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Quality of malting barley grown under different cultivation systems

Three year trials were conducted to investigate the set of spring barley varieties cultivated according to principles of ecological agriculture or using the ordinary agrotechnics (fertilization, seed treatment, herbicides, fungicides, insecticides). The weather conditions affected most of the quality traits more than e.g. nitrogen fertilization or system of cultivation. Significant differences among years were recorded in protein content in grain, relative extract at 45 °C, Kolbach index, diastatic power, and apparent final attenuation. The cultivation system substantially influenced the β -glucan content in wort, it was surprisingly low under ecological system of cultivation. The effect of the cultivation system was also proved in the hot water extract and partially in Kolbach index and friability.

BC 11 Barley

(Descriptors: Barley, malting quality, different growing systems.

Descriptorien: Gerste, Malzqualität, unterschiedliche Anbaumethoden).

1 Introduction

The quality of malting barley depends on the level of different traits and properties which in summary define the value of the material for malt processing.

General weather conditions and the tropical course of weather in the given year much participate on the level of majority traits and properties. It is reasonable to specify distinct barley cultivation regions according to weather and other natural conditions to reach the greater sureness of quality production. For example weather pattern in the regions of central Moravia (Haná) and central Bohemia (Labe river basin) is similar to the long-term average weather patterns of the recognized good regions of cultivation of malting barley in Europe (Petr, 1987).

The forecrop and fertilization are very important factors. Other factors, such as the effect of soil conditions, sowing date, sowing rate and all other agrotechnical measures are manifested rather in the interaction with weather pattern in the year of cultivation.

Ulonka (1960–1962) reported the greatest influence of agroecological conditions on yield (79%), percentage of grain > 2.5 mm (65%), 1000-kernel weight (72%) and protein content in malt (76%). In bulk density this effect is only about 50%, like in Kolbach index, soaking capacity, colour of wort, and diastatic power. The lowest effect of agrotechnical conditions was ob-

served on extract yield and friability, where is significant the genotype of cultivated variety (54 and 45%). That is why the elite malting varieties are preferred by maltsters and why the variety must be declared at the purchase.

The effect of forecrop on the yield of spring malting barley was reported by (Petr, 1989). His results from four-year investigation of malting barley more than 21 thousand hectares the yield after sugar beet was lower by 0.8 tons than after wheat.

A special attention has been paid to the effect of fertilization on malting barley, because higher nitrogen rates or high mineral nitrogen in soil increase the content of proteins in grain as well as in malt and decrease the extract yield. Lepäöe (1968) reported that excess nitrogen fertilization decreased the beer production from 1 ton of barley and reduced the total production of beer from 1 ha by 7 hectolitres. Consequently the whole technology of the malting barley cultivation must be aimed at the high quality grain production, the prerequisite of the highest yield of beer of the top quality.

So-called “bio-beer” has been produced in recent years in some breweries. Ecologically cultivated malting barley is required for its production. This system of cultivation is in agreement with the regulations of the international organization IFOAM (International Federation of Organic Agriculture Movement) and is controlled and certified. Barley cultivated in such way is required also for food production purposes, because it is valued in diets of healthy nutrition. The presented paper gives a report on the differences between technological quality of barley cultivated ecologically according to the IFOAM principles and barley cultivated conventionally-intensively.

2 Material and Methods

Trials were carried out several years to study the set of spring barley varieties included in the List of Recommended Varieties. One series of trials was managed in the way of the ecological system of cultivation without application of fertilizers and pesticides according to the principles of the IFOAM as well as in agreement with the Methodological Instruction for Ecological Agriculture of Ministry of Agriculture of the Czech Republic

Table 1 Nutrient content in soil on ecological and intensive variant (0 – 20 cm) in mg.kg⁻¹

Variant	pH	P	K	Mg	Ca	Mg:K
Ekological	7.23	99	195	135	3127	0.70
Conventional	6.65	135	237	112	2892	0.49
F-test	34.88 *	15.95 *	2.51 ns	4.08 ns	0.62 ns	16.87 *

Source: Stehno 1998

(CR). According to these principles the Experimental Station of the Czech University of Agriculture in Prague-Uhřetěves was certified to conduct these experiments. The trial establishment was preceded by the conversion from conventional to ecological management which is carried out stock-less. Pedological survey was performed to evaluate balance of the nutrients and content of heavy metals and foreign substances. Falls of foreign substances were investigated in the place of trials. These analyses proved that all values are below the limit boundary.

