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PREPARATION OF MALTS FOR PRODUCTION OF SPECIAL BEERS

Hana Kábelová-Ficová, Stanislav Kráčmar, Tomáš Gregor, Miroslav Fišera, Jozef Golian, Vlastimil Kubáň, Tomáš Šopík

ABSTRACT

The article deals with production of various malts intended for manufacture of special types of beer. The malts were used to brew samples of beer with alcoholic strength ranging between 8 – 12% EPM. The above range of original wort content was chosen due to its suitability for sensory evaluation and properties; in stronger types of beer, (more than 12% EPM), nature of the beverage can be drown by mashy flavour. In the experimental samples, the actual residual extract oscillated between 4.0 – 6.5%. The content of ethanol corresponded to the degree of fermentation and thereby also to the residual actual extract in balance equilibrium specifying that higher residual extract corresponds to lower content of alcohol by volume. It ranged between 2.5 – 5.0%. The sample 1 contained the highest amount of ethanol by mass (3.9%) and the sample 13 showed the lowest one (1.9%); alike trend of ethanol content by volume was revealed (5 and 2.44%, respectively). The highest content of actual and apparent extract was found in the sample 2 (6.6 and 5.2%, respectively); the sample 13 showed the lowest levels (4.0 and 3.1%, respectively). The original wort extract content averaged 9.9% in most of the samples; the sample 1 showed distinctly higher value (12.6%) and, on the contrary, the sample 13 demonstrated the lowest one (7.4%). The highest relative density was revealed in the sample 2 (1.02%) and the lowest one in the sample 13 (1.01%). Considering differences in osmotic pressure, the sample 1 exhibited the highest value (1045 mOs) and the sample 13 the lowest one (551 mOs). The highest level of fermentation was found in the sample 19 (61.7%), the lowest one was proved in the sample 19 (44.0%). Sensory analysis corresponded to originality and characteristics of each sample. The sample of beer made from spring barley was evaluated to be the best one.

Keywords: kinds of malts; beers; specialty malts; malt production; brewing

INTRODUCTION

Differences between individual beers are given by production related factors such as ingredients used, technological aspects of brewing process, and fermentation procedures applied. Small and restaurant breweries can manufacture specialty types of beer and approach thus production of the traditional formerly brewed beers **(Basařová et al., 2010)**.

Basařová et al. (2010) also report Pilsner light and the Munich malts to be the most widely used malts worldwide; the former malts are used in production of light beers and the latter ones are utilized in manufacture of dark beers. Besides the above malts, other special malts emphasizing some typical qualitative features and characteristics of basic types of beer or distinguishing certain specific beers from the common light and dark ones are produced, too.

Because of the product quality and also due to technological aspects, the malt from one barley (or other grain crops) variety or from two genetically related varieties must be used in beer brewing **(Briggs, 1998; Basařová et al., 2010; Křižanová et al., 2010; PIVOBIERALE, 2011)**.

In malt making, the spring barley is considered to be the most commonly used cereal. The properties of barley varieties significantly influence quality of both malt and beer.

Malt supplies the main portion of extractive substances and it, together with technological procedures applied, influences redox capacity of beer, which plays an important role in beer resistance against formation of non-biological turbidity and in targeted sensory stability of beer.

Purity, properties of used varieties of cereals, homogeneity, and the level of malt modification represent the most significant characteristics of malt. Optimum progress of manufacturing technology steps and development of fundamental analytical and sensory characteristics of beer are determined by quality of malt. Malt yield plays no less important role **(Briggs and Hough, 1981; Briggs, 1998; Basařová et al., 2010; Ganbaatar et al., 2015)**.

Specialty malts differ from the common ones, mainly barley malts, in a series of characteristics such as enzyme activity, colour, odour, acidity, or redox capacity. They are used in production of special beers. Specialty malts are also added to malts substitutes or they modify selected characteristics of beer wort produced from common malt. Their addition to common malts results primarily in modification of sensory properties like flavour, colour, foam or aroma **(Briggs, 1998)**.

The following types of malts rank among the specialty malts: caramel, colouring, smoked, melanoidin, diastatic, acidic (proteolytic) malts and malts enhancing the redox capacity of beers.

Brewing water, a basic ingredient, is required to show drinking water quality. Its composition influences critically the quality of the product. Moreover, all the processes taking places in brewing are affected by water characteristics like by content of particular ions, especially during mashing and hops boiling **(Briggs and Hough, 1981; Kosař and Procházka, 2000)**.

