UTILIZING MALT FROM PURPLE WHEAT KONINI VARIETY FOR PRODUCTION OF TOP-FERMENTED BEER

DOSTALOVA YVONA[1], HRIVNA LUDEK[1], JANECKOVA MARIE[1], MACHALKOVA LENKA[1], MRKVICOVA EVA[2], VYHNANEK TOMAS[3], TROJAN VACLAV[3], PAVLU MILENA[1], JUZL MIROSLAV[1]
[1]Department of Food Technology
[2]Department of Animal Nutrition and Forage Production
[3]Department of Plant Biology
Mendel University in Brno
Zemedelska 1, 613 00 Brno
CZECH REPUBLIC

yvona.dostalova@mendelu.cz

Abstract: This experiment is focused on the influence of malt produced from purple Konini wheat, which underwent kilning at 80°C, 100°C, and 120°C, on the resulting quality of the top-fermented beer. In the production of six different samples of beer we have used two ratios of barley and wheat malt (50:50, 70:30). Individual samples were subjected to sensory evaluation including evaluation of colour. We have determined the extract content (actual and apparent), alcohol, and original gravity of the hopped wort. The highest alcohol content (5.25%) occurs in samples using light caramel wheat malt in both ratios of malt. The contents of both actual and apparent extract were increased to 6.5%, 4.8% resp., by using malt kilned at higher temperature (100°C or 120°C) and using a higher dose of wheat malt. Beers that show the lightest colour (over L* = 80) are those made with a greater proportion of barley malt and malt kilned at lower temperature (80°C). When comparing both ratios used, the better scoring assessed beers were those using more barley malt, therefore the best evaluated beer was produced from "Pilsner" malt type with 30% wheat and 70% barley malt.

Key Words: anthocyanins, barley malt, extract, colour, starch

INTRODUCTION

There are wheat genotypes *(Triticum aestivum)* that have different colour than common caryopses. These colours include purple, blue, yellow, and white. The different colouration is caused by pigments from the group of anthocyans in purple and blue wheat, while carotenoids account for yellow wheat. These dyes are present in different parts of the caryopsis, such as in pericarp, testa, aleurone layer, and endosperm (Trojan et al. 2010). The purple pigment occurs in the pericarp, while the blue colour appears in the aleurone layer (Zeven 1991). Anthocyanins have a positive effect on human health, such as significant antioxidant activity, characterized by anticarcinogenic and antimutagenic properties. In addition, these substances have a positive effect on diabetes and heart diseases (Bustos et al. 2012). It is known that purple-coloured wheat contains several anthocyans including cyanidin 3-O-glucoside and peonidin 3-O-glucoside, while in blue wheat delphinidin 3-orutinoside and delphinidin 3-O-glucoside predominate (Pasqualone et al. 2015). For its specific composition, coloured wheat can be used in various food products. This is because it offers not only sensory but also nutritional advantages over products that use common wheat (Berghofer et al. 2005). When comparing purple, blue, yellow, and white kinds of wheat, then according to Belay et al. (1995), the purple variety has the best malting quality. For the production of wheat beer, we use both wheat malt and unmalted wheat. Their mutual proportions affect the taste, colour, and clarity of beer. This beer is fermented at about 20°C using special yeast designed for top fermentation. Top-fermented beers or ales are particularly popular in Germany, Austria, and Belgium, and are slowly beginning to return to the Czech market (Hasík 2013).

MATERIALS AND METHODS

For the experiment, we have selected a purple wheat Konini variety (harvest 2013). From it, we have produced three types of malt based on different kilning (drying) temperatures. We have also used light Pilsner barley malt produced in the Rajhrad malt house from the Malz barley variety. Table 1 shows the technological parameters of purple wheat.

Table 1 Parameters of Konini wheat, harvest 2013

Moisture content	13.0%
Bulk density	78.0 kg · hl^{-1}
N-substances	16.6%
Gluten	38.6%
Falling number (FN)	404 s
Zeleny test	70 ml
TGW (Thousand Grain Weight)	42.14 g
Starch	54.60%

For beer production, we have chosen the Premiant and Semi-early Saaz red-bine (Žatecký poloraný červeňák) hops varieties. Hops are added gradually during wort boiling. At the beginning of the wort boiling, we have used the Premiant variety and in the middle and before the end of boiling the Saaz variety. Fermentation was carried out using top-fermenting (ale) yeast *Saccharomyces cerevisiae*, type Safbrew S-33.

