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EFFECT OF MALT MILLING FOR WORT EXTRACT CONTENT

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ABSTRACT

Beer manufacturing is one of the most ancient procedures of food manufacturing. The four (in many cases much more) ingredients, the great numbers of technological steps and variations of technological parameters (temperature, time, pressure etc.) have a major influence on both type and quality of the final product. As a result of this, studying beer brewing may offer a great deal of possibilities for numerous researches, scientific examinations, and can provide useful informations for the manufacturing companies as well. At the „Slovak University of Agriculture in Nitra" we examined an entire beer brewing process in October 2013, utilising the Ahlborn sensors, which were integrated in the instruments. Simultaneously, in Gödöllő at the Szent István University, we analysed the effect of malt milling on extract yield and the filterability of wort. We used the brewing parameters (temperature, time, volume ratios), which were experienced in the microbrewery and published in professional literature. Our results verify the conclusions drawn in the professional literature, however they point out the importance of grinding. Results performed on the yields with different grain-constitution might directly be utilised for the specialists of recently in Slovakia and Hungary spreading small-scale, handicraft, and homemade beer brewing.

Keywords: milling; malt; grain-size distribution; wort; extract

INTRODUCTION

Malting, mashing, brewing, fermentation and bottling are usually mentioned among the beer brewing operational steps. From our perspective, the mashing is a crucial area, during which the malt grist is mixed with water and slowly heated up. The purpose of this process is that the useful substances, proteins and still in soluble phase existing starch shall be dissolved to the highest possible extent and be transformed into sugar. For this process the brewery mostly utilises decoction mashing. Characteristic for this procedure is, that 1/3 portion of the mash from the mash tun is led into a brewing kettle, there it is gradually boiled and then pumped back into the mash tun to mix it up again with the rest of the mash. This step is repeated twice or three times thus reaching the final temperature of 62 - 79 °C of mashing. In smaller factories, home breweries, infusion-method is more commonly used; here the entire content of mash tun is gradually heated up to the desired temperature, applying necessary multiple pause periods. After reaching the desired mashing temperature, mash is stirred until transformation of starch into fermentable sugars terminates. This can be checked by the so-called iodine-test **(Briggs, 1998; Fix 2000; Géczi 1994; Narziss, 1981)**. For quick determining the extract produced during the mashing is carried out by using Balling-grade [°B] or Brix-grade [°Bx] measurement unit, in laboratories the extrakt and dry substance content of wort might be determined by analytical means as well **(Bamforth, 2006; Fix and Fix, 1997)**.

Methods of brewing and later on hop boiling (electrical, gas-operated, etc.) determine beer brewing from both economical and environmental aspects. Nowadays the technologies are deemed as environmental-conscious where energy-consumption is reduced, water-consumption is reduced or the amount of waste is reduced. From this perspective it is worth examining the grinding process from the beer production technological steps. The grinding is an extraordinarily energy-consuming procedure; at the same time it determines the quality of the final product. **(Korzenszky, 2007; Korzenszky and Judák, 2009)**. Grinding the malt is actually milling, executed between rollers, which is of vital importance from the aspects of chemical-biological transformations during mashing, quality content and extraction of wort, plus yield. Malt milling is very special because the grain husk and the internal core need different preparation. Milling the peel must be avoided as it plays an important role at wort separation, forming a filter-layer. In spite of this internal core needs fine milling because this contains the important ingredients from extraction point of view. Checking the malt grist in small-scale production-routine takes place by visual control, but by means of using sieves-series it is possible to acquire quantified evaluation. With the sieve-series, structure of grist can be established, distribution of grain-size is easy to depict in graphs and average grain size which is characteristic for the grist might also be determined **(Frančáková et al, 2011; Ivanišová et al., 2011; Korzenszky, 2012; Miller, n.a.; Mousia, 2004; Reilly et. al., 2004; Warpala and Pandiella, 2000)**.

Quality of beer is influenced by other processes (for example mashing, brewing, chilling, fermentation) and the technological parameters of those **(Tóth et al., 2013; Goode et al., 2005)**. During our researches we examined the wort's extract-content and filterability as a function of grist formed by different milling methods.

MATERIAL AND METHODOLOGY

In the microbrewery of Slovak University of Agriculture in Nitra, Faculty of Biotechnology and Food Sciences we examined, documented and analysed a beer brewing procedure on 5th November 2013. Quantities of basic materials, determining the technological temperatures and periods happened according to the recipe, which was based on the previous experiences. Ahlborn sensors mounted on the mash tun, brewing kettle and fermentation tank made it possible that pressure and temperature values of brewing and fermentation procedures can be continuously recorded and evaluated. Due to continuous sampling, the parameters (malt humidity, grain distribution after milling, extract content of wort, etc.), which are characteristic for brewing procedure, were also determined under laboratory circumstances after brewing in Gödöllő, at Szent István University, Faculty of Chemistry and Biochemistry.

