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THE MALT EXTRACT, RELATIVE EXTRACT AND DIASTATIC POWER AS A VARIETAL CHARACTERISTIC OF MALTING BARLEY

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ABSTRACT

Malting quality of barley depends on genetic and agro-ekological factors. Chemical composition of malting barley and its technological parameters are very important for malting and brewing, due to this fact the quality of barley must be strictly evaluated. The aim of this work was to evaluate the influence of variety, locality and year of production on the 5 technological parameters of malt: extract, relative extract at 45 °C, Kolbach index, diastatic power and friability. It was found out that the barley variety significantly influenced the following parameters: extract, relative extract and diastatic power. The growing locality weakly influenced qualitative parameters i.e. Kolbach index and relative extract at 45°C. The study confirmed the most significant impact of the year on the Kolbach index and friability.

Keywords: malting barley, variety, locality, year, malt parameters

INTRODUCTION

Barley is one of the most ubiquitous cereals worldwide. Russia, Canada and European countries are the biggest producers of barley. It prospers particularly in moderate climates on fertile and profound loamy soils with good water diffusion. Of all cultivated grain varieties, barley exhibits the best adaptability and also grows well in cold, rainy climate zones with long daylight periods as at the edge of hot, dry steppes **(Meussdoerffer and Zarnkow, 2009)**. There were produced 134 million tons of barley in 2011 worldwide (http://faostat.fao.org). About two thirds of barley yield is used as feed, one third for malting and about 2% for human consumption **(Newman and Newman, 2006)**. Although, in recent years, there has been a growing interest in incorporating barley into the human diet, the most important use of barley is for malting purposes, most specifically for the brewing industry (**Keenan *et al.*, 2007**). Barley is the major source for brewing malts, which constitute the single most important raw material for beer production. Its chemical composition, brewing, and technological indices are highly determinative for the beer quality and the economical efficiency of the brewing process. Two-row spring and winter varieties are commonly used for malting industry **(Bamforth, 2003; Gupta *et al.*, 2010)**.
Malt quality is directly affected by the quality of barley, which the evaluation is very important for breeders. Based on the fact that the malt is one of the main raw materials for brewing, its quality must be rigorously assessed **(Savin and Molina-Cano, 2002)**. The key factors for a good malting variety of barley are now much more widely accepted and discussed, such that the requirements of the various supply chain partners are incorporated into decisions in developing and evaluating new varieties. In many countries across the world there are formal systems in place to evaluate the suitability of barley for malting. There is, however, a difference in the degree of rigour of the assessment systems and the numbers of varieties screened, but the basic principles are the same: new varieties must be better than existing ones and be proven to be suitable by pilot malting and brewing **(Davies, 2006)**. A rigorous approach to choosing the most appropriate parameters for determining malting quality is a complex task **(Briggs, 1998; Nielsen and Munck, 2003)**. The brewer determines the necessary quality of raw material for each beer type by choosing a barley variety and the malt quality, and therewith the specification of normal and limit values for the malt analytical features. The precision of the analyses as well as the interaction of different parameters should be considered when choosing the analytical criteria. An accurate execution must by guaranteed when determining the results. The Mitteleuropäische Brautechnische Analysenkommission (MEBAK) and the European Brewery Convention (EBC) publish the analyses specification commonly used in Europe **(Zarnkow *et al.*, 2006)**. From the different quality parameters reported in the literature, hot-water extract, kernel size fractions, kernel weight, β-glucan and protein contents, malting losses, friability, α-amylase activity, viscosity, and soluble nitrogen ratio are common assays used to test the quality of barley **(Fox *et al.*, 2003)**.
Long-term monitoring and evaluation of range of malting barley varieties showed a significant influence of variety on several quality parameters. An important varietal characteristic is crude protein content, starch content and the related content of the extract **(Kosař *et al.*, 2000)**. Although malting quality is dependent upon genotype, environmental fluctuations of temperature and rainfall may also have a strong influence **(Eagles *et al.*, 1995; Molina-Cano *et al.*, 1997)**. Under such varying environmental conditions, overall malting quality can occasionally be reduced and superior genotypes are thus more difficult to identify. Nevertheless, genetic fitness to malting is a proviso for commercial quality and must be evaluated leaving out the environmental effects which influence the actual malting quality of each single lot **(Gianinetti *et al.*, 2005)**.
The aim of our study was to analyze malting barley varieties grown at different locations of the Slovak Republic from 2009 to 2011. In this study 5 selected parameters of malt were evaluated which are used for determination of malting barley quality. Based on the results we can conclude which of parameters depend on the variety, growing location or year.