Wheat malt was made in the micromaltery by the Institute of Food Technology at Mendel University in Brno. The micromaltery consists of three cabinets of size 1153 x 753 x 1010 mm (L x W x H). Individual cabinets carry out the processes of steeping, germination, and kilning (drying). Each cabinet holds eight samplers made of stainless steel with perforated bottoms. Each sampler can accommodate 1 kg of grain. The whole process of malting is controlled by computer.

The malt production process was as follows**:**

Two-day steeping with three steeped volumes, six-day germination with regular grain mixing, two-day drying with three temperature regimes and kiln temperature according to the type of malt ("Pilsner" malt with a kiln temperature of 80°C, "Munich" malt with a kiln temperature of 100°C, "Carapils" malt with a kiln temperature of 120°C)

After drying, the malt was deprived of germs on degerming equipment and prior to the actual beer production crushed on Romill MS 100 grinder. The beer was brewed using wheat and barley malt in proportions 50:50 and 30:70. Wheat malt was represented in three variants ("Pilsner" 80°C, "Munich" 100°C, and "Carapils" 120°C). Each variant was repeated three times.

The process of beer production with the ratio of barley to wheat malt 50:50:

- Weighing 950 g of barley and 950 g of wheat crushed malt
- Adding 10 l of water at 45°C
- Pulping
- Mashing according to the type of malt produced (Table 2).

Table 2 Mashing temperature and time according to the type of malt

	"Pilsner" type wheat malt	"Munich" type wheat malt	"Carapils" type wheat malt
Temperature	Duration of temperature	Duration of temperature	Duration of temperature
45°C	15 min	20 min	25 min
55°C	15 min	20 min	25 min
62°C	30 min	40 min	50 min
72°C	45 min	55 min	60 min
83°C	10 min	10 min	10 min

- Straining
- Treatment of spent grains with 1 litre of water
- Wort boiling was conducted 90 minutes using the following doses of hops:

  - At the beginning of wort boiling, 9 g of Premiant hops were added
  - After 45 minutes of boiling, 14 g of semi-early Saaz red-bine hops were added
  - After 80 minutes of boiling, 14 g of semi-early Saaz red-bine hops were added
- After the boiling, the hopped wort was chilled to room temperature (20 °C)
- Subsequently, 5 g of top-fermenting (ale) yeast *Saccharomyces cerevisiae*, type Safbrew S-33 were added
- Main fermentation took place for four days at 20°C
- Final fermentation took place for three weeks at 12°C in PET bottles

<u>The process of beer production with the ratio of barley to wheat malt 70:30:</u>

- Weighing 1.330 g of barley and 570 g of wheat crushed malt
- The following procedure is the same as at 50:50

Colour assessment using Konica Minolta CM spectrophotometer

To evaluate the beer colour, we have used Konica Minolta table spectrophotometer CM-3500d, geometry d/8°, which measures the wavelength of reflected light. The device is connected to a computer that is running the software program CMs-100W SpectraMagic NX. Here, you can set different modes for processing and export of data. For example, select the desired values, such as (L*a*b*, L*C*h, Hunter Lab). The value L* (lightness), represents the range from 0 (black) to 100 (white). The colour coordinates a* (from red to green color) and b* (from yellow to blue color) take positive or negative values depending on the location in three-dimensional CIELAB system. The value a* indicates the proportion between red and green, while the b* value indicates the proportion from yellow to blue. Based on the total color change (ΔE^*_{ab}), we can then describe the noticeable difference between two measurements. In the analysed beer samples, we have determined the values L*, a*, and b* using the spectrophotometer Konica Minolta CM-3500d.

Sensory evaluation of beer samples

Sensory evaluation was carried out at the Institute of Food Technology in a special sensory lab. Samples were submitted anonymously. We had ten valuators - five men and five women.

