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# Changes in the Beer Wort in Partial Substitution of Barley Malt with Malted Einkorn

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Running title: **Beer Wort with Barley Malt and Malted Einkorn**

**Abstract**
The current experiment has examined the changes in the basic quality parameters of the malt mash and the wort, obtained using different ratios of malted einkorn and barley malt between 0 and 50%. A standard method of EBC and analytical methods generally accepted in the brewing practice have been applied during the mashing. Minor amendments of the wort extract content but significant difficulties in the starch saccharification have been experimentally established while increasing the share of the malted einkorn within the total malt grist. Growth in the dynamic viscosity, decrease in the content of the alpha-amino nitrogen as well as loss of the wort color have been also determined under the same conditions. As a result of the experiments, a serious deterioration in the quality characteristics of the wort has been observed while using more than 25% malted einkorn.

**Practical applications**
As a result of the study is practically established the possibility for application of malted einkorn in the production of special lager beer. The boundaries of the optimal technological parameters to the incorporation of the raw material were marked. Created the basis for new and extensive researches on the application of the raw materials under real semi manufacturing conditions.

**Key words:** malt, einkorn, triticum, wort, mashing

## Introduction

The einkorn is known as one of the oldest foods used by human. This is a type of wheat in one of its earliest cultivated forms, proof of which was found in a number of historical studies. The einkorn is a cereal of the genus Triticum, with a species name Triticum monococcum (Hidalgo et al., 2013). The einkorn often refers to wild wheat varieties. It grows on unpretentious soils and it usually does not need fertilizing, weed and pest control. The grain, well protected by four glumes, is not attacked by insects and is resistant to fungal diseases. It does not absorb any harmful substances from the soil such as heavy metals. This is a property of the modern varieties and is an increasing problem in the up-to-date industrial world.

Due to its suitable chemical composition, the einkorn is used in a large number of areas in the food industry (Hidalgo et al., 2016).

The einkorn has a high content of polyphenols and carotenoids, and respectively high antioxidant capacity compared to some hybrid wheat varieties **(Fogarasi et al., 1983)**. According to some scientists (Pizzutia et al., 2006), the einkorn gliadin protein does not cause allergic reactions in people suffering from celiac disease. The einkorn contains gluten, but it is different from most of the wheat types. Therefore, it is often applied to a gluten-free diet. In spite of eliciting weaker toxic reactions than other Triticum species, einkorn is not suitable for coeliacs. In spite of eliciting weaker toxic reactions than other Triticum species, einkorn is not suitable for coeliacs (Hidalgo et al., 2013). According to Mohammadkhani et al., (1998), the amylose content varies between 15 and 28%.

The application of wheat and wheat malt in Beer production itself is known for a long time. Initially, the use of unmalted wheat has been widely spread, but with the improvement of malting, the use of wheat malt has been progresively introduced and it contributes to the characteristic types of wheat beer in Germany and Belgium (Hieronymus, 2010). The usage of einkorn in beer production, however, is strongly limited and almost unexplored. The changes in the einkorn and the obtained wort, within malting also remains unclear.

The aim of the current study is monitoring the change in the main quality indicators of the mash and the wort in partial and gradual substitution of barley malt with malted einkorn and laboratoritory mashing under a standart method of EBC.

## Materials and methods

### *Materials*

*Cereal raw materials*

The experiments have been carried out using two types of basic grain materials-light barley malt and malted einkorn. The barley malt originates from Austria, and the einkorn is produced in Bulgaria. The subsequent process of malting has been held in the Czech Republic.

The laboratory data of the barley malt analysis are presented in **Table 1**.

**Table 1.** Characteristic of barley malt

| Parameter | Unit | Result |
|---|---|---|
| Moisture | % | 5,71 |
| Saccharification time | min | 15 ÷ 20 |
| Hartong index 45°C | | 37,60 |
| Extract content a.d.w. | % | 83,22 |
| Extract difference | % | 1,43 |
| pH | | 5,86 |
| Color of wort | EBC | 4,83 |
| Viscosity of wort 8,6°P | mPa.s | 1,48 |
| Total protein | % | 10,20 |
| Diastatic power | W.K. | 259,00 |
| Kolbach index | | 41,00 |
| α-amino nitrogen | $mg/dm^3$ | 201,27 |
| α-amylase activity | U/g | 175,00 |
| β-glucans | $mg/dm^3$ | 187,00 |

### *Staging of the experience*

The study has been conducted using a laboratory mashing and subsequent analysing of the mash and the wort, obtained from variants with partial and gradual replacement of the barley malt with malted einkorn. The substitution of the malt varies between 5% and 50%, and as a control a sample without portion of malted einkorn is used, i.e. 100% barley malt. The grinding of the malt has been finely made using a laboratory disk mill Buhler Miag DLFU.

