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Collection of Malting Barley Varieties in the Czech Republic in 2010

The present study reviews changes in the requirements for malting quality and collection of malting barley varieties in the Czech Republic in 2010. It gives micromalting results and results of malt and wort analyses of 22 most widespread and new malting barley varieties registered in the Czech Republic. Varieties causing haze were withdrawn from the collection. The actual collection includes two groups of malting barley varieties. The varieties with high activity of hydrolytic enzymes and high attenuation and the varieties recommended for production of beer with the Protected Geographical Indication Czech Beer, i.e. varieties with lower degree of final attenuation, lower values of Kolbach index, friability, etc.

Descriptors: barley, variety, malting quality

1 Introduction

Spring barley is an important agricultural commodity in the Czech Republic and malt houses and breweries as well as state authorities pay considerable attention to spring barley varieties and quality of harvested grain [1, 2]. The present article follows previous studies and maps changes in the collection of malting barley varieties in the Czech Republic in the recent years [3, 4].

Before the economic crisis, half of the spring barley production, i.e. ca 700 000 tons, was used for malt production directly in the Czech Republic every year. A considerable portion of the malt produced, more than 250 000 tons, was exported either as malt or beer. Depending on quality of barley harvested in the Czech Republic and surrounding countries, barley was exported for processing in outland malt houses.

Besides export needs, varietal composition of malting barley varieties was also affected by the effort to obtain the Protected Geographical Indication (PGI) "České pivo" (Czech Beer).

In line with the EC regulation no. 510/2006 application for the registration of the name "České pivo" was published in the Official Journal of the European Union C 16, 23/1/2008. On October 16 2008 "České pivo" was entered in the register of the Protected Geographical Indications by the Commission regulation no. 1014/2008.

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Tables see Appendix

The PGI "České pivo" does not apply to all beers produced in the territory of the Czech Republic, but only to those that are brewed using the method described in the application and fulfilling the parameters given there. The indication cannot be used for example for cheap low-alcohol beers, special beers with alcohol content exceeding the limit of 6 %.

Number of brand beers produced in the Czech Republic have obtained the PGI (e.g. "Budějovické pivo", "Budějovický měšťanský var", "Českobudějovické pivo", "Chodské pivo", "Znojemské pivo", "Brněnské pivo" or "Starobrněnské pivo").

The Official Journal of the European Union writes about "České pivo": "The distinctiveness of Czech Beer results from many factors, first of all raw materials used and special brewing procedures."

Czech Beer is made from pale malt, also known as "Pilsner malt", produced from spring two-row barley. According to the application for PGI, the varieties for "České pivo" production must be recommended by the Research Institute of Brewing and Malting based on wort quality [5]. Malt for production of laboratory wort is obtained by micromalting [6] of varieties tested within the registration procedure pursuant to the law 219/2003 Coll (Act no. 219/2003 Coll. on the marketing of seed and planting material of cultivated plants).

Current global and European requirements for quality of brewing barley varieties prefer the varieties with high enzymatic activity, high extract content and high values of apparent final attenuation. On the contrary, the barley varieties recommended for "České pivo" production are characterized by a lower level of proteolytic and cytolytic modification and lower attenuation level. The taste profile of "České pivo" is guaranteed by fact that at least 80 % of the total amount of the crushed malt grist is malt made from the recommended varieties.

Many breweries in the Czech Republic have used the PGI logo "České pivo". Some of them do not use this indication but they purchase raw materials recommended for production of Czech Beer.

Entering the PGI "České pivo" into the register of these indications and huge attention devoted to this issue, began to influence varietal composition of spring malting barley in the Czech Republic. The replication areas of the varieties recommended for production of beer with the PGI "České pivo" have been increased.

In 2008 the varieties registered previously that fulfilled on average in the last few years the characteristics of barley varieties specified in the application for PGI were included to the varieties recommended for "České pivo" production. New varieties can be recommended for production of "České pivo" if their sweet wort exhibited on average in the last few years characteristics specified in the application for the "České pivo" PGI. Based on the results, the RIBM recommended the varieties Advent, Aksamit, Calgary, Blanik, Bojos, Malz, Radegast, and Tolar for the production of "České pivo".

The Commission on Quality Evaluation of Malting Barley Varieties at the Research Institute of Brewing and Malting decided that the varieties exhibiting problems with wort clarity would be considered as non-malting varieties [4, 7]. Based on the Commission's decision, growing of varieties with this negative character was significantly limited.

