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THE EFFECT OF THE MALT GRINDING DEGREE ON THE pH VALUE AND EXTRACT CONTENT IN BEER MASH

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ABSTRACT

In recent years, a dynamic development of brewing has been observed. Increasingly, production of malt and beer takes place even in smaller industrial factories, breweries restaurants or at home. Extraction is a process applied in a variety of industries, including food production, as a way of extracting specific ingredients from their mixtures. As a result of this process, not only sugars, proteins, fats, enzymes, vitamins, colorants, fragrances and flavors, but also malt and hop extracts are being isolated. In the process of mashing, in which the malt ingredients are being extracted, many biochemical, physical and chemical changes take place. The aim of the study was to analyze the effect of the degree of fragmentation of pilsner type malt on the amount of extract obtained and the pH of the mash. It has been observed that the degree of malt fragmentation has a significant effect on the content of the extract in the mash: the more fragmented malt, the more malt extract in mash produced using the malt. It has also been found that the pH of the mash increases with the average particle size of malt.

Introduction

The process of extraction takes place in two-phase solid – liquid or liquid – liquid systems and it is being used to separate liquid and solid mixtures (Błasiński and Młodziński, 1983; Molenda, 1997; Warych, 2004; Couper et al., 2012). The extraction is carried out with a solvent in brine, and its products are extract and raffinate (Lewicki, 1999; Brandam et al., 2003; Pijanowski et al., 2004).

The efficiency of the extraction process depends on various factors, the most important of which are temperature and pressure. The size of the extracted molecules also corresponds to the efficiency of the process. Extraction is carried out at elevated solvent temperatures. The fragmentation degree of the solid influences the size of the solvent surface and rectified spirit, but its excessive increase causes difficulties in separating the extract and the raffinate. The flow of the solvent and its physicochemical properties are also very important (Lewicki, 1999; Tarko et al., 2008; Stepnowski et al., 2010). The intensity of the extraction process also depends on the diffusion (Boruch and Król, 1993; Szarawara and Piotrowski 2010). The solid-liquid extraction process runs in several stages. Initially, the solvent is permeated into the pores of the carrier of the extracted substance, and then dissolves the specific component. The extracted substance moves from the pores of the solid to the interface and is then transported to the main mass of the solvent (Lewicki, 1999; Atkins and Jones, 2012). If the plant raw material is extracted, the ingredient that is subjected to this process is inside the cells (Błasiński and Młodziński, 1983; Couper et al., 2012). Ingredients extracted from capillary-porous solids can be found in cells as a free space or particle pores solution and as a soluble solid (Stepnowski et al., 2010; Kobus, 2013).

In case of malt, the starch is inside the grain in the form of crystalline granules that under the influence of high temperature, change their properties. During the swelling of the starch grains, the intramolecular and intermolecular hydrogen bonds of its components break. Barley starch is composed of 80% amylopectin and 20% amylose. The solvent elutes the amylose to a colloid form, resulting in new hydrogen bonds between amylose and water (Pazera and Rzemieniuk, 1998; Muller, 2000; Lewis and Young, 2001). In grain, chemically pure starch is 98%, the remaining 2% are proteins, fats and phosphoric acid (Kunze, 1999; MacGregor et al., 1999). Amylolytic enzymes have the ability to penetrate to the solution while mixing ground malt with water. Providing optimal conditions such as temperature and pH allowed their activation. The mechanism of extraction of substances contained in malt consists of absorption of water by starch granules that swell and burst, then the starch is passed to the liquid phase i.e. mash, undergoing hydrolysis by amylolytic enzymes (Dylkowski, 1984; Kettunen et al., 1996; Kunze, 1999).

The aim of the study was to determine the effect of the malting process on the course and efficiency of extraction during the mashing. The extract that can enter the mash affects the degree of fermentation of the mash and the taste characteristics of the produced beer.

Materials and methods

The research methodology is based on a standard laboratory procedure, such as the European Brewery Convention (EBC) method. As a research material, 7 mixtures of various levels of fragmentation of pilsner malt were used. The first 3 samples were malt mixtures of varying degree of fragmentation without separating the individual dimension fractions therefrom. The remaining 4 were obtained by separating the mixture on a sieve separator.