Table 1 Sieve analysis of grain-size distribution of malt grist used in Nitra brewing

Grind	Size [mm]	%
Husk	>1.0	43.7
Coarse grits	0.5 - 1.0	30.5
Fine grits	0.25 - 0.5	15.0
Flour	<0.25	10.9

Making the beer started with milling 13 kg of malt. A little portion of malt was milled twice, for the sake of more favourable grain-size distribution. Grain-size distribution was determined by sieve-analysis, (VEB MLW Labortechnik Ilmenau Thyr2, DDR). The received data is shown in Table 1. More than ten percent of malt grist was of flour quality, 15% of it can be characterised as fine grist and 30.5% was the so-called coarse grist. The fraction larger than 1.0 mm comprised of husks and uncrushed grain particles. The malt grist can be characterised with 0.99 mm average grain size. Country of origin of the malt is Slovakia.

The planned and measured temperature-rise of mashing is shown in Figure 1. Based on the recipe, mixing the malt took place in 50 °C water. After 10 minutes rest-time we increased the temperature to 55 °C. Including heating time, we had intended to keep it at this temperature for 20 minutes, and then the next target was 64 °C. Temperature territory of 55 - 64 °C we had aimed to maintain for at least 60 minutes. Based on the recipe, the final temperature is 76 °C, at which the wort is kept until transformation of starch into fermentable sugars. It was checked by iodine-test. Due to inertness of electric heating the planned temperature-steps are not obvious based on our measured values. Temperature of wort increased continuously, after two and half hours of brewing we could start the separating of liquid wort from the residual grist (brewers' grains). This operation is the lautering or filtering.

As a result of quick evaluation performed by Balling-hydrometer the extract-content of wort is 15.2 °B, which was finally modified by the amount of mash and extract content to 9.8 °B. The introduction also pointed out that beer brewing is influenced by several parameters. Out of these factors we would like to emphasize the importance of malt milling hereafter. The aims of laboratory examinations investigated the extract-content and filterability of wort. It was prepared based on the values experienced during the hereby-presented beer-brewing and professional literature data.

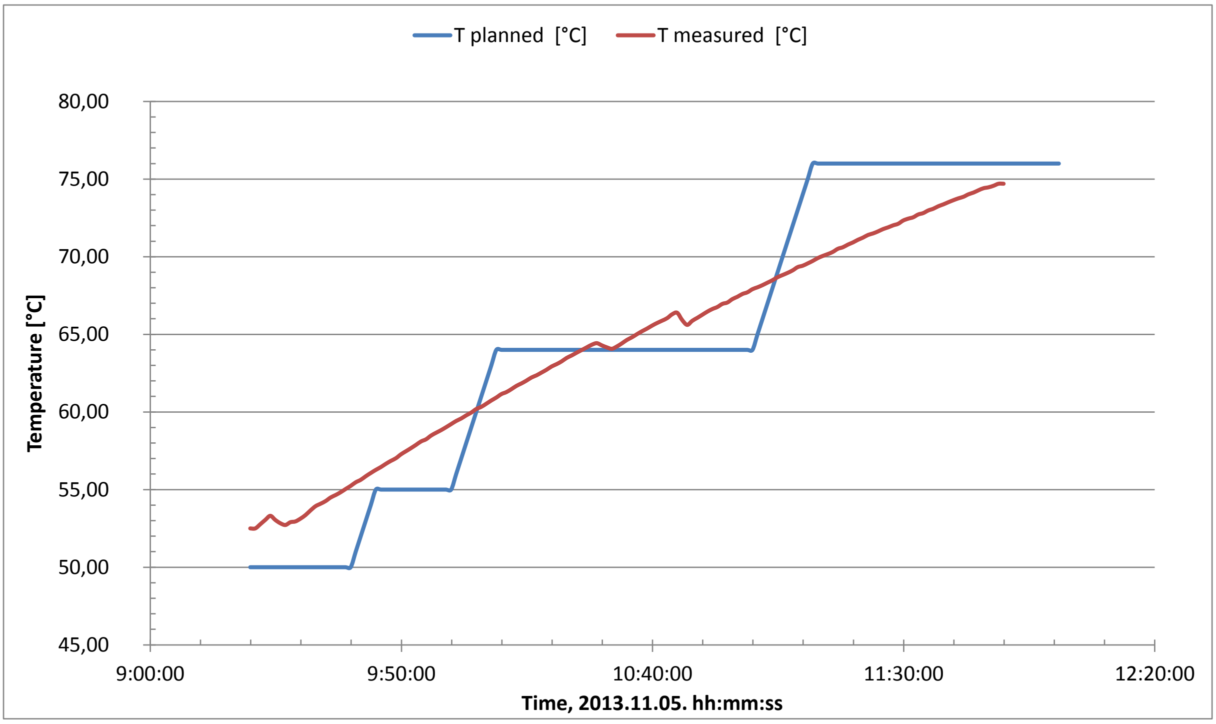

Figure 1 The planned and measured temperature-rise of mashing as a function the time