By June 2010, fifty-six spring barley varieties were registered in the Czech Republic (44 of them of malting quality) and 39 winter barley varieties (one of malting quality). Due to the pressure from the side of malt houses on barley growers, the actual composition of spring barley is substantially smaller [8]. In the present study only malting varieties registered in the list of recommended varieties and malting varieties newly registered in the Czech Republic are described.

2 Materials and methods

2.1 Micromalting

Grain for micromalting was supplied by the National Plant Variety Office of the Central Institute for Supervising and Testing in Agriculture in Brno. Samples with optimal or nearly optimal protein content were micromalted. Thus it was ensured that the malting parameters determined were not unfavorably affected by low or high protein content.

Sieving fractions over 2.5 mm were used for micromalting. Samples of barley varieties (0.5 kg) were malted in the micromalting plant of the company KVM (CR). For laboratory malting a method described below was used. This method is traditionally used in the RIBM and it is principally identical with the method of MEBAK [6]:

Steeping: temperature of water and temperature of air during the air rests: 14.5 °C. Length of steeping: 1st day – 5 hours; 2nd day – 4 hours. On the third day water content in germinating grain was adjusted by steeping or spraying to the value of 45.5 %.

Germination: temperature in the course of germination was 14.5 °C. Total time of steeping and germination was 144 h

Kilning: one-floor electrically heated kiln. Total germination time was 22 h, prekilning at 55 °C, kilning temperature was 80 °C for 4 hours.

2.2 Evaluation of the varieties

Study evaluates two sets of varieties. The varieties included in the list of recommended varieties (Table 1) and new varieties registered in 2010 (Table 2). Malting quality parameters based on the *Analytica-EBC* [5] and *MEBAK* [6] were determined in the varieties tested.

3 Results and discussion

Breeding of a new malting barley variety with traits satisfactory for growers, malsters and brewers [8, 9, 10, 12] is a complicated and long-term process. In most countries with traditional and developed brewing industry new malting barley varieties are subject to national trials. In the Czech Republic, new varieties are at first tested in sixteen testing locations for a three-year period and yield potential, field characters, resistance to diseases and grain quality are assessed. A new variety must be different, unique and stable (so called DUS characteristics) and it also must fulfill a requirement for the utility value so that it could be included in the National List of Varieties. The variety has a utility value if it represents in a sum of its characters, compared with other registered varieties, at least in some growing area, an evident contribution for growing or for its use.

Testing both on the national [2, 4, 13] and international levels has brought progress not only in yield but also in malting quality [8]. Unfortunately, termination of the international field trials organized by the *EBC Barley & Malt Committee* [11] will possibly lead to a loss of a lot of valuable information on the performance of varieties under different soil and weather conditions and particularly the impact of these conditions on malting quality. The trials organized by the EBC helped improve breeding (increase in yield, enzymatic activity, etc.), they allowed to compare varieties from many countries in many locations in Europe. Only such trials can help find varieties achieving optimum balance between yield and malting quality in more European regions. The suitable varietal composition will be positively reflected in quality of the final product and economy of malt and beer production.

3.1 Spring barley – List of recommended varieties

Share of foreign varieties in the collection of varieties of the Czech Republic in the reproduction areas slightly decreased from 72 % in 2005 to 66 % in 2009. In 2004 Czech varieties represented 30 % of the reproduction areas; Slovak varieties 5 %, foreign varieties formed 65 % [3].

The varieties Tolar, Jersey, Prestige, Xanadu, Publican, Marthe, and Henley were tested in the EBC field trials for two years (region central) [11]. In 2007 also the variety Bojos was tested but the results of malting quality were not processed and published.

Average values of the followed technological parameters (Table 1) for the period of 2006–2008 were obtained from 12 observations (4 localities per 3 years).

The table clearly shows that starch modification in the set studied was on a good level. The set included three varieties with extract content under 81.5 %. Eight varieties had extract content higher than 82.0 %.