Malt moisture was determined according to PN-EN ISO 712: 2012 standard. There were 3 widths of perforations determined experimentally in order to distinguish 3 fractions of grist: fine, medium and coarse fractions. The malt was crushed in ML 155 laboratory grinder. The crushed malt sieved through sieves with a mesh diameter of 3.15 mm; 2 mm; 1 mm and 0.5 mm. The following fractions of crushed malt were separated by sieve analysis: >2 mm; 1 mm - 2 mm; 0.5 mm - 1 mm; <0.5 mm. For each of the mixtures, the average particle size was determined.

The mashing process was conducted by the infusion method. As a sample, 80 g of ground malt for 320 ml of water was used. The water used for mashing was technological water (pH value was 5.5). Three temperature breaks were used at different time intervals: a protein break that lasted 10 minutes at 50°C, a maltose gap that lasted 20 minutes with a temperature of 62°C, and a saccharification gap that lasted 40 minutes with temperature of 72°C. The process was completed by keeping the mash for 15 minutes at 78°C. The temperature of the mash during heating increased by 1°C per minute, and the mashing process itself took about 2 hours. The obtained mash was allowed to cool to the temperature of 20°C and then adjusted to the initial volume with distilled water and the contents of the mash extract were tested and the pH was measured. The pH of the mash was measured using the Elmetron CP-411 pH meter and the extract content was measured with a PAL 3 digital refractometer and Balling's aerometer.

The research was repeated 3 times. The arithmetic mean and standard deviation were calculated. A statistical analysis of the significance of the crushed malt average particle size on the tested parameters was carried out using the significance test of Tukey differences at the significance level of α=0.05 using Statistica 13.1 program.

Research results

Figure 1 shows research results of the extract content in mash, formed without separation of fractions in a sieve separator.

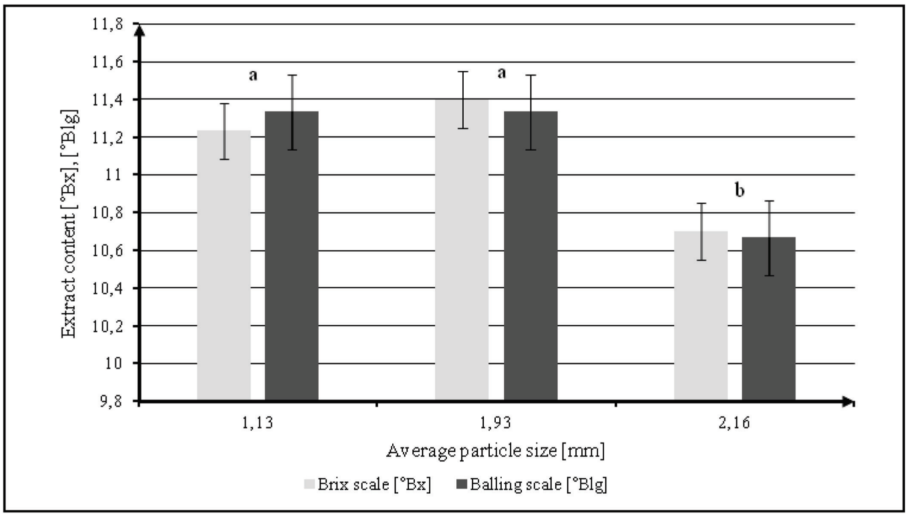

Figure 1. Content of extract in mash, formed from crushed malt without separating fractions from it in sieve separator, depending on average particle size. Letters above columns are results of Tukey difference test that was carried out and they denote individual dimensional groups

Based on the analysis of results presented in Fig. 1 it was found that the size of the crushed malt, without separating the individual dimension fractions from it, has no significant effect on the extract content in mash with the measuring scales with a particle size of 2.16 mm used in the experiment. The highest content of the dissolved extract was in the mash produced from the medium fraction malt, approximately 11.4 measured in Brix scale and the fine and medium fraction, approximately 11.33 measured in Balling scale. The lowest dissolved extract content concentration was noted in the mash produced from the coarse malt fraction.

Figure 2 shows the results of investigations of the extract content in mash obtained from the crushed malt from which the individual fractions were separated on the sieve separator.

