter taste. After 40 minutes another sample of 10g was added and five minutes before the end of hopping the last sample was added – 10 g of hops responsible for the aroma.

After hopping the wort was cooled using the immersion cooler to 17–18°C and filtrated to separate the hops residues. In the boiling tank a whirl was made facilitating hops and other solids to settle down in the middle of the pot. The filtered wort was poured out into two sterile fermentation containers and 100 ml of the cooled wort was transferred into two flasks for the preparation of yeast (5.5 g yeast of top and bottom fermentation per the flask). To the first and the second container we introduced about 10 ml of chilled wort and added hydrated and active yeast respectively of the top and bottom type. The containers were tightly closed with sterilized lids with fermentation pipes. A container with top fermentation yeast was incubated in 17–18°C while the bottom fermentation container was placed in a temperature of 10°C.

After completion of first fermentation (7 days – top fermentation, 14 days – bottom fermentation) the green beer was decanted into sterile fermentation containers and placed in a fermentation chamber at a temperature of 5°C for the bottom fermented beer (lager) and 12°C for the top fermented.

After 14 (ale) and 21 days (lager), we started the process of bottling and the apparent extracts of the obtained beers were measured. The filled bottles of top and bottom fermentation beers were left at room temperature for a period of three days. Then the lager type beer was stored at 10°C and the ale type was stored at 12°C for a period of three weeks to perform bottle fermentation.

Sensory analysis

The beers were evaluated dually. The main evaluation was based on the Polish National Standard PN–A–79093–1 (Figure 1) and additional evaluation by a trained panel following the guidelines of the Polish Association of Home Brewers (Figure 2).

Panelist:
Beer type:
Assessment date:
Sampling date:

Lp. (1)	Beer feature (2)	Factor (3)	Results (4)							$\overline{X}$ (4) *(3) (5)
	Points	-	2,0	2,5	3,0	3,5	4,0	4,5	5,0	
1.	Foamity	2								
2.	Transparency	2								
3.	Colour	1								
4.	CO2 saturation	2								
5.	Taste and smell	8								
6.	Bitterness	5								
	SUM									

Detailed comments for each feature:

Fig. 1. Sensory beer assessment chart
Rys. 1. Karta oceny sensorycznej piwa

Source: own study based on [Polish National Standard PN–A–79093–1].
Źródło: opracowanie własne na podstawie [Polish National Standard PN–A–79093–1].

PLACE
DAY/MONTH/YEAR

ASSSESMENT CHART

PANELIST
(NAME AND SURNAME)

1. ....
2. ....
3. ....
4. ....
5. ....
6. ....

BEER STYLE

NUMBER IN QUEUE: ....

STYLE: ....

DEFECTS PRESENT IN BEER
(MARK ALL YOU NOTICE WITHIN 1-3;
1 - BACKGROUND, 2 - DISTURB, 3 - DOMINATE)

- ☐ Aldehyde acetate - aroma of immature, green apples, Emulsion paint.
- ☐ Alcohol - aroma, taste and warming effect of ethanol and igher alcohols.
- ☐ Diacetyl – aroma and taste of butter, butter popcorn, toffee, sometimes slippery sensation on the tongue.
- ☐ DMS (dimethyl sulfide) – canne corn aroma. At higher concentrations cooked old vegetables aroma.
- ☐ Yeast - aroma and taste of crumb bread. As a result of autolysis yeast: burnt milk, broth, soy sauce.
- ☐ Esters / Fruits - aroma and taste of various fruits, such as banana, red apple, pineapple; Fruit candies
- ☐ Esters / solvents - aroma of ethyl acetate, higher alcohols, eg nail polish remover, oil paints, varnishes.
- ☐ Phenolic - aroma of spices (eg cloves, vanilia) or smoke, smoked, plastic or medicinal.
- ☐ Isovaleric acid - aroma of old hop, overriped Blue cheese, sweaty, stale socks.
- ☐ Acidic - acidic in flavor and taste. Sourness can be Crisp and clear (lactic acid), fruity or acetic.
- ☐ Metallic - smell of coins, copper, iron, rust, ink; Taste similar to blood.
- ☐ Light exposed, skunks secretion smell, just open PU bottle Or another beer from a green bottle.
- ☐ Sulphur - sewage smell, rotten eggs (hydrogen sulphide), fired match (sulfur dioxide) or mercaptane
- ☐ Stale - aroma and / or musty taste, decayed, mouldy, of basement.
- ☐ Strangling - tart, tannin, sharply focused and / or dryness after taste; Grainy roughness, scaly.
- ☐ Grassy - aroma of freshly cut grass or green leaves.
- ☐ Oxidized - combination or one of flavors and flavors: feline, of basement, cardboard, paper, sherry, honey.
- ☐ Rancid - aroma and taste of old butter, vomit, soap.