Degradation of nitrogenous substances was on the optimal level. Average value of Kolbach index in the followed set was 44.1 % at 0.76 % of soluble nitrogen. The varieties Henley (47.2 %) and Henrike (53.4 %) had strong activity of proteolytic enzymes. Proteolytic modification is one of the important traits characterizing the varieties recommended for "České pivo" production. Lower values of relative extract at 45 °C and Kolbach index required for malts for production of beer with the "České pivo" PGI were exhibited by the varieties Advent, Aksamit, Blaník, Bojos, Malz, Radegast, and Tolar. Proteolytic modification of these varieties was 40.8 % (38.5 – 42.0 %).

Only the variety Prestige had a higher value of relative extract at 45 °C than Kolbach index.

Average values of friability (85 %), β-glucan content in wort (196 mg/l) and values of viscosity (1.44 mPa.s) show an excellent ability of the varieties studied to degrade cell walls. Only the varieties Aksamit and Radegast had an average value of friability lower than 80 %. Lower β-glucanase activity in the varieties Blaník, Aksamit, and Advent was also confirmed by increased content of β-glucans in sweet wort (261, 288, 301 mg/l, respectively).

Activity of amylolytic enzymes (first of all β-amylase) was on the optimal level (389 WK u.). in the studied set. Value of diastatic power did not drop under 300 WK in any of the values studied.

Wort quality expressed by apparent final attenuation was in the studied set 82.0 %. Level of proteolytic modification and degree of apparent attenuation are parameters in which the varieties recommended for production of "České pivo" differ most from the other varieties of the studied collection. Apparent final attenuation recommended for production of Czech Beer was on the level of 80.5 % (78.5–81.6 %). These traditional Czech varieties are also cited in the list of Barley varieties accepted by Carlsberg Breweries [14].

3.2 Spring barley – varieties registered in 2010

In 2010 based on three-year tests (2007–2009) following varieties were registered: Berlioz, Gladys, Paulis, and Lilly [15, 16] (Table 2).

The French variety Berlioz gave malts with higher extract content (82.7 %). The variety tends to a higher proteolytic modification. Amylolytic modification was on the optimal level, friability also achieved optimal values (87 %). β-glucan content in wort was mildly higher (198 mg/l). Apparent final attenuation moved around 81.8 %. The variety did not have any problems with wort clarity.

Malt of the Dutch variety Gladys provided excellent extract yield (83.2 %). Modification of nitrogenous substances was very good and it developed adequate levels of hydrolytic enzymes as indicated by the level of diastatic power. Cytolytic modification was on a very good level (friability 85 %, β-glucan content in wort 196 mg/l). Apparent final attenuation achieved the values around 82.5 %. Wort of the variety Gladys did not have any principal problems with wort clarity.

Malt of the German variety Lilly provided average content of extract (82.4 %). It tended to higher proteolytic modification. Amylolytic and cytolytic modification was on the optimal level. Wort composition was optimal and apparent final attenuation achieved the values of 81.9 %. The variety had minor problems with wort clarity.

Malt of the Czech variety Paulis had extract content on the average level (82.1 %). Proteolytic and amylolytic modification was on the optimal level. The tested variety was on the above average to optimal level in all the parameters indicating modification of cell walls. Apparent final attenuation moved around 82.5 %. The variety did not have problems with wort clarity.

3.3 Winter barley

In 2009 the winter barley variety Wintmalt with malt quality [15] was registered extending thus raw materials for malting industry.

Extract content in the German variety of the two-rowed winter barley Wintmalt was 81.8 %. Proteolytic and amylolytic modification of malt was on the optimal level. Hydrolysis of cell walls was without problems, friability was 86 % and β-glucan content in wort moved around 141 mg/l. Wort quality composition was on the optimal level. The variety did not have problem with wort clarity.

4 Conclusion

The set of 20 malting spring barley varieties registered in the list of recommended varieties in the Czech Republic was assessed. The varieties Sebastian, Xanadu, Signora, and Henley had extract content in malt dry matter 82.5 % and higher. Proteolytic modification of the varieties recommended for "České pivo" production was 40.8 %. The average of the whole set studied was 44.1 %. Activity of amylolytic enzymes was in all the followed varieties on the optimal level. Degree of attenuation in all the varieties recommended for "České pivo" production was 80.5 %. Modification of cell walls was on the optimal level (friability 85 %, β-glucans in wort 196 mg/l). Only the varieties Blaník, Aksamit, and Advent had β-glucan content more markedly higher than 250 mg/l.