The Experimental Station Uhřetěves is situated in fertile beet growing region at altitude 295 m above sea level on luvisol clay soils with production capacity of 84 points. The content of available nutrients in soil in the layer 0 – 20 cm is presented in Tab. 1. The quantity of P was good, of K and Mg satisfactory. Average annual temperature amounts 8.3 °C and sum of annual precipitation is 575 mm. The course of weather is given in Tab. 2. In all experimental years 1995 – 1997 the trials were planted after wheat forecrop. The sowing of ecological was done in the first decade of April in all the years. Harrowing with weeding harrow once or twice a year was performed during vegetation. The set of this system of cultivation is denoted by the abbreviation "ECO".

The other series of experiments was performed at Plant Breeding Station Stupice. It is situated some 2 km from Uhřetěves and the

natural environment is almost identical. The trials were managed in the way of the conventional system using seed treatment, fertilizers and pesticides. Sugar beet was used as a forecrop.

Soil reaction was more favourable at Stupice, there was higher P content, good K content, lower Mg and Ca contents, and less favourable ratio Mg:K. Content of mineral nitrogen (N_{min}) at the depth 0 – 30 cm of soil was higher at Stupice than at Uhřetěves in most months except June and July 1996 (Stehno, 1998). Fertilization in the form of combined NPK fertilizer at the rate 30 – 40 kg N, 30 – 40 kg P₂O₅ and 30 – 40 kg K₂O close before sowing was done. Herbicides were applied in post-emergently and insecticide against cock was also used. Sowing was performed in the first decade of April. The set of this cultivation system is denoted as "INT".

The results of analyses of identical varieties from four experimental stations of the Central Institute for Supervising and Testing in Agriculture (CISTA) of CR are presented for comparison. The system of barley cultivation at these stations was similar to the system used at Stupice. The set is denoted as "CR".

Grain samples from the experiments were micro-malted by procedure recommended by EBC and modified at the Brewery and Malting Research Institute, Brno, CR. The modification consists in the shortening of the total time of malting from 168 hours to 144 hours (Psota et al., 1998). Barley and produced malt were analyzed according to the EBC methodologies (1978) and MEBAK (1979).

The trial included the most important Czech and Slovak malt varieties: Akcent and Amulet (Selgen, a.s., Prague, Czech Republic), Jubilant, Sladko and Kompakt (Hordeum, s.r.o., Sládkovičovo, Slovak Republic and Forum (Hybritech, a.s., Kroměříž, Czech Republic).

The experimental data were analyzed by means of ANOVA and the effects of varieties, years and cultivation systems were estimated.

Table 2 Weather in experimental years 1994 to 1997 (average monthly air temperature °C and monthly sum of precipitation)

Year Month	1994 – 1995		1995 – 1996		1996 – 1997		Long-term average	
	Air temperatur °C	Sum of precipitation (mm)	Air temperatur °C	Sum of precipitation (mm)	Air temperatur °C	Sum of precipitation (mm)	Air temperatur °C	Sum of precipitation (mm)
IX	14.4	56.5	13.2	89.2	10.7	48.9	14.0	49.0
X	6.9	30.9	10.9	10.3	9.8	23.1	8.6	41.0
XI	6.7	22.7	1.7	31.5	5.2	28.6	3.2	34.0
XII	-2.6	55.1	-1.4	30.6	-4.4	21.5	-0.5	34.0
I	-0.6	27.1	-3.5	9.8	-4.4	21.5	-2.1	28.0
II	5.2	12.4	-3.0	19.9	3.4	22.4	-0.8	27.0
III	3.5	63.7	0.3	21.8	5.2	44.8	3.4	31.0
IV	9.5	0.0	9.5	23.3	6.3	35.1	8.2	46.0
V	13.2	115.2	13.0	169.7	14.6	25.7	13.4	65.0
VI	15.5	89.4	16.8	110.6	17.0	84.1	16.3	74.0
VII	21.1	32.6	16.5	105.7	17.8	110.2	18.2	74.0
VIII	18.7	99.3	17.6	57.5	19.5	60.6	17.5	72.0
Annual sum of temperatures/ precipitation	9.3	605	7.6	680	8.4	526	8.3	575.0

3 Results and Discussion

The values of quality parameters in the three cultivation systems are given in Tab. 3a, b.