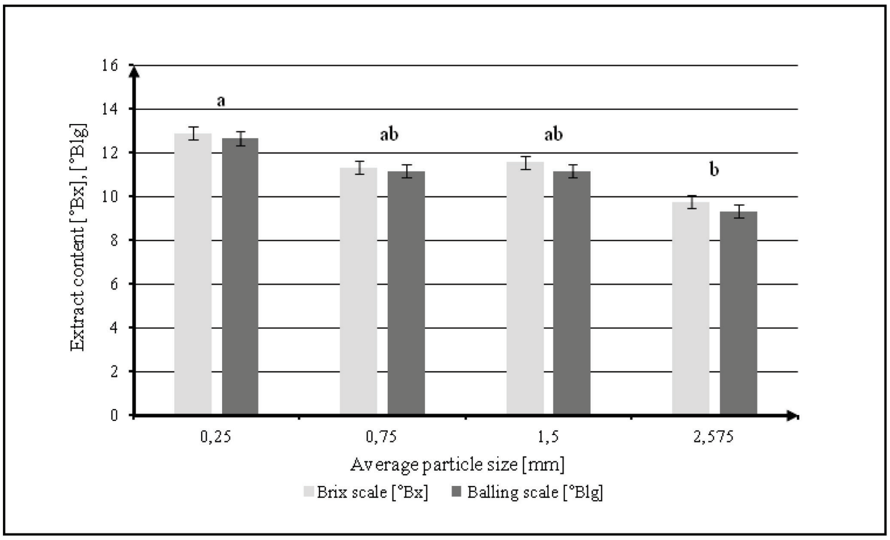

Figure 2. Content of extract in mash obtained from crushed malt, from which individual fractions were separated on sieve separator. Letters above columns are results of Tukey difference test that was carried out and denote individual dimensional groups

As for the fraction separated by means of the sieve analysis, it was observed that the highest extract content was in the mash produced using the fragmented malt with particles sized <0.5 mm. The lowest extract content was observed in the mash produced using the samples of fractions with particles sized >2 mm, where the average amounted to approximately 9.33 [˚Blg]. Regardless of the method used for estimating the content of extract in mash, it has been concluded that the mash produced using the malt with particles sized <0.5 mm vary significantly from the mash obtained from the malt with particles sized >2 mm.

Figure 3 shows the results of the study of the pH of the mash produced from the crushed malt without separating the fractions from the sieve separator according to the average particle size.

The research shows that the pH of mash increased with the average size of particles in the crushed ground malt. The difference between the highest average pH and the lowest average pH of mash is 0.6.

Figure 4 shows the results of the study on pH of the mash obtained from the separated fraction of malted malt depending on the average particle size.

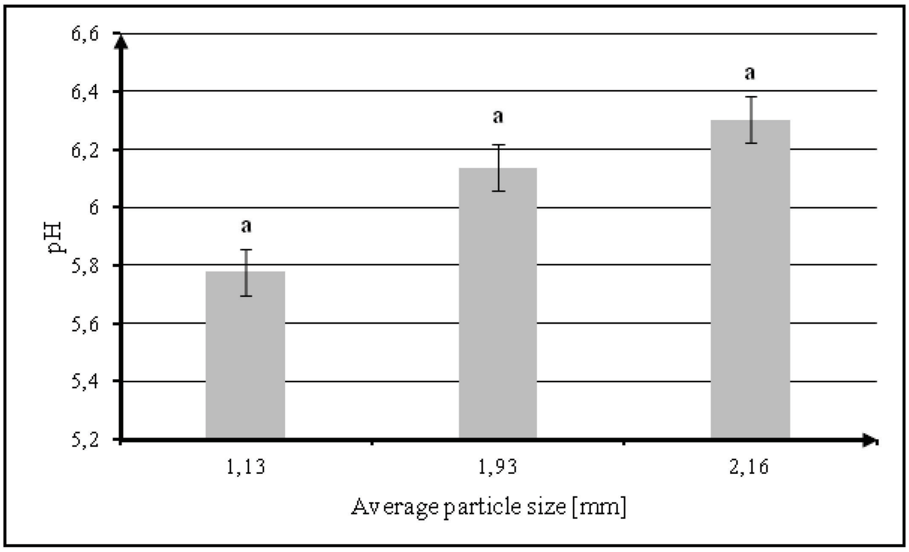

Figure 3. pH value of mash obtained from crushed malt from which individual fractions were separated on sieve separator. Letters above columns are results of Tukey difference test that was carried out and denote individual dimensional groups