In 2010 the malting varieties Berlioz, Gladys, Lilly, and Paulis were registered in the Czech Republic. Extract content in these varieties exceeded 82 %. Level of proteolytic modification was also higher (47.7–52.9 %). Amylolytic modification was optimal (309–334 WK). Degradation of cell walls was also on the optimal level, very intensive in the variety Lilly. Wort quality in all four new varieties was very similar (81.8–82.5 %) .

In 2009 the winter barley variety Wintmalt with malting quality was registered in the Czech Republic, extending thus spectrum of malting varieties.

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Appendix

Tab. 1 Quality of malt and wort of the varieties included in the list of recommended varieties (2006–2008, part I)

Methods	Units	References	Tolar 1997	Jersey 2000	Prestige 2002	Diplom 2002	Bojos 2005	Radegast 2005	Sebastian 2005	Xanadu 2006	Blaník 2007	Aksamit 2007
Protein content of barley (factor 6.25)	%	EBC 1998	11,6	11,3	11,5	11,4	11,7	12,0	10,7	11,3	11,5	11,2
Starch content of barley	%		62,3	62,8	63,0	63,1	63,3	63,0	63,6	63,9	63,0	62,9
Degree of steeping 1	%		31,5	32,6	31,6	32,1	32,0	32,5	31,6	31,9	31,7	32,5
Degree of steeping 2	%		39,2	40,2	39,6	39,8	39,7	40,3	39,4	39,8	39,3	40,1
Malt yield d. m.	%		91,6	91,2	91,3	91,4	91,3	91,0	91,1	90,9	91,9	91,8
Respiration losses d. m.	%		4,6	4,7	4,5	4,6	4,5	4,7	4,6	4,8	4,5	4,4
Rootlet losses d. m.	%		3,9	4,1	4,2	4,1	4,2	4,3	4,3	4,4	3,7	3,8
Extract of malt, congress mash	%	EBC 1998	80,7	81,4	81,7	81,9	81,8	81,7	82,5	82,5	81,6	81,5
Mash method according to Hartong and Kretschmer VZ 45 °C	%	MEBAK 1997	36,2	42,8	44,9	39,5	37,7	38,2	41,1	44,3	36,3	35,7
Kolbach index	%	EBC 1998	40,3	44,1	43,3	44,4	42,0	42,2	44,8	45,1	40,6	38,5
Diastatic power	u.WK	EBC 1998	432	392	444	318	395	388	417	440	408	383
Final attenuation of laboratory wort from malt	%	EBC 1998	80,9	82,2	83,2	82,3	79,5	78,5	82,8	80,8	81,6	81,5
Friability	%	EBC 1998	84	87	82	82	86	79	85	86	80	79
High molecular weight b-glucan content of malt, FIA	$mg.l^{-1}$	EBC 1998	258	194	208	218	165	189	177	117	261	288
Protein content of malt (factor 6.25)	%	EBC 1998	11,1	10,9	11,0	11,0	11,2	11,5	10,3	10,8	11,1	10,7
Total nitrogen of malt, Dumas method	%	EBC 1998	1,779	1,748	1,752	1,757	1,788	1,844	1,645	1,723	1,768	1,715
Soluble nitrogen of malt, Dumas method	$mg.l^{-1}$	EBC 1998	716	769	757	779	751	778	737	777	717	661
Soluble nitrogen of malt, Dumas method	%	EBC 1998	0,716	0,769	0,757	0,779	0,751	0,778	0,737	0,777	0,717	0,661
Saccharidic extract of malt	%	EBC 1998	76,2	76,6	76,9	77,0	77,1	76,8	77,9	77,7	77,2	77,3
Viscosity of laboratory wort from malt	mPa.s	EBC 1998	1,467	1,45	1,445	1,449	1,432	1,454	1,45	1,426	1,461	1,474
Colour of malt, visual method	EBC	EBC 1998	3,075	3,158	3,242	3,15	3,075	3,025	3,55	3,55	3,092	2,892
Saccharification time	min	EBC 1998	13	10	10	10	11	11	11	10	13	12
Glassy corns	%	EBC 1998	0,2	0,2	0,2	0,3	0,2	0,3	0,3	0,2	0,3	0,5
Partly unmodified grains	%	EBC 1998	2,2	1,9	3,5	3,6	2,6	5,0	3,1	2,6	5,1	6,2
Homogeneity (by friabilimeter)	%	JIB 1983 [5]	97,6	97,9	96,3	96,2	97,2	94,8	96,6	97,2	94,6	93,3
Appearance (clarity) of wort		MEBAK 1997	1,08	1,00	1,00	1,00	1,00	1,00	1,08	1,00	1,58	1,00
Haze of wort (90°)	EBC	EBC 1998	1,43	0,89	0,72	0,71	0,66	0,79	1,12	0,70	2,18	0,88
Haze of wort (15°)	EBC	EBC 1998	1,32	0,84	0,68	0,68	0,69	0,78	1,06	0,69	2,44	0,9