Table 2 Grain-size distribution of malt grist used in laboratory mashing, Gödöllő

Size [mm] / Methods of milling (grinding)	>1.0*	0.5 - 1.0	0.25 - 0.5	<0.25	$X_{average}$ [mm]
	[%]				
A – Laboratory mill	5.9	15.9	64.4	13.8	**0.46**
B – Poppy seed grinder	37.6	38.5	17.5	6.5	**0.78**
C – Mortar	68.9	15.3	9.4	6.4	**1.39**
D – Walnut grinder	90.9	5.2	2.2	1.8	**1.94**
E – Grape press	93.0	3.9	1.8	1.3	**2.21**
F – Without milling	100	0	0	0	**>2,5**

* not husks only, but in case of D,E,F whole grains also.

Quality of milling is interpreted by the grain-size distribution. Depending on the malt-type, breweries formed an “ideal” grain-size distribution, which results in greater and greater yield, however at the same time it does not obstruct separating wort from brewers' grains. To examine this, we made 5 samples of Münch Malt type malt (w = 3.54%, MSZ 318-3:1979) with different grain-size distribution, using laboratory mill (Młyn walcowy Typ SK, Sadkiewicz Instruments, Poland, Bydgoszcz) and household grinders (poppy-seed grinder, walnut grinder, grape press and mortar). For control purposes, we used the 6th sample of malt without milling. The characteristics of the 6 malt samples with different grain-size distribution were summarized in Table 2 as well.

Figure 2 Mashing in laboratory in water-bath thermostat

Grain-size distributions are rather different from each other; the malt used during the brewing in Nitra resembles the most to the sample prepared with poppy-seed grinder. The mashing was modelled under laboratory circumstances with using 100 g malt and 330 ml of water, in water-bath thermostat (Memmert WB 14, Germany). The “mashing” of the 6 samples took place simultaneously (Figure 2), mixing in the malt at 35 °C, then heated to 50 °C and 65 °C, finally to 79 °C and terminated after transformation of starch into sugars. At least 25 minute long break periods had been planned at each temperature step during the mashing process. Making the wort finally took 120 minutes; the temperature values measured in the brewing glasses are shown in Figure 3.

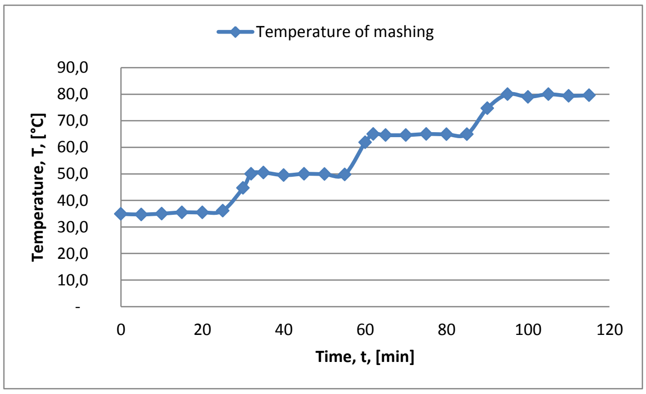

Figure 3 Temperature-rise of mashing as a function the time measured in water-bath thermostat

Separating the wort from the brewers' grains was carried out by sudden overturning of the brewing glass which was covered with filter canvas, gravity way. The quality of brewers' grains forming layers during filtering, the chronological build-up of flow rate presented the filterability. During the filtering experiment we measured filtered amount as the function of time and determined the volume of wort flowing through in 90 seconds. Determining the extract content of wort was performed by refractometer (OG-101/A, Hungary), which was also checked by analytical density measurement as well (SHIMADZU AY220M, Japan).

RESULTS AND DISCUSSION

The quantified results of making wort under laboratory circumstances are presented in Table 3. The utilised grinding (milling) methods were classified into an ascending order based on the average grain size. It shows that the sample containing the finest grains produces the highest extract content and it gradually decreases aligning with the increasing average grain size. The amount of filtrate is quite the opposite, it is less in case of fine grains, and it is more with large grains. The filtrate amount flowing through in 90 seconds is displayed in the filtrate column, but the gravity-driven flow ceased in all cases due to the brewers' grains forming layers. Further amount of filtrate could be gained by moving and stirring up.

Table 3 Extract content and the filterability of wort mashed in laboratory.