Aroma*: .... /14
DESCRIBE THE IMPACT OF RAW MATERIALS AND FERMENTATION PRODUCTS

Appearance*: .... /6
DESCRIBE COLOUR, TRANSPARENCY OF BEER AND FOAM FEATURES

Taste*: .... /18
DESCRIBE THE IMPACT OF USED MALT, HOPS, WATER, FERMENTATION TY AND OTHER TASTE CHARACTERISTICS.

Bitterness*: .... /6
EVALUATE THE INTENSITY AND QUALITY OF BITTERNESS

Mouth sensation*: .... /6
EVALUATE THE FULL TASTE, CO2 SATURATION, WARMING, CONSISTENCY, AND OTHER SENSATIONS IN MOUTH

Overall impression*:
DESCRIBE THE OVERALL IMPRESSION FROM DRINKING BEER
INSERT SUGGESTION HOW TO IMPROVE THE BEER YOU HAVE TASTED

Sum: .... /50

POINTS INTERPRETATION:

50-46 PERFECT	39-32 GOOD	21-14 POOR
45-40 VERY GOOD	31-22 FAIR	< 14 VERY POOR

*EVALUATE DUE TO STYLE GUIDELINESS

Fig. 2. Assessment chart due to the guidelines of the Polish Association of Home Brewers
Rys. 2. Karta oceny zgodnie z wytycznymi Polskiego Stowarzyszenia Piwowarów Domowych

Source: own study based on [www.pspd.org.pl].
Źródło: opracowanie własne na podstawie [www.pspd.org.pl].

3. Results and discussion

Using the elaborated model presented in detail in a previous article [Podeszwa at al. 2016], manuscript submitted] the pilot batch of 20 l was manufactured of both top and bottom fermented beer. The results of the beers' analysis are shown in Table 2.

Table 2. Results of the analysis of beer
Tabela 2. Wyniki analizy piwa

	Wort viscosity after sparging [mPas]	Apparent beer extract [% m/m]	Real beer extract [% m/m]	Alcohol [% m/m]	Original wort extract [% m/m]	pH [–]
bottom beer fermentation	1.7	4.5	5.58	4.52	14.44	4.4
top beer fermentation		3.3	4.58	5.13	14.41	4.4

Source: own study.
Źródło: badania własne.

The viscosity of the wort is considered to be the main marker of the modification of endosperm components of malt [Kunze 1999]. High viscosity wort indicates insufficient cytolytic activity, hence the smaller extraction degree and mostly difficulties in wort and finished beer filtration. A component that affects the increase of viscosity of wort, received for example from the wheat malts, are pentosans (arabinoxylans) and beta–glucans. Generally it is assumed that the barley malt with good and very good cytolytic activity has a viscosity of wort from 1.51 to 1.63 mPas [Kunze 1999]. The resulting higher viscosity of wort with buckwheat malt contribution may indicate the insufficient cytolysis of malt or can be distinct comparing to the adopted barley wort viscosity standards levels of viscosity possible to obtain.

Wijngaard and Arendt have argued that probably it is not possible to produce beer of a *lager* type with the traditional method using a 100% buckwheat malt, without adding commercial enzyme preparations [Wijngaard, Arendt 2006]. In 2010, Nic Phiarais with the team published results of the research on buckwheat malting and malt mashing for beer production in a pilot scale. The malt used in the pilot study was of inferior quality from the malt obtained by laboratory malting. Furthermore, it was found that the mash from the preliminary mashing process in pilot scale did not achieve the sufficient saccharification level. It was necessary to apply very complex procedures for mashing, along with commercial preparations of α–amylase and glucoamylase enzymes. Wort filtration problems encountered in laboratory studies also occurred in the scale of the pilot brewery. Obtained in this way, the wort yielded 54.5% of total mash. The cause of this low performance was the inability to sparge because of very high viscosity wort (2.59 mPas). Fermentation took place in accordance with established parameters [Nic Phiarais et al. 2010]. During the sensory analysis of the final buckwheat beer, it was expected to notice the characteristic differences between the green and mature beer. It is worth mentioning that among others, yeasts are responsible for the volatile and non–volatile compounds of beer, and the main sources of taste in beer are raw materials, processing conditions and fermentation. Sensory analysis carried out by the German Agricultural Society (DLG) and the Gottfried Eichhorn scheme showed that the fresh buckwheat beer received a positive review for all the organoleptic characteristics i.e. flavor, purity, taste and bitterness [Nic Phiarais et al. 2010].