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Tab. 1 Quality of malt and wort of the varieties included in the list of recommended varieties (2006–2008, part II)

Methods	Units	References	Kangoo 2008	Aktiv 2008	Publican 2008	Marthe 2008	Vista 2009	Advent 2009	Signora 2009	Streif 2009	Henley 2009	Henrike 2009
Protein content of barley (factor 6.25)	%	EBC 1998	11,2	11,5	11,2	11,3	11,0	11,3	11,0	11,1	10,9	11,1
Starch content of barley	%		62,8	63,1	63,3	63,3	62,7	63,2	63,1	63,1	63,3	63,0
Degree of steeping 1	%		31,8	32,6	32,3	32,7	32,3	31,6	31,7	32,6	33,1	32,5
Degree of steeping 2	%		39,7	40,2	40,1	40,3	40,1	39,3	39,6	40,4	40,3	40,3
Malt yield d. m.	%		91,4	91,3	91,6	91,0	92,0	91,7	91,9	91,4	91,5	91,9
Respiration losses d. m.	%		4,6	4,7	4,6	4,8	4,4	4,5	4,4	4,6	4,8	4,6
Rootlet losses d. m.	%		4,0	4,0	3,9	4,2	3,6	3,8	3,7	4,0	3,7	3,6
Extract of malt, congress mash	%	EBC 1998	81,7	80,6	82,1	82,4	81,6	82,0	83,0	82,0	82,6	82,4
Mash method according to Hartong and Kretschmer VZ 45 °C	%	MEBAK 1997	41,1	41,0	38,7	47,5	44,9	37,9	44,0	46,0	44,4	53,2
Kolbach index	%	EBC 1998	44,2	42,0	43,5	46,4	45,5	41,4	44,2	48,9	47,2	53,4
Diastatic power	u.WK	EBC 1998	450	364	362	424	382	312	358	372	374	372
Final attenuation of laboratory wort from malt	%	EBC 1998	83,2	81,9	81,8	84,1	81,8	81,1	83,3	82,6	82,9	83,0
Friability	%	EBC 1998	90	83	84	90	90	84	88	86	90	91
High molecular weight b-glucan content of malt, FIA	$mg.l^{-1}$	EBC 1998	123	223	222	136	161	301	185	253	177	71
Protein content of malt (factor 6.25)	%	EBC 1998	10,8	11,0	10,7	10,9	10,5	10,8	10,5	10,6	10,5	10,6
Total nitrogen of malt, Dumas method	%	EBC 1998	1,719	1,755	1,710	1,733	1,677	1,722	1,673	1,692	1,668	1,694
Soluble nitrogen of malt, Dumas method	$mg.l^{-1}$	EBC 1998	759	735	744	803	762	711	738	826	785	903
Soluble nitrogen of malt, Dumas method	%	EBC 1998	0,759	0,735	0,744	0,803	0,762	0,711	0,738	0,826	0,785	0,903
Saccharidic extract of malt	%	EBC 1998	76,9	76,0	77,5	77,4	76,8	77,5	78,4	76,8	77,7	76,7
Viscosity of laboratory wort from malt	mPa.s	EBC 1998	1,441	1,434	1,462	1,417	1,45	1,445	1,436	1,439	1,424	1,418
Colour of malt, visual method	EBC	EBC 1998	3,417	3,083	3,333	3,258	3,592	3,325	3,233	4,183	3,325	3,983
Saccharification time	min	EBC 1998	10	11	11	11	10	11	10	10	10	10
Glassy corns	%	EBC 1998	0,2	0,3	0,4	0,2	0,2	0,2	0,2	0,2	0,2	0,2
Partly unmodified grains	%	EBC 1998	1,5	3,7	3,7	1,1	1,7	2,5	1,7	2,1	1,2	1,2
Homogeneity (by friabilimeter)	%	JIB 1983 [5]	98,2	96,1	95,9	98,8	98,1	97,3	98,1	97,6	98,6	98,6
Appearance (clarity) of wort		MEBAK 1997	1,00	1,00	1,00	1,08	1,00	1,00	1,00	1,00	1,00	1,08
Haze of wort (90°)	EBC	EBC 1998	0,83	0,72	1,28	0,77	0,99	0,81	0,73	0,83	0,79	1,51
Haze of wort (15°)	EBC	EBC 1998	0,82	0,73	1,24	0,74	1,00	0,86	0,78	0,81	0,79	1,55