Chládek (2007) reports, that both the industrially produced beers and the homemade ones cannot be brewed without using proper strains of yeast.

For production of specialty beers like Ales and others, the foreign manufacturers mostly use the top-fermenting yeast (*Saccharomyces cerevisiae*, *var. cerevisiae*) that is surfaced by the evolved carbon dioxide where it forms cover or film called "kreuzen". Fermentation is implemented at 20 – 24 °C.

In the Czech and Slovak Republic, mainly bottom-fermenting yeast (*Saccharomyces carlsbergensis*) is used in brewing industry. It is utilized for the production of Pilsner type beers and lagers. During beer production, fermentation takes place at 8 – 14 °C. After its completion, the yeasts fall downward to the fermentation tank bottom.

In brewing, an irreplaceable role is played by hops and hops products that impart Czech beers typical bitterness and also aroma distinguishing beer from other alcoholic or non-alcoholic beverages. Moreover, hops also influence the production process and other qualitative features of beer. Only female plants are used in brewing industry; they form hop cones that are considered essential ingredients for beer brewing **(Basařová et al., 2010)**.

Polyphenolic substances, hop oils and hop resins represent the main hops components which are essential for brewing technology. Due to their high reactivity, the polyphenols are considered to be crucial for beer brewing. In the completed beer, they act as stabilizers and protect hop resins against oxidation **(Hough et al., 1982; Kosař and Procházka, 2000; Basařová et al., 2010; Ganbaatar et al., 2015)**.

Basařová et al. (2010) reports that throughout the history, the determining characteristics of beers have been developing dependent on technological conditions and procedures employed. Transparence, turbidity, foam, bitterness, character of bitterness, bite, and colour represent the most distinct properties of beer.

The aim of the study was to produce specialty malts and, moreover, using the microproduction method, we intended to brew 19 samples of specialty beers obtained by combination of specialty malts and various types of hops.

MATERIAL AND METHODOLOGY

The Pilsner and colouring malt was purchased from the Sladovna BERNARD, a.s. (Bernard Malt-House, join-stock company), Czech Republic. The smoked malt was obtained from the SLADOVNA, spol. s r.o. (SLADOVNA, Ltd) company, Bruntál, Czech Republic. Production of specialty malts from various cereals such as winter or spring barley, corn, rye, and oats was implemented in the micro-malt house of the Mendel University in Brno, Czech Republic.

The grains (1000 g) of the cereals were stored in steel samplers and placed into soaking boxes with the water level overlap of 2 – 3 cm. The cereals were soaked with water for 48 hours in three 6-hour cycles with 10-hour air breaks. All the soaking procedures were implemented at 12 – 14 °C. The grains underwent germination in water for 6 days at 12 – 13 °C; the temperature of grain was 13 – 14 °C. Kilning was implemented for 1 day at gradually increasing temperature; it was carried out under a sieve (45 – 77 °C) and above a sieve (50 – 79 °C). Using a sieve, hand removal of sprouts from dry germinated malt was done one week after kilning. The following types of hops were purchased from the ARIX s.r.o. (Arix, Ltd) company: Žatecký poloraný červeňák, Premiant, Kazbek, Agnus, and Perle. For micro-production of specialty beers, a liquid preparation containing the RIBM 95 – Lager Yeast strain was used. It is a traditional strain originating in

Table 1 Combinations of malts and hops used in brewing samples of special beers.

sample	malt	hop	beer	EPM%	sample	malt	hop	beer	EPM%
1	MP	PRE+ZPC	LA	12.6	11	MP+MR*	PRE+KAZ	DR	8.9
2	MWB	AGN+ZPC	LA	11.3	12	MP+MM*	AGN+KAZ	DR	8.8
3	MSB	PRE+KAZ	DR	10.9	13	MP+MM*	PRE+KAZ	LI	7.4
4	MP+MM*	ZPC	DR	10.3	14	MP+MO*	AGN	DR	10.2
5	MP+MM*	PER	DR	8.6	15	MP+MO*	PRE+KAZ	DR	8.0
6	MP+MR*	ZPC	DR	10.9	16	MP+MO*	ZPC	DR	10.5
7	MP+MR*	PER	DR	9.3	17	MP+MO*	PER	DR	8.4
8	MP+MR*	KAZ	LA	11.7	18	MP+MO*	KAZ	DR	10.1
9	MP+MR*	PRE+ZPC	DR	10.3	19	MP+MO*	PRE+ZPC	DR	8.7
10	MP+MR*	AGN	DR	10.9					

Note: Malt: Pilsner – MP; winter barley – MWB; spring barley – MSB; maize – MM; rye – MR; oat – MO; *dosage 1:1; Hop: Premiant – PRE; Žatecký poloraný červeňák – ZPC; Agnus – AGN; Kazbek – KAZ; Perle – PER; Beer: lager – LA; draft – DR; light – LI.