MATERIAL AND METHODS

Barley samples

In the present, study 5 varieties of spring barley *Hordeum vulgare* L. were monitored (Table 1). Samples of the Nitran and the Xanadu were grown as standard malt varieties and samples of the Signum, the IS Carmenta and the IS Castor are newer varieties registered in the Slovak Republic in 2012.
The varieties were grown in the years 2009-2011 in the three different agricultural production areas in the Slovak Republic to compare the impact of different climatic conditions. Sugar beet production area was located in western Slovakia, at an elevation of 188 m. a. s. l., with 30-year average annual temperature 9.7 ° C and the average rainfall of 582 mm. Corn production area was located in western Slovakia, at an elevation of 159 m. a. s. l., with 30-year

average annual temperature 9.3 ° C and the average rainfall of 531 mm. Potato production area is located in eastern Slovakia, at an elevation of 625 m. a. s. l., with 30-year average annual temperature 6.2 ° C and the average rainfall of 612 mm.

Table 1 List of the studied varieties

Variety / Code	Pedigree	Maintainer / Agent in the SR
Nitran SK 5138	KOMPAKT x FORUM	HORDEUM, s. r. o.
Xanadu NORD 00/2310	VISKOSA x SCARLETT	NORDSAAT Saatzuchtgesellschaft mbH Ing. Dušan Briedik
Signum HE 575	HE 8621 C x SEBASTIAN	Limagrain Central Europe Cereals, s.r.o
IS Carmenta SOH 811 IS	BODEGA x KOMPAKT	ISTROPOL SOLARY
IS Castor SOH 812 IS	BOJOS x BETTY	ISTROPOL SOLARY

Micromalting sample

Before analyzing the samples were prepared by malting process. Laboratory malting of samples was carried out based on the standard procedure used in RIBM, which is almost identical to the **MEBAK** methodology **(2011)**. Malting parameters were as follows:
Steeping: 1st day. – 5 hours, 2nd day – 4 hours, 3rd day – spraying or steeping to water content in grain 45.5%. Water and air temperature during the air rests was 14.5 °C.
Germination: total germination time was 144 hours at 14.5 °C.
Kilning: one-floor electrically heated kiln. Total kilning time was 22 hours. Pre-kilnig was carried out at 55 °C and at kilning temperature of 80 °C for 4 hours.

Analyzed parameters of malt

Samples prepared by malting process were subjected to the following analyzes:
Extract (Hot Water Extract) was determined following a small-scale infusion mashing and filtration between EBC Method 4.5.1 **(EBC, 2010)**. *Relative extract at 45 ° C* is the value calculated from the quantity of materials converted by enzymes to soluble form at 45 ° C in proportion to the malt extract. This parameter was determined according to the Brewing and Malting Analytics **(Basařová et al., 1992*)***. *Kolbach index*, the ratio between the total nitrogen content in malt and the content of soluble nitrogen in congress wort was determined by EBC Method 4.9.3 **(EBC, 2010)**. *Diastatic power* was determined by the method EBC 4.12 **(EBC, 2010)**. *Malt friability* was determined by the Method 4.15 EBC **(EBC, 2010)**.

Statistical evaluation

The obtained data were evaluated by analysis of variance followed by the Tukey HSD test. As a source of variability were observed varieties, growing areas and experimental years. Homogeneous groups of the factors are designated by the letters a, b, c. The statistical software STATISTICA 10 (StatSoft, Inc. 2011) was used.

RESULTS AND DISCUSSION

Extract

Malt extract is perhaps the most important quality parameter for maltsters and brewers when selecting or purchasing malting barley. The amount of extract a malting cultivar can produce in the brewhouse will always be of crucial economic importance, as it determines the amount of beer that can be produced. As a consequence, malt extract is also a major focus of breeding programs. Breeders, maltsters, and brewers are all striving to achieve high extract **(Li *et al*., 2008)**. According to **Fox *et al.* (2003)** the quality of the extract is influenced by several factors. The first is environmental, such as growing conditions, temperature, fertilizer, available nitrogen, or moisture. These factors do not impact on extract directly but rather affect traits that influence extract particularly protein and starch levels and composition. The second is several genetic biochemical components that influence the final level of extract. These include 2- or 6-row types, husk thickness, grain size, protein, starch, non-starch polysaccharides and enzyme production. The other important factors that influence extract are the malting process and mashing conditions (pH, temperature, mash time, grist/particle size etc).

