# Malting quality indicators of Croatian dual-purpose barley varieties

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## Summary

Malting barley varieties usually demand higher expences than feed varieties, at least as far as management practice is concerned. For this reason, many growers in Croatia search for a quality replacement of malting varieties. Croatian market allows dual-purpose varieties, but strict quality parameters have to be met in order for a variety to be recognized as a malting/feed variety. The aim of this research was to preliminary assess the malting quality of several malting, feed and multipurpose (dual or combined) malting/feed barley varieties. 11 barley varieties were grown in Osijek area during 2011: seven malting/feed (M/F), two malting (M) and two feed barley varieties (F). The suitability for the beer production was assessed according to the malting quality indicators, determined by using standard methods of analytica EBC (European Brewing Convention). As expected, both malting varieties (Vanessa and Tiffany) demonstrated the best malting quality parameters. Most of the combined malting/feed varieties were within recommended values, except Maxim, Lukas and Gazda, which showed the lowest results in friability. Considering that the results were collected and evaluated over a period of one year, this study was taken as a good pointer to future, longer lasting investigations.

*Keywords:* dual-purpose barley, malting, quality indicators

## Introduction

A traditional raw material for malting and beer production is barley. About 2/3 of barley production is used for animal feed, mostly cattle and pigs, and barley grown for malting (beer and whiskey) currently takes up second largest place in the market (Kumlehn and Stein, 2014; Oser, 2015). The intended end use, in respect to their characteristics, ultimately defines barley varieties in Croatia as: 'malting' (M), 'feed' (F) or 'malting/feed' (M/F). The entry into the European Union (EU) has opened Croatian market to malting barley varieties originating from EU countries. Since malting and brewing industries set up strict requirements for a variety to be declared as malting, it takes strenuous work to select desirable traits in order for a variety to meet those requirements. Because it takes a long time to select, establish and maintain competitiveness on the European market with new domestic malting varieties, the Croatian Varietal Commission has allowed a dual-purpose labelling of varieties that were primarily registered as livestock feed. Dual-purpose varieties have higher yields with less intensive management practices (irrigation, fertility amendments, the implementation of pest/pathogen mitigation strategies etc.) in comparison to malting barley varieties (Oser, 2015; Krstanović et al., 2016). This makes them more attractive to barley growers. For brewers, brewing yield and efficiency are most important, and malts with high extract values, high enzymic activities and good modification are highly desirable (Woonton et al., 2005).

Barley and malt, suitable for malting and brewing, are analyzed according to MEBAK (Middle European Brewing Analysis Commission) or EBC (European Brewery Convention) methods. Quality protocols described in these analiticas are very similar and it is just a matter of analyzers' preference which one will be used.

For a variety to be accepted as M/F (combined, dual- or multi-purpose), some of the main quality parameters have to be met, such as protein content, β-glucan content, Kolbach index, malt extract, extract difference, etc. (Krstanović et al., 2016). High quality malt requires high quality barley as a raw material. Strict limits are set for maltsters, in order to obtain high quality malt. Some of the basic quality properties for malting barley are shown in Table 1.

Protein content <11% is a crucial indicator of barley quality, because higher protein content causes heighten soluble proteins content in wort which leads to off flavours in finished beer. Protein content correlates with low carbohydrate levels and lower extract values (Bishop, 1930). However, if the protein content in malt is too low, brewing process may be affected because of the poor yeast amino acid nutrition. Protein levels are also important in packaged beer and positively influence the foam stability. On the down side, they shorten the shelf life of beer by contributing to chill hazes (Fox et al., 2003).

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**Table 1.** Some malt quality indicators (modified from Kunze, 2010)

| Quality indicator | Recommended values |
|---|---|
| Protein content | < 10.8% |
| Kolbach index | 38 – 34 % |
| Extract content | > 82% |
| Extract difference | 1.2 – 1.8 % |
| Viscosity | < 1.55 mPas |
| β-glucan in wort | < 300 mg/L |
| Wort color | < 3.4 EBC |
| Friability | > 87% |