Germany; one litre of the above product is able to ferment 130 litres of wort.

Combinations of malts and hops used in special beer brewing are shown in Table 1.

Micro-brewing of special beers

In the process of micro-brewing, four-litre batches were produced. A particular type of malt was ground and, subsequently, the malt was weighed out (180 g per one litre of water, all types of beer). In production of beers from corn, barley and oats malt, one half of the batch was replaced with the Pilsner malt containing glumes that served as a filtration layer during percolation.

The single infusion method performed in one vessel was employed. The use of infusion mashing resulted in dissolution and cleavage of malt extract substances carried out by long-term effect of malt enzymes. No mechanical and heat processing via wort boiling, which is employed in decoction method, was used **(Basařová, 2011)**.

Identical temperatures and types of production process were employed with all the mashes produced; thereby, brewing technology reflected the quality of the processed ingredients. The production process was characterized with the following parameters: acid-rest temperature (35 °C); protein-rest temperature (50 °C); lower saccharification temperature (62 °C); higher saccharification temperature (72 °C), and mash out temperature (80 °C).

After completion of mashing, the boiling vessel was cooled and subsequently the product was subjected to percolation and wort rinsing. Percolation was done using both a cloth and a glume layer.

The hop was divided into three parts: the first portion was used at the beginning of hops boiling, the next portion after 40 minutes and the last one 10 minutes before the end of boiling.

On the day of boiling, the wort was inoculated with bottom-fermenting yeasts and stored at 10 °C. It was mostly kept in one storage room for three days and, subsequently, it was transferred into another one and stored at 5 °C. The main fermentation took seven days. For final fermentation, PET bottles were used; satiation of the beer with carbon dioxide could have been checked by touching the bottles.

For the proper course of final fermentation, wort (20 mL, produced from 100 g of malt per one litre of water, 3 g of ŽPČ hops) was added to each bottle. Finalization of the beer fermentation (5 °C) took one month, before both sensory and chemical analyses were implemented.

Chemical analysis was carried out using Fermentoflash device (Funke-Dr.N.Gerber Labortechnik GmbH Berlin, Germany) **(FERMENTOFLASH, 2014)**.

A panel of five specialists (one woman, four men) evaluated sensory characteristics of the brewed beers at Mendel University in Brno.

Statistical methods

The data were statistically analysed by means of the statistical programme Unistat v 5.5.05 (cCopyright 1984 – 2003 UNISTAT Ltd., London, England), using analysis of variance (ANOVA).

RESULTS AND DISCUSSION

Table 2 specifies distinct parameters of individual beer samples such as average content of mass alcohol, alcohol by volume, actual extract, apparent extract, original wort extract, relative density and fermentation in%, and osmotic pressure in mOs.

The amount of malts used for micro-production of beer samples reflected alcoholic strength of the beers (8 – 12% EPM); the above principle was applied in all the samples with the exception of the sample 1 (Table 1). The above concentration of original wort was selected with the respect to sensory analysis; the character of stronger beers (above 12% EPM) can be drowned by mashy flavour. The content of ethanol corresponded to the degree of fermentation and thereby also to the residual actual extract in balance equilibrium specifying that higher residual extract corresponds to lower content of alcohol by volume. It ranged between 2.5 – 5.0%. Comparing beers obtained by micro-production, sample 1 contained the highest amount of ethanol by mass (3.9%) and the sample 13 showed the lowest one (1.9%); alike trend of ethanol percentage by volume was revealed in the above samples (5.0 and 2.4%, respectively). The highest content of actual or apparent extract was found in the sample 2 (6.6 and 5.2%, respectively); the sample 13 showed the lowest levels (4.0 and 3.1%, respectively).

The original wort extract content averaged 9.9% in most of the samples; the sample 1 showed distinctly higher value (12.6%) and, on the contrary, the sample 13 demonstrated the lowest one (7.4%). The highest relative density was revealed in the sample 2 (1.02%) and the lowest one in the sample 13 (1.01%). Considering differences in osmotic pressure, the sample 1 exhibited the highest value (1045 mOs) and the sample 13 the lowest one (551 mOs). The highest level of fermentation was found in the sample 1 (61.7%), the lowest one was proved in the sample 19 (44.0%).