Samples (Based on milling)	$X_{average}$ [mm]	Extract content [°Bx]	Volume of filtrate** [ml]
A – Laboratory mill	0.46	16.9	35
B – Poppy seeds grinder	0.78	15.7	45
C - Mortar	1.39	14.5	85
D – Walnut grinder	1.94	12.7	130
E – Grape press	2.21	7.4	140
F – Without milling	>2.5	1.9	240

** Volume of filtrate under 90 second

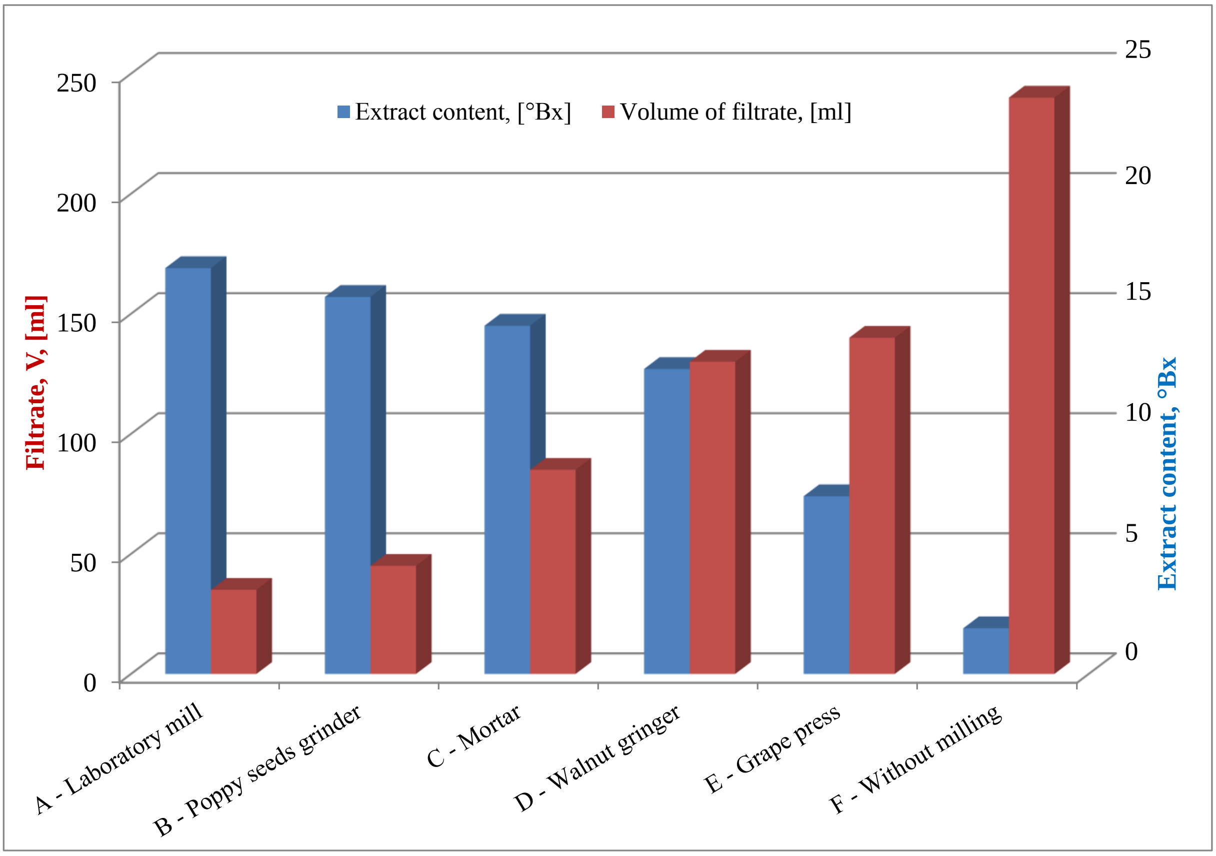

Figure 4 Extract content and filtrate volume of wort as a function of milling methods.

It would seem to be logical to establish an ideal grain-size distribution. Though we represented the results in a bar chart as well (Figure 4), however it would be an incautious statement to choose the grist fraction which is characterised by a "quite high" column from both filterability and extract content perspective. As the amount of filtrate and extract content are different parameters from units of measurement aspect as well, therefore comparing them with each other largely depends on the scale of diagram. Figure 4 nicely demonstrates the conclusions drawn from the table.

To repeat, malt grist of finer grain size can be characterised with larger extract and worse filterability. A better filterability can be achieved with larger grain fractions but from yield perspective it is not preferred. In the small-scale routine the favourable grain distribution can be realised by double triple milling of one portion of the malt, considering at the same time the experimental fact that milling of the malt husks must be avoided.

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