β-glucans are not desirable compounds in cereals intended for malting and brewing, but in small amounts they can contribute to beer foam stability and improve beer organoleptic properties, flavour and aroma (Collins et al., 2003; Havlová et al., 2006). In general, when present in higher amounts, they can cause poor mash conversion and the increase of wort viscosity (Sadosky et al., 2002). β-glucans form gel and cause process problems during the filtration process (Vis and Lorenz, 1998; Evans et al., 1999; Wang et al., 2004). For that reason, barley with β-glucan content <4 g/100 g d.m. (EBC, 1998) is suitable for malt production. According to Marić (2000), β-glucan content in malt should range from 2.58 to 4.87 g/100 g d.m., and for wort recommended values should be <300 mg/L (Kunze, 2010). In many cases, wort viscosity is influenced by small proportions (<5%) of water sensitive grains which fail to germinate properly, as well as by the overall degree of endosperm modification (Bathgate, 1983; Bryce et al., 2010). Such grains cause more problems than dead grains which fail to germinate at all. The friabilimeter allows quick and accurate determination of whole vitreous grains in a malt sample (Bathgate, 1983). Kolbach index represents level of protein degradation, and optimal values range from 38 – 42 %. Malt extract is a basic indicator of malting procedure efficiancy, representing all water-soluble compounds that transfer into wort during mashing (MEBAK, 1997), and is the most important trait when selecting potential new malting varieties (Collins et al., 2003). Malt extract can be influenced by several factors, such as growing conditions, temperature, fertiliser, available nitrogen and moisture. These factors, however, indirectly affect malt extract levels, because they directly inluence protein and starch levels and composition (Fox et al., 2003). Extract difference is an indicator of endosperm cell walls degradation. High quality malt has an extract difference between 1.20 – 1.80 % (Kunze, 2010). Wort colour is always measured, because it gives information on the malt type. However, practice has shown that it has no influence on the final beer colour (Kunze, 2010), and as such, has no actual value to the brewer in predicting the colour of beer (Siegfried, 1955; Bremner, 1963). Normal values for pale malts go up to 4 EBC units (Kunze, 1999).

This investigation included 11 barley varieties: 7 are declared as multipurpose and 2 feed varieties, originating from the Agricultural Institute Osijek. 2 malting varieties, Tiffany and Vanessa, are German malting varieties used as control. All varieties were grown at Osijek location. The aim of this work was to analyse some of the malting quality indicators of the chosen varieties and to asses which of multipurpose or feed varieties can be used for malting.

## Materials and methods

Multipurpose varieties used in this research were: Rex, Barun, Maxim, Premium, Lukas, Maestro, Trenk, Lord, Merkur and Gazda. Feed varieties were: Bingo and Bravo, and malting varieties were Tifanny and Vanessa. Barley samples were obtained from the Agricultural Institute Osijek. Samples of 11 different varieties were collected in 2011 from the variety trials of the Agricultural Institute Osijek. Barley varieties were grown under field conditions at location Osijek (OS). The experiments were conducted in randomized block designs (RCBD) with six replications; plot size was 7.56 $m^2$. Sampling (5 kg per sample) was performed on the cleaned and processed barley grains (EBC 3.3.1.), and samples were kept refrigerated in dry containers.

Micromalting was performed in an Automated Joe White Malting Systems Micro-malting Unit (Perth, Australia).

### *Standard malt analyses*

Malt analyses (total proteins, malt extract, extract difference, soluble proteins, friability, wort viscosity, Kolbach index, malt colour) were performed at Agricultural Institute Osijek. Malts were ground using a Bühler Universal Laboratory Disc Mill (DLFU type) with the gap between grinding discs set at 0.2 mm. Total proteins (EBC method 4.3.1), corresponding extract (EBC method 4.5.1), extract difference (EBC method 4.5.2), soluble proteins (EBC method 4.9.1), friability (EBC method 4.15), wort viscosity (EBC method 4.8), Kolbach index (EBC methods 4.3.1 and 4.9.1), and malt colour (EBC method 4.7.1) were determined according to the European Brewery Convention methods (ANALYTICA-EBC, 1998).

### *Determination of the total β-glucan content*

Firstly, the barley samples were milled using a standard laboratory mill with a 1 mm sieve (MF10.2 basic, IKA Labortechnik, Germany), and after that using a kitchen coffee grinder (Braun KMM 10). The ground samples were kept in the sealed plastic bags until the enzymatic determination of total β-glucan content (AOAC, 1995) using a commercial assay kit (Mixed linkage β-glucan assay kit, Megazyme Int., Bray, Ireland).

## Results and discussion

Feed varieties that show good quality indicators in accordance with malting requirements, such as low protein content, good grain friability, etc., can be used as malting varieties and declared as malting/feed. In general, feed varieties show off better yields, which ultimately suits growers. In this research, some quality indicators showed good values, which leads to a conclusion that some multi-purpose varieties can be declared as malting ones.