The protein content in barley differs significantly within years. The highest average protein content was observed in 1995 and the lowest one in 1996.

The differences in the nitrogen compounds content in different cultivation systems and years were not significant. Only in 1996 the protein content was significantly lower in the cultivation systems INT and ECO and in 1997 the protein content was significantly higher in intensive cultivation system (INT).

Generally, the extract content was highest in all cultivation systems in 1996 – 82.9%. In 1995 the content was 81.5% and 1997 81.9% and these differences were not significant. However, the differences of other traits within cultivation systems and years were significant.

The highest values of extract brought intensive (INT) and ecological (ECO) cultivation systems, 82.6% and 82.5%, respectively, significantly more than in the CR variant.

The relative extract at 45 °C was highest in 1996, too, - 48.7% and lowest in 1997 – 41.0%. The effect of years was decisive, the cultivation systems' effect was less important.

Year and cultivation system affected Kolbach index in a decisive way. The highest values were observed in 1996 – 51.4% and the lowest values in 1997 – 45.9%. The differences of the Kolbach index values between ECO and INT systems were not significant, but they were higher than in the variant CR.

Diastatic power was influenced mainly by the year. The highest values were found in 1995 (356 j. WK) and the significantly lowest values occurred in 1996 (298 j. WK). No effect of cultivation system was recorded.

Table 3 a Quality parameters of varieties of malting barley from different cultivation systems

Parameter	Year	1995			1996			1997			1995 – 1997			Average for all systems and years
		Cultivation system	CR	INT	ECO	CR	INT	ECO	CR	INT	ECO	CR	INT	
PG	Akcent	11.8	11.2	11.8	10.5	9.7	9.4	10.5	11.8	10.8	10.9	10.9	10.7	10.8
	Amulet	11.9	11.2	11.4	10.4	9.6	10.0	10.4	11.8	11.8	10.9	10.9	11.1	11.0
	Forum	11.3	11.1	11.1	10.4	9.5	9.3	10.4	10.7	9.3	10.7	10.4	9.9	10.3
	Jubilant	11.3	10.9	11.5	10.8	10.0	9.6	10.8	11.0	10.9	11.0	10.6	10.7	10.8
	Kompakt	11.3	11.7	11.8	10.3	9.4	10.6	10.3	10.9	9.8	10.6	10.7	10.7	10.7
	Sladko	11.0	11.3	11.6	10.6	10.1	10.3	10.6	11.9	10.7	10.7	11.1	10.9	10.9
	Average	11.4	11.2	11.5	10.5	9.7*	9.9*	10.5	11.4*	10.6	10.8	10.8	10.7	10.7
E	Akcent	80.7	81.8	80.6	81.1	82.7	83.2	81.1	81.2	81.9	81.0	81.9	81.9	81.6
	Amulet	81.4	82.7	81.2	81.9	83.6	84.3	81.9	82.2	80.6	81.7	82.8	82.8	82.3
	Forum	82.1	82.9	81.4	81.6	84.2	84.8	81.6	82.6	83.5	81.7	83.2	83.2	82.7
	Jubilant	81.3	82.1	80.7	80.7	83.2	83.5	80.7	82.1	82.2	80.9	82.5	82.5	81.9
	Kompakt	81.9	82.1	81.2	82.1	83.7	84.2	82.1	82.6	83.5	82.0	82.8	82.8	82.6
	Sladko	81.5	82.1	80.8	81.8	83.4	83.8	81.8	81.3	82.2	81.7	82.3	82.3	82.1
	Average	81.5	82.3	81.0	81.5	83.5*	84.0*	81.5	82.0	82.3	81.5	82.6*	82.6*	82.2
RE 45	Akcent	45.7	50.5	48.1	44.6	49.5	55.0	44.6	40.4	41.9	45	46.8	48.3	46.7
	Amulet	38.5	40.4	38.2	36.4	45.8	48.2	36.4	35.6	34.1	37.1	40.6	40.2	39.3
	Forum	39.0	42.2	38.8	37.5	41.5	47.2	37.5	38.2	38.4	38	40.6	41.5	40.0
	Jubilant	44.8	48.2	46.2	42.0	53.1	54.9	42	43.1	41.4	42.9	48.1	47.5	46.2
	Kompakt	46.9	48.7	46.5	49.0	53.9	55.6	49	35.3	43.6	48.3	46.0	48.6	47.6
	Sladko	50.6	52.7	53.1	48.1	56.4	58.7	48.1	43.5	45.6	48.9	50.9	52.5	50.8
	Average	44.3	47.1	45.2	42.9	50.0	53.3*	42.9	39.4*	40.8*	43.4	45.5	46.4	45.1
K	Akcent	44.5	52.2	49.9	45.0	50.9	54.0	45.0	42.8	46.2	44.8	48.6	50.0	47.8
	Amulet	44.7	49.7	47.8	45.1	52.7	55.2	45.1	43.1	41.1	45.0	48.5	48.0	47.2
	Forum	46.0	52.3	49.2	44.5	49.6	54.7	44.5	44.6	48.3	45.0	48.8	50.7	48.2
	Jubilant	45.9	49.1	48.2	43.9	52.2	57.0	43.9	43.4	47.0	44.6	48.2	50.7	47.8
	Kompakt	50.1	51.8	51.8	49.9	55.9	55.6	49.9	47.5	51.5	50.0	51.7	53.0	51.6
	Sladko	51.3	54.3	54.2	47.8	53.9	57.4	47.8	44.6	50.0	49.0	50.9	53.9	51.3
	Average	47.1*	51.6	50.2	46.0*	52.5	55.7	46.0	44.3	47.4	46.4	49.5	51.1	49.0