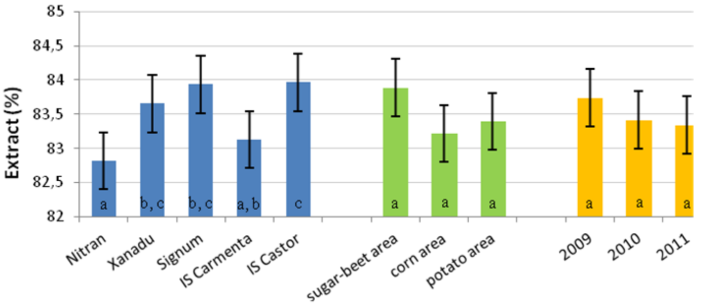

Figure 1 Average values of malt extract in evaluated varieties, localities and years with homogenous groups and confidence intervals 95 %

Kaczmarek *et al.* (1999) reported that the extract had mainly genetic effect, but it was also influenced by the crop and environmental conditions. The results of our work confirm the significant influence of the variety on the extract value. Also, **Eagles *et al.* (1995)** in their work confirm the high significant effect (P <0.01) of the variety on the extract content. The Nitran variety with an average extract 82.8% is highly significantly differed (P <0.01) from the IS Castor variety with the highest average extract 83.9%. As can be seen in figure 1, in years 2009, 2010 and 2011 average values were on similar level and the influence of year on the extract content was not confirmed.

Relative extract at 45 °C

The relative extract (RE) at 45 ° C is used at present to assess the quality of malt **(Chejn and Zajpt, 2007)**. Despite the fact that some works noted on its low informative value **(Kessler *et al.*, 2005)**, other authors point to a significant relationship between the relative extract and deciphering grain malt **(Basařová, 1992; Kunze, 2004)** because it refers to the activity of proteolytic and cytolytic enzymes and it is a measure of the level of cracking the malted grains **(Grujić et al., 2009)**.

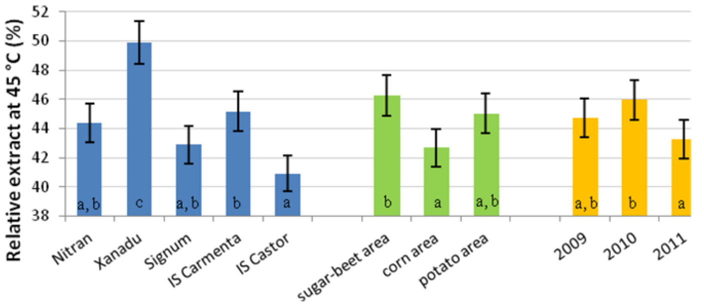

Figure 2 Average values of relative extract at 45 °C in evaluated varieties, localities and years with homogenous groups and confidence intervals 95 %

The average values of all monitored varieties ranged in optimal limit, which is according to **Psota and Kosař (2002)** 40 to 48 % . The highest level of proteolytic modification of malt had the Xanadu variety with an average value of 49.9 %. Analysis of the RE 45 ° C confirmed highly statistically significant (P < 0.01) differences between the varieties, the varieties formed three homogeneous groups. **Ogushi *et al.* (2002)** describe the effect of the interaction of variety, locality and year on monitored character. The results of our work confirmed the findings of these authors (Fig. 2). Among all sources of variability variety had the most significant influence (P < 0.01) on the variability of the RE 45 ° C. The monitoring of locality influence on this parameter confirmed its highly statistically significant effect (P < 0.01). Significant difference was observed between corn and sugar beet areas but also in the years 2009-2011 observed (Fig. 2). **Psota *et al.* (2009)** in their study of malting and agronomic characteristics of barley varieties grown for the last 50 years in the RE 45 ° C mainly reflect the impact of the variety and year. Also **Briggs (1998)** indicates the effect of variety and year on this parameter.

Kolbach index

The Kolbach index is an important indicator of protein degradation. According to **Bamforth and Barclay (1993)**, the KI values of malt used in the brewing industry should be in the range of 39-44%. Tested varieties had high values of the KI, ranging from 48.5% (the IS Castor) to 50,7% (the IS Carmenta) demonstrating a high level of proteolytic modification.

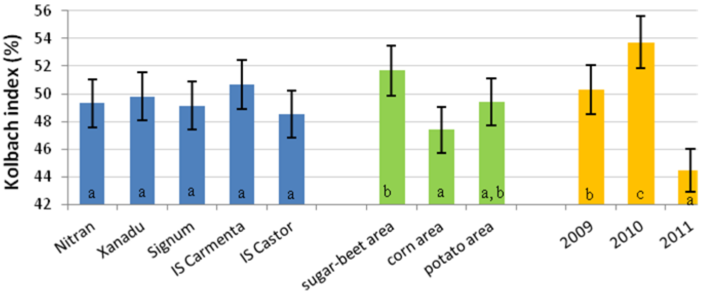

Figure 3 Average values of the Kolbach index in evaluated varieties, localities and years with homogenous groups and confidence intervals 95 %