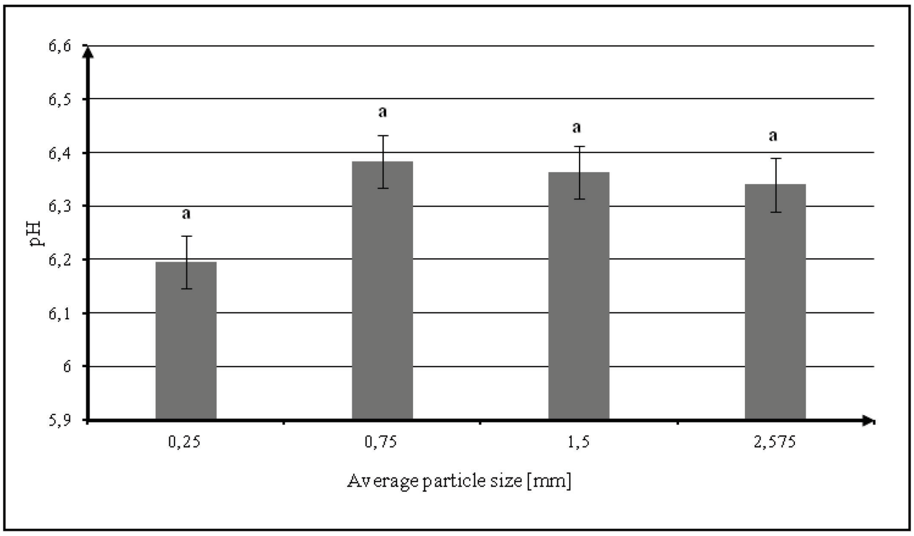

Figure 4. pH value of mash obtained from separated fraction of crushed malt depending on average particle size. Letters above columns result from Tukey difference test carried out and denote individual dimensional groups

In all the examined samples, the pH value is slightly acidic, though in case of the same volume of mash, it was reported that pH value increased. The lowest pH was observed in the mash produced using the samples of fractions with particles sized <0.5 mm - on average 6.19. The difference in the pH in the remaining 3 samples of the distinguished fractions was slight and ranged from 0.2 to 0.4.

Conclusions

Based on the results of the research, the following conclusions were drawn:

1. The extract content in mash suggests a relation: the more fragmented malt, the more malt extract in the mash produced from the malt.
2. The more extractive beer, the more intensive taste. More extractive beers are also fuller and heavier.
3. The pH value in mash increases with the fragmentation degree of malt for the mixed fractions.
4. It is difficult to determine the explicit tendency of the pH value of the mash obtained from the separated fraction of the crushed malt.

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WPŁYW STOPNIA ROZDROBNIENIA SŁODU NA pH I ZAWARTOŚĆ EKSTRAKTU W BRZECZCE PIWNEJ

Streszczenie. W ostatnich latach obserwowany jest dynamiczny rozwój browarnictwa. Coraz częściej produkcja słodu i piwa ma miejsce nawet w mniejszych zakładach przemysłowych, restauracji browarniczej lub w domu. Ekstrakcja jest procesem wykorzystywanym w różnych gałęziach przemysłu, w tym w produkcji żywności, jako sposób wyodrębniania określonych składników z ich mieszanin. Wskutek tego procesu wydzielane są nie tylko cukry, białka, tłuszcze, enzymy, witaminy, substancje barwiące, zapachowe i smakowe, ale również izolowane są ekstrakty słodowe i chmielowe. W procesie zacierania, w którym następuje ekstrakcja składników słodu dochodzi do wielu przemian biochemicznych, fizycznych i chemicznych. Celem badań była analiza wpływu stopnia rozdrobnienia słodu typu pilzneńskiego na ilość otrzymanego ekstraktu oraz pH zacieru. Zaobserwowano, że stopień rozdrobnienia słodu istotnie wpływa na zawartość ekstraktu: im bardziej rozdrobniony słód, tym więcej ekstraktu w wytworzonych z niego zacierach. Stwierdzono również, że wartość pH zacieru zwiększa się wraz ze wzrostem średniego wymiaru cząstek słodu.

Słowa kluczowe: zawartość ekstraktu, pH, słód, zacier, stopień rozdrobnienia słodu

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