Note: * significantly different values, PG = proteins in grain (%), E = extract (%), RE 45 = relative extract at 45 °C (%), K = Kolbach number

Tab. 3 b Quality parameters of varieties of malting barley from different cultivation systems

Parameter	Year	1995			1996			1997			1995 – 1997			Average for all systems and years
		CR	INT	ECO	CR	INT	ECO	CR	INT	ECO	CR	INT	ECO	
	Cultivation system													
DP	Akcent	358	350	375	310	290	235	310	325	330	326	322	313	320
	Amulet	368	360	335	320	280	305	320	390	415	336	343	352	344
	Forum	403	415	400	380	320	315	380	380	340	388	372	352	370
	Jubilant	299	315	335	325	295	230	325	335	325	316	315	297	309
	Kompakt	355	370	385	318	235	350	318	335	280	330	313	338	327
	Sladko	319	325	355	318	245	310	318	320	310	318	297	325	313
	Average	350	356	364	329	278*	291*	329*	348*	334*	336	327	330	331
AFA	Akcent	82.8	84.7	82.8	81.5	83.3	82.8	81.5	80.2	81.5	81.9	82.7	82.4	82.3
	Amulet	82.5	82.3	81.5	80.6	84.8	83.9	80.6	80.2	79.6	81.2	82.4	81.7	81.8
	Forum	83.4	84.6	83.1	82.6	84.5	85.0	82.6	81.0	83.5	82.9	83.4	83.9	83.4
	Jubilant	81.6	82.0	81.1	80.8	82.3	80.0	80.8	79.9	79.8	81.1	81.4	80.3	80.9
	Kompakt	82.3	83.2	80.2	81.7	83.8	83.3	81.7	80.3	80.5	81.9	82.4	81.3	81.9
	Sladko	84.9	84.9	84.0	82.9	84.6	84.8	82.9	80.1	81.1	83.6	83.5	83.3	83.4
	Average	82.9	83.6	82.1	81.7	83.9*	83.3*	81.7	80.3*	81.0	82.1	82.6	82.2	82.3
F	Akcent	80.4	87.0	85.8	78.8	84.3	91.4	79.0	70.0	88.0	79.4	80.4	88.4	82.7
	Amulet	77.3	83.0	80.8	77.0	87.9	87.2	77.0	77.0	74.0	77.1	82.6	80.7	80.1
	Forum	86.8	91.0	93.5	86.0	85.8	93.3	86.0	89.0	97.0	86.3	88.6	94.6	89.8
	Jubilant	84.5	89.0	91.6	83.5	86.5	90.0	83.0	84.0	89.0	83.7	86.5	90.2	86.8
	Kompakt	88.9	91.0	91.3	87.3	90.0	89.2	87.0	85.0	95.0	87.7	88.7	91.8	89.4
	Sladko	84.8	88.0	88.0	80.8	89.2	90.5	80.0	73.0	91.0	81.9	83.4	89.8	85.0
	Average	83.8	88.2	88.5*	82.2	87.3	90.3*	82.0	79.7	89.0*	82.7	85.0	89.3*	85.7
BG	Akcent	193	149	88	273	259	198	273	291	241	246	233	176	218
	Amulet	140	160	106	278	191	164	278	201	221	232	184	164	193
	Forum	145	79	51	243	241	153	243	267	173	210	196	126	177
	Jubilant	98	108	43	191	184	158	191	214	158	160	169	120	150
	Kompakt	65	59	42	199	149	153	199	151	148	154	120	114	129
	Sladko	123	81	59	285	173	122	285	296	188	231	183	123	179
	Average	127	106	65*	245	200	158*	245	237	188*	206	181	137*	174