Ethanol represents the primary volatile component of beer; its amount is given by original wort concentration and by fermentation degree. Beverages classified as 10% beers contain 2.8 – 3.5% of alcohol by mass and lagers labelled 12% include 3.5 – 4.2% of alcohol by mass **(Kosař and Procházka, 2000; Márová et al., 2001; Gorjanovic et al., 2010; Knorr et al., 2016)**. The 10% beer samples 2 – 4, 6 – 11, and 14 showed the above proportion of alcohol by mass.

Kosař and Procházka (2000) report 80% fermentation as the ideal level to be achieved; no sample brewed within the experiment reached the above fermentation degree. Fermentation could have been influenced by many factors such as ingredients, technological procedures, hygienic conditions, yeast strain, unsatisfactory aeration of wort and yeasts, optimum fermentation and final-fermentation time, temperatures applied, etc. **(Křižanová et al., 2010; Gorjanovic et al., 2010; Ganbaatar et al., 2015; Knorr et al., 2016)**.

In sensory analysis, the foam showed stability for 260 s in average; it was classified as thick foam with the height of 45 mm. Medium amount of carbon dioxide was released and turbidity was found when transparence was evaluated.

Table 2 Average content of Mass alcohol; Alcohol by volume; Actual extract; Apparent extract; Original wort extract; Relative density and Fermentation in%, Osmotic pressure in mOs in 19 samples of beer brewed within the experiment (mean ±S.D.).

		1	2	3	4	5
Mass alcohol	%	3.9 ±0.11	2.7 ±0.15	2.9 ±0.21	2.8 ±0.08	2.0 ±0.15
Alcohol by volume	%	0.5 ±0.21	3.5 ±0.19	3.8 ±0.09	3.6 ±0.11	2.6 ±0.31
Actual extract	%	5.2 ±0.17	6.6 ±0.21	5.6 ±0.19	5.1 ±0.13	5.0 ±0.10
Apparent extract	%	3.3 ±0.09	5.2 ±0.10	4.2 ±0.11	3.8 ±0.09	3.9 ±0.22
Original wort extract	%	12.6 ±0.26	11.3 ±0.44	11.0 ±0.30	10.3 ±0.06	8.6 ±0.43
Relative density	%	1.01±0.01	1.02 ±0.01	1.02 ±0.01	1.01 ±0.01	1.01 ±0.01
Fermentation	%	61.7 ±1.06	46.9 ±1.22	52.9 ±1.16	54.4 ±1.36	47.1 ±1.56
Osmotic pressure (mOs)		1045.0 ±2.15	805.0 ±2.45	834.0 ±2.35	798.0 ±1.22	612.0 ±2.45

		6	7	8	9	10
Mass alcohol	%	3.1 ±0.09	2.5 ±0.11	3.3 ±0.13	2.9 ±0.15	3.1 ±0.10
Alcohol by volume	%	4.0 ±0.15	3.2 ±0.23	4.2 ±0.28	3.8 ±0.27	4.0 ±0.22
Actual extract	%	5.1 ±0.17	4.8 ±0.19	5.6 ±0.13	4.8 ±0.07	5.2 ±0.11
Apparent extract	%	3.6 ±0.19	3.6 ±0.19	4.0 ±0.22	3.4 ±0.11	3.4 ±0.15
Original wort extract	%	11.0 ±0.31	9.3 ±0.41	11.7 ±0.16	10.3 ±0.21	11.0 ±0.20
Relative density	%	1.01 ±0.01	1.01 ±0.01	1.01 ±0.01	1.01 ±0.01	1.01 ±0.01
Fermentation	%	57.1 ±1.36	52.7 ±1.16	55.8 ±1.25	56.7 ±1.31	56.1 ±1.11
Osmotic pressure (mOs)		870.0 ±3.01	706.0 ±2.45	913.0 ±2.01	818.0 ±2.45	861.0 ±2.01