Analysis of beer samples using FermentoFlash beer analyser

This analyser determines the most important parameters of beer by thermal analysis and mathematical calculation. Beer sample is sucked via tube into a measuring cuvette. A thermal analysis determines the content of alcohol and extract, as well as density. Mathematical calculation determines the values of an apparent extract, beer gravity, and osmotic pressure. The minimum amount of sample for analysis is 10 ml. We have analysed samples of beers brewed from individual types of wheat malt according to the kilning temperature and from each of the individual ratios of wheat and barley malt. For each sample we have determined the alcohol content in volume per cent, extract real and apparent in per cent, and original hopped wort gravity in per cent.

The measured results were statistically analysed using the ANOVA method on STATISTICA 12 programme.

RESULTS AND DISCUSSION

Analysis of beer samples

The method of kilning wheat malt played a larger role in the alcohol content of analysed samples than the selected ratio of malts (see Figure 1). We can say that the more kilning temperature in the production of wheat malt increased, the more increased the growth tendency of alcohol content in beer. Figure 1 shows statistically significant difference in the alcohol volume in malts kilning at 80°C and 120°C, while using two different proportions of barley and wheat malts. This is probably due to the fact that higher levels of malt modification kilned at 120°C also increase its fragility and thereby increasing the fineness and availability of extractive material for better fermentation. The mashing process also played role. Using higher kilning temperatures increases the content of real extract in the sample.

At the same time, the increase of content of the actual extract is also affected by the higher dose of wheat malt in beer brewing (see Figure 2). Hartman (2013) reports negative correlation between higher protein content in the grain and the subsequent extractivity, which concerns mostly wheat, which compared with barley has higher nitrate content. Despite that, in samples with higher content of wheat malt, the actual extract value was higher than that of malt with a predominance of barley malt. According to Líšková et al. (2011) the malt extractivity is given by the activity of proteolytic and amylolytic enzymes. We can therefore conclude that the activity of these enzymes was larger in the samples using 50% of wheat malt than in samples with 30% of wheat malt.

Figure 1 Effects of recipe on the alcohol content

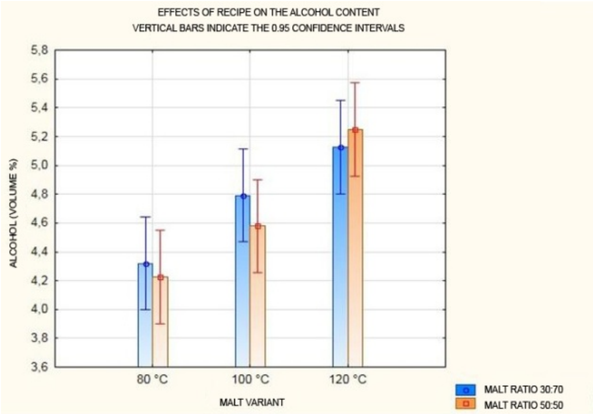
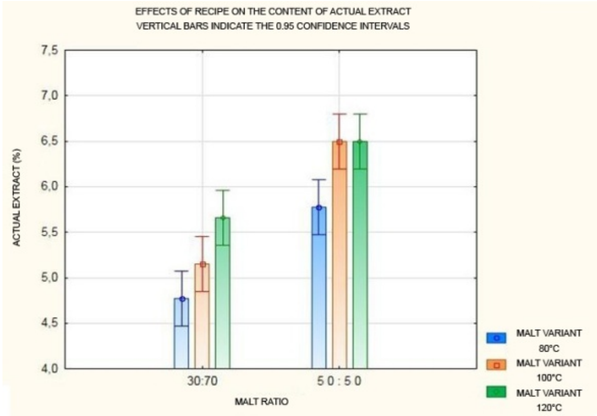