Note: * significantly different values. **DP** = diastatic power (WK). **AFA** = apparent final attenuation (%). **F** = friability (%), **BG** = β -glucan content in wort (mg/l).

The values of apparent final attenuation among varieties and cultivation system are not much different. Significant differences were observed among years.

Friability was significantly affected by the cultivation systems but not by the years. The highest values were recorded in ecological cultivation system.

β -glucan content in wort was surprisingly low in ecological cultivation system – 137 mg/l in total average of the trial.

The effect of cultivation system and year was manifested significantly.

In majority of the investigated traits the effect of weather (years) was confirmed and expressed by significant difference between the values obtained. Similar results were achieved also by Ulonska (1960–1962), as mentioned above. These dependences as presented by Prugar and Hraško (1989) are relatively in detail. In our results the effect of different years was not manifested only in friability.

The best malting quality was reached in samples from the ECO system in the years 1996 and 1997. In 1995 only this set showed lower values of extract content and increased values of protein content in barley grain. In survey presented by Prugar and Hraško (1989) greater effect of weather than nitrogen fertilization is emphasized. Here can be also found the importance of weather for good barley quality: early and warm spring, cold May rich in precipitation, drier but cooler weather after cessation of blooming as well as in the time of caryopsis formation and dry in the time of harvest - such weather pattern contributes to the best quality grain production. The year 1995 may be considered good in our experiments, and in view of quality also the year 1996, but not from the viewpoint of the yield.

From the results obtained it is evident that all varieties used in our experiments are of excellent malting quality.

Protein content in barley grain was in most cases close to the required range 10.7% – 11.2%. None of the samples exceeded the

value 11.9% and the value 9.5% or less was reached only by two samples in 1996. Extract content values were on an excellent level in most cases. Only in three samples in the years 1996 and 1997 the value was falling below 81.0%. It is evident from the results that the best values were reached by the varieties Forum, Kompakt and Amulet.

The optimum values of relative extract at 45 °C are within range 36 – 38%. The varieties Amulet and Forum were closest to the present requirements.

The demands on proteolytic break down fell down and now the values around 38 – 42% of Kolbach index are required. All tested varieties had good levels of this trait. None of the used cultivation systems decreased this value significantly.

Generally it can be said that the activity of amylolytic enzymes was on excellent level in all samples. The diastatic power value was only exceptionally below 280 WK (in 1996) and in no case it fell below 220 WK.