Since protein content has a deep impact on the malt quality, maltsters stick to the recommendation that desirable protein content for malting and brewing is below 10.80%. Although some literature references allow protein content 8.0 – 15.0 % (Gupta et al., 2010), majority of maltsters tolerate protein content between 9.5 – 12.0 % (Oser, 2015). High protein content can reduce the availability of carbohydrates, negatively influencing the brewing process (Peltonen et al., 1994; Fox et al., 2002; Fox et al., 2003; Shewry and Ullrich, 2014). According to the protein content in Fig. 1, almost all varieties were above 10%, with Maestro having somewhat lower protein content of just below 10%. Gazda stood out with protein content slightly over 12%.

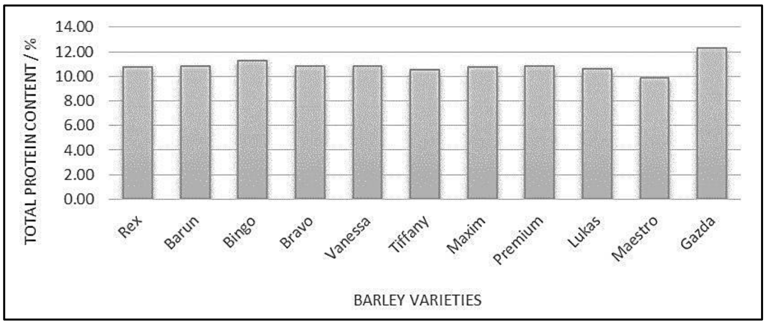


**Fig. 1.** Total protein content of barley malt

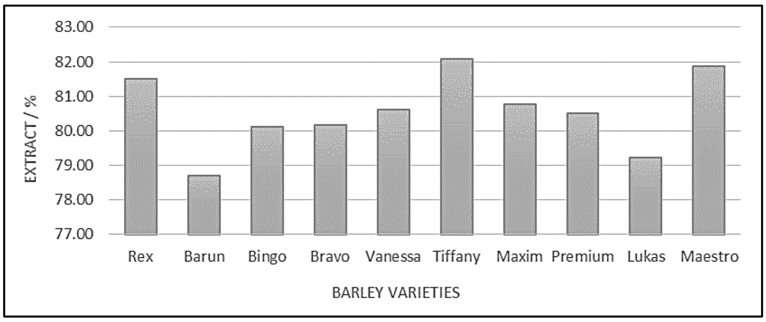


**Fig. 2.** Extract content of barley malt

Extract content is an economic indicator of the malting process efficiency and the overall grain quality. Malt extract represents all water-soluble ingredients, fermentable and non-fermentable (simple sugars, dextrins, amino acids, and proteins), which transfer into wort during mashing. Indicator of high quality malt is malt extract >80%. Barun and Lukas had the lowest proportion of malt extract, below 80% (Fig. 2). All other varieties showed good values for malt extract, amounting over 80%.

Extract difference (difference between fine (F) and coarse (C) grinding) is an indicator of endosperm cell walls degradation efficiency. High quality malt has extract difference values <1.80%, whilst extract difference >1.80% defines malt as malt of a moderate quality (Kunze, 1999). Extract difference results are shown in Fig. 3. Extract difference values for all varieties were higher than specified, and only Bravo showed somewhat acceptable F/C difference of 2%.

Higher protein content affects the increase of soluble nitrogen as proteins represent a substrate for proteolysis. The content of soluble proteins in the malt must not be too high, because it causes process problems in breweries and disrupts the sensory quality of beer. Bamforth and Barclay (1993) advise nitrogen content in six-row malting barley to be between 1.8 - 2.0 %. However, in order to carry out a successful fermentation process, yeasts need nitrogen. Low nitrogen levels can disrupt the fermentation process (Shewry and Ullrich, 2014). The lowest soluble protein values were observed in malting/feed variety Maxim (3.97%) (Fig. 4). Tiffany showed relatively high soluble protein values in regard to Vanessa considering that total protein content did not differ as much.

Malt friability values are also important indicators of malt quality and should be >80%. In this study (Fig. 5), five varieties met this requirement (Rex, Bravo, Vanessa, Tiffany, Premium and Maestro). However, Vanessa and Tiffany showed the best results.