Figure 2 Effects of recipe on the content of actual extract



Moreover, it is necessary to recall the higher carbohydrate content in the wheat grain as compared with barley. A higher value of the apparent extract occurs in a recipe using a larger quantity of wheat malt. This corresponds with a higher extractivity of this malt mixture on the one hand and the worse modification on the other. Figure 3 indicates that within the different recipes, there is no statistically significant difference (P>0.05) between variants of temperature; nevertheless, there were differences (P<0.05) between malt ratios (30:70 and 50:50) in the content of apparent extract. However, this is not valid (P>0.05) for 30:70 ratio with temperature variant 120°C compared with 50:50 ratio (variant 80°C). Looking at different recipes, we can notice a trend to increase the initial hopped wort gravity using malt kilned at higher temperatures (see Figure 4). The highest values occur in malt kilned at 120°C, but it is not statistically significant (P>0.05). In contrast, the lowest value is malt of "Pilsner" type. The differences are probably due to the deeper levels of modification of malt dried at higher kiln temperatures. Malt fragility and beer wort production process, where the mashing process has been modified, also played a certain role.

Figure 3 Effects of recipe on the content of apparent extract

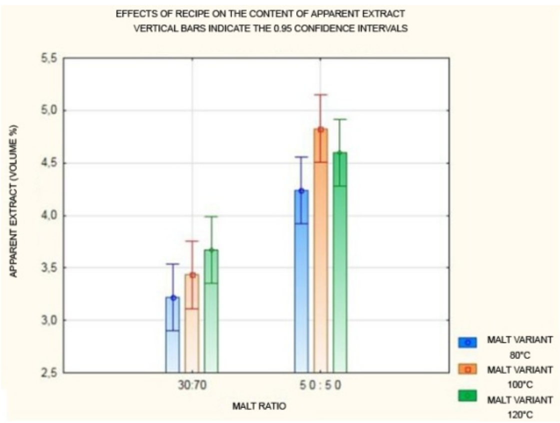
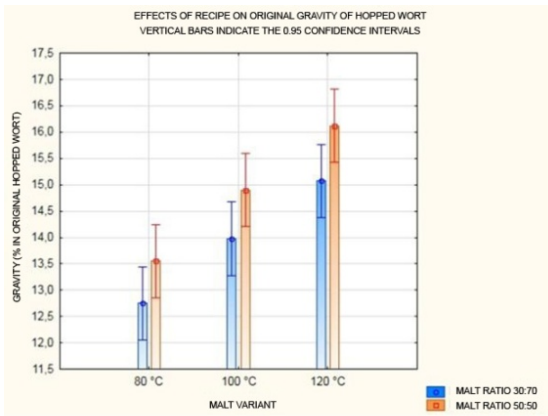


Figure 4 Effects of recipe on original gravity of hopped wort



Sensory profile of beer is influenced by the raw materials, namely malt, hops, water, or surrogates. It also depends on the production process, such as mashing, wort boiling, and in particular fermentation and bottling, as well as the storage conditions of the finished product (Čejka 1997). Figures 5 and 6 give an overview of how different kinds of malt acted on the sensory properties of beer. When the ratio of malts was 50:50, regardless of the type of malt, we have observed less foaming in all samples. The use of "Carapils" increased bitterness, strange aroma and flavour, and decreased fullness and taste of the beer. When using the "Pilsner" and "Munich" malt, the differences were small, only the strange flavour increased with the application of "Munich" malt. A smaller amount of "wheat" malt resulted in more significant differences between individual beer recipes (see Figure 6). The largest differences were found when using "Munich" malt. Beer so produced showed more zest, foaming, and intensity of strange flavour. In contrast, its taste, aroma and fullness were less pronounced.

Figure 5 Sensory profile of beer, malt ratio of 50:50

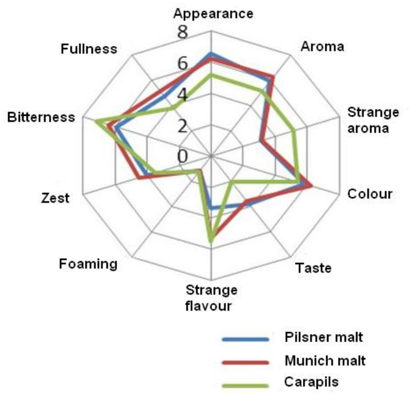
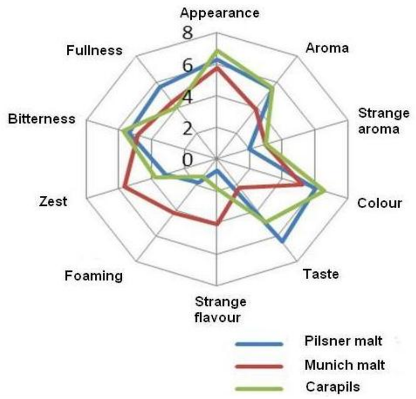