Tab. 2 Quality of malt and wort of new varieties (2007–2009)

Methods	Units	References	Bojos C	Sebastian C	Xanadu C	Kangoo C	Gladys	Berlioz	Paulis	Lilly
Protein content of barley (factor 6.25)	%	EBC 1998	11,7	10,7	11,5	11,2	11,2	11,1	11,2	11,3
Starch content of barley	%		64,0	64,3	64,3	63,6	64,1	63,6	64,2	63,2
Degree of steeping 1	%		32,3	32,2	32,5	32,2	32,4	31,8	32,6	33,0
Degree of steeping 2	%		40,0	40,1	40,4	40,3	40,3	39,7	40,3	40,7
Malt yield d. m.	%		90,7	90,3	90,1	90,7	90,5	90,3	90,5	91,0
Respiration losses d. m.	%		5,0	5,2	5,3	5,0	5,3	5,3	5,1	5,3
Rootlet losses d. m.	%		4,3	4,5	4,6	4,3	4,3	4,4	4,4	3,7
Extract of malt, congress mash	%	EBC 1998	81,7	82,5	82,5	81,6	83,2	82,7	82,1	82,4
Mash method according to Hartong and Kretschmer VZ 45 °C	%	MEBAK 1997	38,4	42,9	45,0	42,7	46,8	50,3	41,5	50,2
Kolbach index	%	EBC 1998	44,4	47,8	47,4	47,1	49,6	50,3	47,7	52,9
Diastatic power	WK	EBC 1998	387	412	442	468	334	326	327	309
Final attenuation of laboratory wort from malt	%	EBC 1998	80,5	83,3	81,9	83,6	82,5	81,8	82,5	81,9
Friability	%	EBC 1998	88	87	86	90	85	87	89	95
High molecular weight b-glucan content of malt, FIA	mg/l	EBC 1998	153	143	124	122	196	198	153	89
Protein content of malt (factor 6.25)	%	EBC 1998	11,3	10,3	11,0	10,8	10,7	10,5	10,7	10,8
Total nitrogen of malt, Dumas method	%	EBC 1998	1,799	1,638	1,752	1,720	1,701	1,680	1,713	1,717
Soluble nitrogen of malt, Dumas method	mg/l	EBC 1998	797	781	830	808	841	842	814	905
Soluble nitrogen of malt, Dumas method	%	EBC 1998	0,797	0,781	0,830	0,808	0,841	0,842	0,814	0,905
Saccharidic extract of malt	%		76,7	77,6	77,3	76,5	78,0	77,4	77,0	76,7
Viscosity of laboratory wort from malt	mPa.s	EBC 1998	1,43	1,44	1,43	1,44	1,44	1,44	1,43	1,44
Colour of malt, visual method	EBC	EBC 1998	3,4	4,1	4,0	4,1	4,5	4,1	3,9	4,6
Saccharification time	min	EBC 1998	11	10	10	10	10	10	10	10
Glassy corns	%	EBC 1998	0,2	0,3	0,3	0,2	0,3	0,1	0,2	0,3
Partly unmodified grains	%	EBC 1998	2,0	2,9	2,8	1,6	2,2	1,8	1,8	0,8
Homogeneity (by friabilimeter)	%	Baxter, O'Farrell	97,8	96,8	96,9	98,3	97,5	98,0	98,1	99,3
Appearance (clarity) of wort		MEBAK 1997	1,00	1,00	1,00	1,00	1,08	1,00	1,00	1,25
Haze of wort (90°)	EBC	EBC 1998	0,79	1,08	0,83	0,93	1,46	0,85	0,96	2,03
Haze of wort (15°)	EBC	EBC 1998	0,78	1,03	0,78	0,91	1,67	0,94	0,99	2,25

C = standard varieties