Based on our results (Fig. 3) we can conclude that between varieties was no significant difference. **Wang *et al.* (2007)** reported that the Kolbach index is associated with a growing area. **Kaczmarek *et al.* (1999)** in their study found a high significant ($P \leq 0.01$) influence of the environment on this parameter. The results of the analysis agree with the arguments of these authors, because the locality had a highly significant influence on the values of this parameter. A highly significant difference ($P < 0.01$) was confirmed between the Corn area containing the lowest average value of the KI (47.4 %) and the sugar beet area with the highest average value of the KI (51.7 %) (Fig. 3). From all tested effects the year had a highly significant influence on the Kolbach index. Our results agree with findings of **Molina-Cano *et al.* (1997)**, who observed a significant ($P < 0.05$) influence of climatic conditions of year on the KI.

Diastatic power

Kreisz (2009) reported that a good malt should reach values of the DP above 200 j WK. Diastatic power values of tested samples as a parameter pointing to the activity of amylolytic enzymes ranged from 270 j. WK to 420 j. WK (Fig. 4).

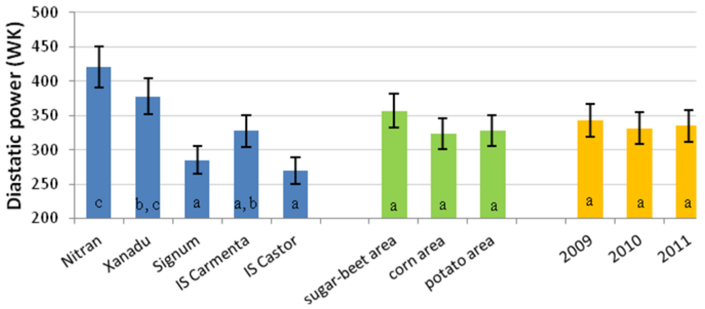

Figure 4 Average values of the Diastatic power in evaluated varieties, localities and years with homogenous groups and confidence intervals 95 %

Eagles *et al.* (1995) describe that the variety has a significant effect on the DP. This statement is confirmed by the results of our analysis, in which ~~a~~ the variety as the only character of variability significantly ($P < 0.01$) participated in the creation of this parameter. Three homogeneous groups with a highly significant different average values were created among the monitored varieties (Fig. 4). The practical results of other authors **(Gibson and Solah, 1995; Arends *et al.*, 1995)** associate variability of the diastatic power with the effect of the locality. Our results did not confirmed the influence of the locality. We can also exclude the influence of year on monitored parameter.

Friability

Friability was used to determine the modification of cell wall of malt grains. Tested genotypes were in the range of 90-92%. The lowest average value was determined for the IS Castor variety, the highest for the Signum variety (Fig. 5).

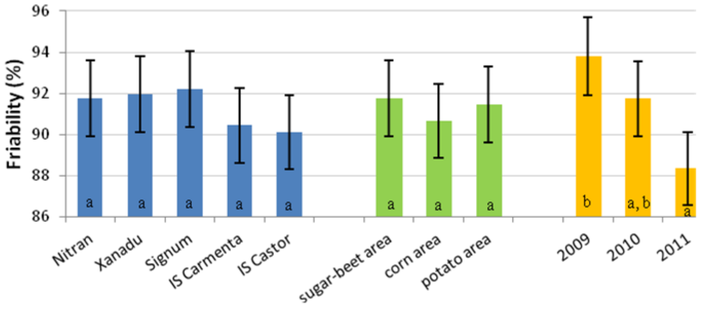

Figure 5 Average values of malt friability in evaluated varieties, localities and years with homogenous groups and confidence intervals 95 %

The results of our work did not confirm the influence of the variety on friability. The average friability values of tested varieties ranged about the same level and statistical analysis did not record significant influence on this parameter. Despite this finding the work of some authors point to the influence of genotype on the variability of friability. **Gianinetti *et al.* (2005)** state that friability is a highly heritable trait. **Edney *et al.* (2012)** point to a highly significant influence of the variety on the level of this parameter. In addition to the genetic influence they determined a highly significant impact of the environment ($P < 0.01$). The average friability values were lower in corn area, but statistic comparison did not confirm significant differences between the tested areas. The year had a highly significant influence ($P < 0.01$) on the cytolytic modification. Among the monitored years, 2011 was characterized by the lowest value of this parameter (88.4 %). A highly significant difference was confirmed between 2009 and 2011.

CONCLUSION

In the present study we found out that among five analyzed parameters of malt 3 were significantly affected by the variety, namely: extract, the relative extract at 45 ° C and the diastatic power. The diastatic power was shown as the most important varietal characteristic parameter, in which the influence of year and locality appeared to be negligible. The Kolbach index and friability were strongly affected by the year.

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