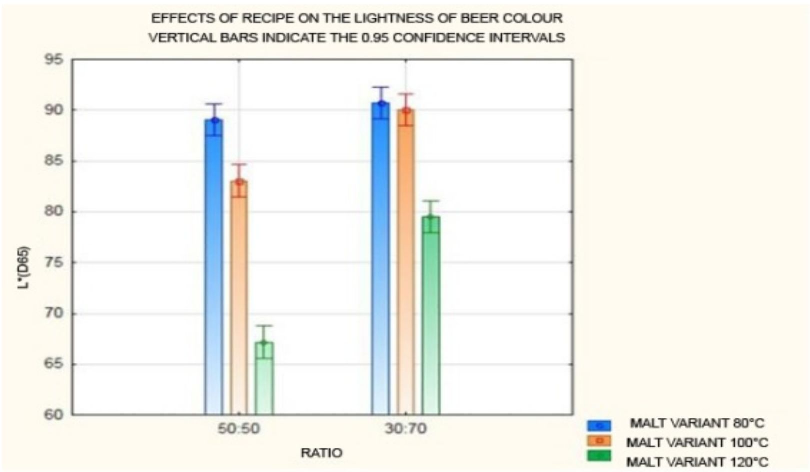
Figure 6 Sensory profile of beer, malt ratio 30:70



Colour Assessment

The colour of beer is measured in EBC units. In light beers, it ranges between about 8 and 12 EBC units. Amber beers usually range between 20 and 40 EBC units, while dark beers vary from 60 to 120 units (Kosař, Procházka 2000). Figure 7 clearly shows statistically significant differences between the temperature of malt kilning and the colour and brightness of the resulting beer. These differences are due to different absorbance of light of beer samples at a certain wavelength. Malt kilning at a lower temperature causes a higher lightness of colour. "Pilsner" malt is thus the lightest of the malts used in brewing beer. In contrast, the least bright malt the "Carapils" is kilned at a temperature of 120°C and comprises more coloured compounds. The colour of this malt wort, according to Basařová et al. (2010), ranges between 3.5 and 6 EBC units.

Figure 7 Effects of recipe on the lightness of beer colour



Malt so modified is used mainly to improve foaming, redox capacity, and taste of light beers. The ratio of malt also significantly influenced the beer colour. It is evident that with higher content of barley malt in the recipe, the lightness of the beer colour increases. Generally, we can say that one can evaluate as darkest the beer with malt kilned at 120°C. Then the lightest beer is the one made from "Pilsner" malt with higher content of barley malt.

CONCLUSIONS

In the production of six different samples of beer, we have used two ratios of barley and wheat malt (50:50, 70:30), and three different types of wheat malt, including "Pilsner," "Munich," and "Carapils" according to the used kilning temperature (80°C, 100°C, 120°C). During the sensory evaluation of both ratios, the beers that scored better were those that used more barley malt. Therefore, the best evaluated beer was produced from "Pilsner" malt type with 30% wheat and 70% barley malt. Beers that show the lightest colour are those made with a greater proportion of barley malt and malt kilned at lower temperature. Thus the lightest samples are beers brewed from "Pilsner" wheat malt in a ratio of 50% wheat and 50% barley malt, as well as with proportion of 30% of wheat and 70% barley malt, which is even brighter. The highest alcohol content occurs in samples using light caramel wheat malt in both ratios of barley and wheat malt. On the contrary, the lowest alcohol content is evident in samples brewed with "Pilsner" malt, again in both used ratios of barley and wheat malt. The contents of both actual and apparent extract were increased by using malt kilned at higher temperature and using a higher dose of wheat malt. Higher values of original wort gravity occur in samples with high content of wheat malt and malt kilned at higher temperature.

ACKNOWLEDGEMENT

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