		11	12	13	14	15
Mass alcohol	%	2.3 ±0.15	2.1 ±0.18	1.9 ±0.11	2.9 ±0.10	2.1 ±0.09
Alcohol by volume	%	3.0 ±0.31	2.7 ±0.41	2.4 ±0.25	3.7 ±0.28	2.7 ±0.29
Actual extract	%	4.6 ±0.15	5.1 ±0.19	4.0 ±0.11	4.9 ±0.19	4.2 ±0.19
Apparent extract	%	3.5 ±0.15	4.1 ±0.18	3.1 ±0.09	3.5 ±0.11	3.2 ±0.18
Original wort extract	%	8.9 ±0.37	8.8 ±0.16	7.4 ±0.36	10.2 ±0.15	8.0 ±0.16
Relative density	%	1.01 ±0.01	1.01 ±0.01	1.01 ±0.01	1.01 ±0.01	1.01 ±0.01
Fermentation	%	52.4 ±2.06	46.9 ±1.86	53.5 ±1.22	56.0 ±1.46	51.6 ±1.12
Osmotic pressure (mOs)		669.0 ±2.44	625.0 ±2.20	551.0 ±2.45	805.0 ±2.75	599.0 ±2.66

		16	17	18	19
Mass alcohol	%	2.7 ±0.21	2.1 ±0.31	2.4 ±0.11	1.9 ±0.09
Alcohol by volume	%	3.5 ±0.25	2.7 ±0.25	3.1 ±0.35	2.5 ±0.31
Actual extract	%	5.6 ±0.18	4.6 ±0.07	5.9 ±0.11	5.3 ±0.09
Apparent extract	%	4.3 ±0.11	3.6 ±0.19	4.7 ±0.17	4.3 ±0.13
Original wort extract	%	10.5 ±0.29	8.4 ±0.15	10.1 ±0.18	8.7 ±0.36
Relative density	%	1.02 ±0.01	1.01 ±0.01	1.02 ±0.01	1.01 ±0.01
Fermentation	%	50.9 ±1.33	49.2 ±1.28	46.7 ±1.49	44.0 ±1.34
Osmotic pressure (mOs)		778.0 ±2.75	611.0 ±2.29	715.0 ±2.35	599.0 ±2.05

CONCLUSION

Alcoholic strength of brewed beers ranged between 8 – 12% EPM. The actual residual extract oscillated between 4.0 – 6.5%. The content of ethanol corresponded to the degree of fermentation and thereby also to the residual actual extract in balance equilibrium specifying that higher residual extract corresponds to lower content of alcohol by volume. It ranged between 2.5 – 5.0%.

The sample 1 contained the highest amount of ethanol by mass (3.9%) and the sample 13 showed the lowest one (1.9%); alike trend of ethanol content by volume was revealed in the above samples (5.0 and 2.4%, respectively). The highest content of actual and apparent extract was found in the sample 2 (6.6 and 5.2%, respectively); the sample 13 showed the lowest levels (4.0 and 3.1%, respectively). The original wort extract content averaged 9.9% in most of the samples; the sample 1 showed distinctly higher value (12.6%) and, on the contrary, the sample 13 demonstrated the lowest one (7.4%).

The highest density measured was 1.02% and the lowest one 1.01%. The sample 1 reached the highest degree of fermentation (61.7%) and the lowest degree was detected in the sample 19 (44.0% only). Considering differences in osmotic pressure, the sample 1 exhibited the highest value (1045 mOs) and the sample 13 the lowest one (551 mOs).

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Contact address:

Hana Kábelová-Ficová, University of South Bohemia in České Budějovice, Department of Agricultural Products Quality, Studentská 1668, 370 05, České Budějovice, Czech Republic, E-mail: h.kabelova@seznam.cz

Stanislav Kráčmar, College of Business and Hotel Management, Department of Gastronomy, Bosonožská 9, 625 00 Brno, Czech Republic, E-mail: kracmar@hotskolabrno.cz

Tomáš Gregor, Mendel University in Brno, Department of Food technology, Zemědělská 1, 613 00 Brno, Czech Republic, E-mail: gregor@mendelu.cz

Miroslav Fišera, College of Business and Hotel Management, Department of Gastronomy, Bosonožská 9, 625 00 Brno, Czech Republic, E-mail: fisera@hotskolabrno.cz

Jozef Golian, Slovak University of Agriculture, Faculty of Biotechnology and Food Sciences, Department of Hygiene and Food Safety, Tr. A. Hlinku 2, 949 76 Nitra, Slovakia, E-mail: jozef.golian@uniag.sk

Vlastimil Kubáň, Tomas Bata University in Zlín, Faculty of Technology, Department of Food Technology, Vavrečkova 275, 762 72 Zlín, Czech Republic, E-mail: kuban@ft.utb.cz

Tomáš Šopík, Tomas Bata University in Zlín, Faculty of Technology, Department of Food Technology, Vavrečkova 275, 762 72 Zlín, Czech Republic, E-mail: sopik@ft.utb.cz