Wort composition on average neared to the optimum level, apparent final attenuation fell below the value 80% only in two cases in 1997. The best values were manifested by the varieties Forum and Sladko from INT cultivation system.

Cytolytic solution, characterized by the friability values and the content of β -glucans in wort, was the most affected by the cultivation system in favour of ECO system. Only in six samples the friability values fell below 79.0%. The highest values were reached by the variety Forum. β -glucan content in wort was in 17 samples higher than 200 mg/l from the years 1996 and 1997. The lowest values were obtained by the variety Kompakt. Only in this variety all samples showed β -glucan content in wort lower than 200 mg/l. The ECO system most suited the varieties Forum, Kompakt, Sladko, the least the variety Amulet. In the ECO system the majority of studied varieties reached better results than in other two systems. The quality increased significantly especially in those varieties which showed the worst results in the CR set.

In the INT system the best technological parameters were reached by the varieties Kompakt, Jubilant and Sladko, the worst results were reached by the variety Akcent.

In the CR set of experiments the best technological quality reached the varieties Kompakt, Sladko and Forum, the worst – the variety Amulet. Worse results obtained in the set could be explained by the fact that this set comprised also the sites outside the region suitable for cultivation of malting barleys. It is related particularly to the years 1996 and 1997, when the greater proportion of barley grain samples originated from less favourable regions.

From point of view of malting quality the variety Kompakt was the most successful in all three cultivation systems.

4 Zusammenfassung

Petr, J., Škeřík, J., Psota, V., und Langer, I.: Qualität von Braugerste, die nach verschiedenen Anbaumethoden angebaut wurde — Monatschrift für Brauwissenschaft 53, Nr. 5/6, 90 – 94, 2000

BC 11 Gerste

Über einen Zeitraum von drei Jahren wurden Versuche durchgeführt, um eine Auswahl verschiedener Sommergerstensorten zu untersuchen, die

nach den Grundsätzen des ökologischen Landbaus bzw. mittels herkömmlicher landwirtschaftlicher Techniken (Düngung, Saatgutbehandlung, Herbizide, Fungizide, Insektizide) angebaut wurden. Die Witterungsbedingungen hatten auf die meisten Qualitätsmerkmale einen größeren Einfluß als z.B. Stickstoffdüngung oder Anbausystem. Erhebliche Unterschiede zwischen den verschiedenen Jahren waren beim Proteingehalt im Getreide, Extrakt der VZ 45, Kolbachzahl, der Diastatischen Kraft und des scheinbaren Vergärungsgrades zu verzeichnen. Durch die Anbaumethode wurde im wesentlichen der β -Glucan-Gehalt der Würze beeinflusst, er war erstaunlich niedrig bei der ökologischen Anbaumethode. Die Auswirkungen der Anbaumethode konnten auch im Heißwasserextrakt und teilweise in der Kolbachzahl und im Friabilimeterwert nachgewiesen werden.

Petr, J., Škeřík, J., Psota, V., et Langer, I.: Qualité des orges brassicoles qui ont été emblavées par différentes méthodes de culture — Monatschrift für Brauwissenschaft 53, No. 5/6, 90 – 94, 2000

BC 11 Orge

Sur une durée de trois ans, on a effectué des essais dans le but d'examiner le choix de différentes orges de printemps qui ont été cultivées suivant les bases d'une culture écologique, c'est-à-dire par la mise en oeuvre de techniques agroculturelles traditionnelles (fumure, traitement des semences, herbicides, fongicides insecticides). Les conditions météorologiques avaient une plus grande influence que, par exemple, la fumure azotée ou le système de culture. Des différences importantes ont été observées entre les différentes années au niveau de la teneur en protéines des céréales, extrait de VZ 45, indice Kolbach, pouvoir diastatique et degré d'atténuation apparent. La méthode de culture a influencé essentiellement la teneur en bêta-glucane du moût qui était étonnamment bas pour la méthode de culture écologique. Les conséquences de la méthode de culture pouvaient être identifiées sur l'extrait d'eau chaude et partiellement sur l'indice Kolbach et sur les valeurs du Friabilimètre.

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