Dezelak and others [2014], published a study on the fermented beer–like beverage manufacturing using 100% of buckwheat malt obtained based on the methods developed by Zarnkow [Zarnkow et al. 2005]. A mashing program using commercial enzyme preparations was formulated to obtain the extract of wort at 10%. The viscosity of the wort was 2.07 mPas.

The contribution of commercial buckwheat malt of 20% in a mixture of malts used for mashing does not adversely affect the clarification and filtration of the wort in the brewery, since the viscosity for congress wort should fit within the scope of 1.51–1.63 mPas. The manufacturer assumes the possibility of using this malt to 40% [castlemalting.com], so it can be estimated that the viscosity of congress wort with such buckwheat malt contribution will be 1.7-1.8 mPas. Increasing gradually the buckwheat malt contribution to above 20%, it should be expected to obtain a significant change of fluidity of wort for more and more density, and above 70% even presenting a sticky gel consistency [Podeszwa et al. 2016].

Fig. 3. Bottom (on the left) and top (on the right) fermented beers made from 20% buckwheat malt addition
Rys. 3. Piwo dolnej (po lewej) i górnej (po prawej) fermentacji wytworzone z mieszanki słodu z udziałem 20% słodu gryczanego

Source: own study.
Źródło: badania własne.

Wort filtration after mashing process did not provide any complications and the viscosity of the wort amounted to 1.7 mPas.

Fermentation with the top fermentation yeast allows to achieve a higher degree of attenuation of wort, and consequently, a higher level of alcohol in the final beer in a shorter time, comparing the process duration of both fermentation types.

The apparent and real extract of both beers are similar to the extracts obtained from commercial beers. The cause may be the 20% buckwheat malt addition in a mixture of malts used for manufacturing of beer, which contributed to the extract content of other polysaccharides and non–fermented compounds such as beta–glucans and pentosans. These compounds are probably also responsible for the aroma and taste similar to buckwheat honey in both types of beer. The pH of both beers is in the range of typical pH values for the commercial beers (4.3–4.6).

Sensory evaluation

For lager beer the foam properties were evaluated as good, transparency insufficient, color compatible with the Polish National Standard, CO_2 saturation quite good, taste and aroma quite good and bitterness quite good. For *ale* beer the foam properties were evaluated as quite good, transparency insufficient, hazy, color compatible with the Polish National Standard, CO_2 saturation quite good, taste and aroma good and bitterness quite good. For the 100 possible points to achieve, *lager* beer received 68 and ale 69 points. Finally, the panel concluded that the existing Polish National Standards have been designed for typical *lagers* with high transparency, high bitterness though the foam may be inadequate for beers brewed in ale type or with the addition of atypical malts.

Using the evaluation guidelines from the Polish Association of Home Brewers was dictated by the potential consumers of commercial buckwheat malt. The rising trend of home and craft brewing benefits from atypical malts and creates market trends. That is why the opinion of this forum can support further buckwheat malt usage.

The proper evaluation of the resulting beer was difficult, as the beers were not composed on purpose in any beer style. That is why the evaluation panel assessed the beers as “Ale to 14°BLG” and “Lager to 14°BLG”. In the opinion of the panel, even such a narrowed category is insufficient as there is a lack of precision as to which aroma types and features are correct and which should be assessed as a defect. Finally the panel decided which features could be assessed as advantageous and which ones disrupt the satisfaction.

Both beers were evaluated as fair within their categories. The panel recorded the specific aromas and taste of citrus and honey, fresh nuts, green peas and sponge cake.

4. Conclusions

Several attempt have been made to obtain the 100% buckwheat malt beer, each time revealing the technological problems which restrict the use of this valuable compound in brewing. The solution for buckwheat malt usage can be the partial replacement of typical malt during mashing. Using a model equation, the potential viscosity of wort after buckwheat malt addition can be predicted, which facilitates the formulation of recipies and opens the brewing market for this valuable grain.

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