Fig. 6 shows viscosity of wort obtained from the chosen barley malts. A viscosity value less than 1.53 mPas represents a very good level of degradation, while higher than 1.68 mPas indicates a weak degradation level. Best wort viscosities in this study were shown by Rex, Premium and Maestro, all M/F varieties.

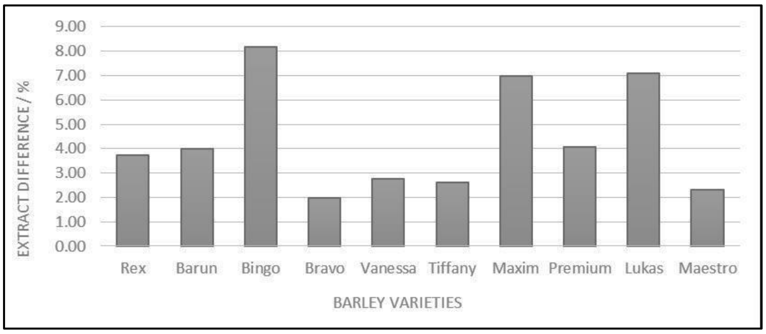


**Fig. 3.** Extract difference of barley malt

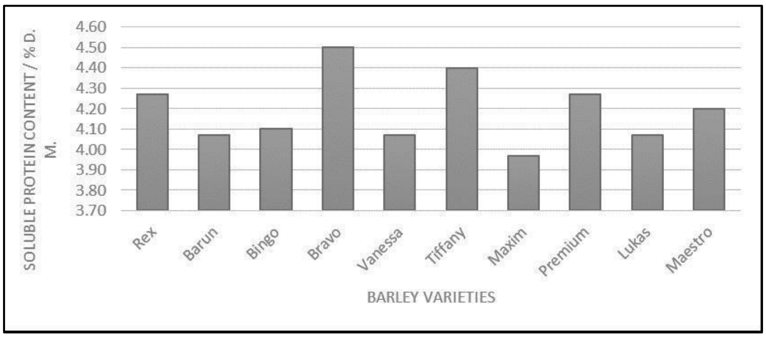


**Fig. 4.** Soluble protein content in barley malt

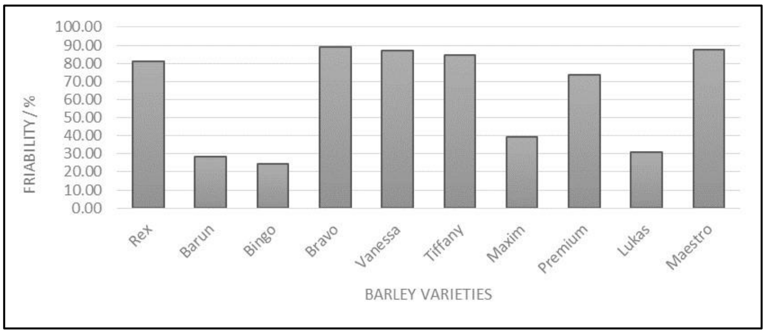


**Fig. 5.** Friability of barley malt

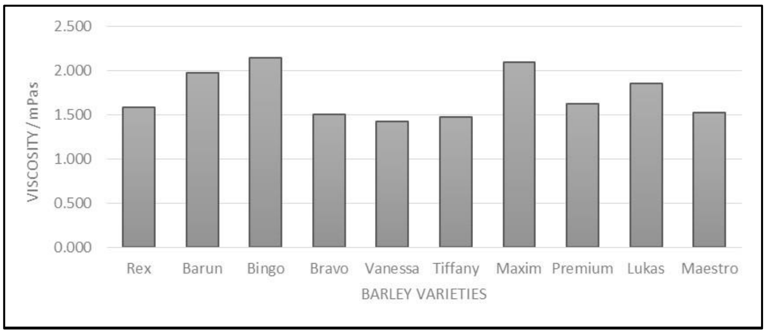


**Fig. 6.** Viscosity of wort

Fig. 7 shows the Kolbach index values for the chosen samples. Kolbach index represents the degree of protein degradation in the malt grain. Desirable values for beer making range from 35 to 41 % (Kunze, 1999). During this investigation all varieties showed good Kolbach index values amounting over 35%. When compared to Vanessa, Tiffany showed better value for Kolbach. Bravo was the best feed variety with Kolbach index over 41% and Maestro, an M/F variety showed the highest result amounting over 42%.

Results shown in Fig. 8 are going over 4 EBC units, and this indicates that all malt samples analysed in this study can be included into medium coloured malts group with 5 – 8 EBC units. Since wort colour is not a reliable indicator of beer colour, heighten values of this indicator do not mean that the beer will appear darker.

β-glucan content of barley is an important indicator for a malt quality, since these compounds, if not degraded during malting, can cause trouble during lautering and filtration phases. Recommended values for the β-glucan content for barley range 2.58 – 4.87 g/100 g d. m. Almost all varieties were inside these limits, except feed variety Bravo (5.22 g/100 g d. m.), and Maestro and Trenk were left out of this analysis because of lack of samples (Fig. 9). The obtained results are in accordance with the results of Krstanović et al. (2016) reported on the β-glucan content in the same multipurpose varieties over the coming two years, 2012 and 2013, on several locations: Osijek, Slavonski Brod and Tovarnik.

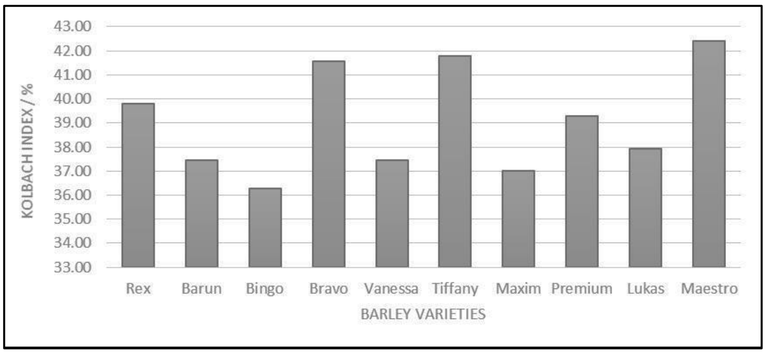


**Fig. 7.** Kolbach index of barley malt

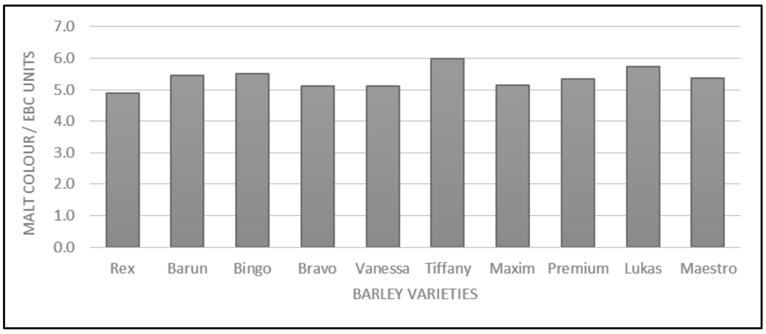


**Fig. 8.** Wort colour

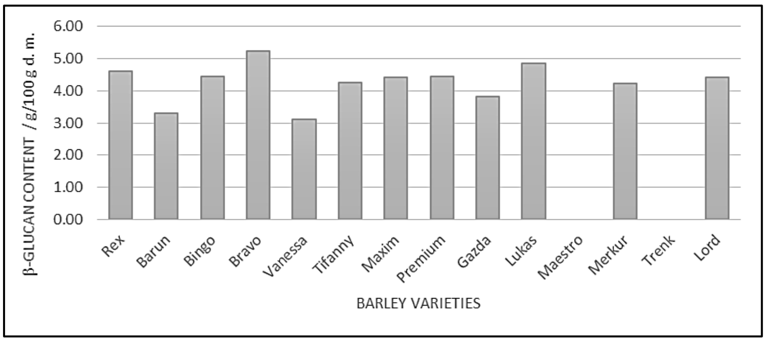


**Fig. 9.** β-glucan content in barley

## Conclusions

2011 was a starting year for this investigation. The preliminary results obtained from this research directed us to further investigations concerning this topic (data not published yet). Overall results of malt quality indicators for 2011 suggest that all varieties had satisfactory protein and soluble protein content. Also, extract values and Kolbach index were satisfactory for all varieties. However, according to some indicators, such as Kolbach index, friability, viscosity and wort colour, some varieties showed off better than the others; malting/brewing varieties, Rex and Maestro showed a high malting quality, and Bravo, a feed variety also proved to be suitable for malting and could be declared as M/F variety. Additional studies should be conducted, since the effect of soil type, agro-climatic conditions and management practice can change over the years and significantly influence the selected malting indicators.

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