Since the study is related to the quality parameters of the wort, a standard method of mashing of EBC, presented on **Figure 1** has been used in the experiment. The method is universal for such type of analysis and allows obtaining comparable

results. The water used for sample mixing is demineralized.

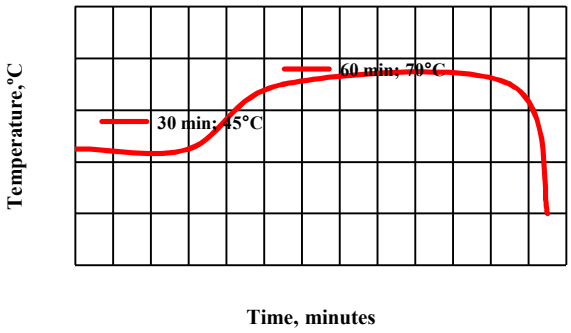


**Figure 1.** Standart mashing method of EBC

Mashing was conducted within a laboratory mash aparatus Lochner LB-8 with a high degree of automation, which allows a precise achievement of the specified mode of mashing.

***Analytical methods***

The determinating and analysing of all the technological parameters of the resulting malt mash and wort have been carried out using generally accepted analytical methods of the European Brewery Convention (EBC-Analytica, 2005).

**Results and discussion**

At the initial stage of the experiments, the saccharification time of the malt mash varies within quite normal and usual values of approximately 10 - 15 minutes due to the predominant amount of barley malt. In the course of the experiments, however, the gradual growth in the values of the indicator has been noted, as it can be observed from the data in **Table 2**. This change has been emphasized in the sample with malted einkorn portion of 30%.

**Table 2.** Saccharification time of mash

| *Variant* | *Saccharification time, min* |
|---|---|
| 0% ME : 100% BM | 10 – 15 |
| 5% ME : 95% BM | 10 – 15 |
| 10% ME : 90% BM | 10 – 15 |
| 15% ME : 85% BM | 10 – 15 |
| 20% ME : 80% BM | 10 – 15 |
| 25% ME : 75% BM | 10 – 15 |
| 30% ME : 70% BM | 15 – 20 |
| 35% ME : 65% BM | 20 – 25 |
| 40% ME : 60% BM | 20 – 25 |
| 45% ME : 55% BM | 20 – 25 |
| 50% ME : 50% BM | 25 – 30 |

It is obvious that there is a deficient amylose enzyme activity, which defines the hydrolysis of the starch, and this tendency is supported by the studies of Marinova et al. (2014). Subsequently, the growing share of the malted einkorn strengthens the negative trend towards difficulties in the saccharification of the mash with time of 25-30 minutes in samples with 50% ratio of the raw materials which is considered as unacceptable.

In regard with one of the most important technological parameters of the wort, namely its extract content, the obtained results do not show any indications towards significant changes with the increase of the malted einkorn portion. The data are shown in **Figure 2**.

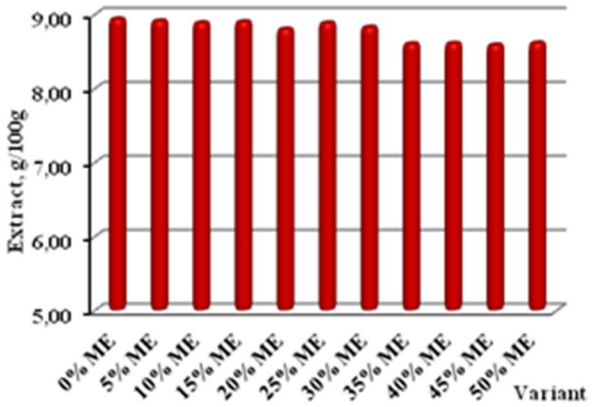


**Figure 2.** Changes of extract content of the wort

The changes in the extract values varies between 8,94% and 8,62% within the whole range of the trials. It is important to be noted that using malted einkorn there is no presence of flakes, which characterizes the barley malt. This should lead to an increase in the extract within the growth of the share of the malted einkorn, but in practice, the results show just the opposite. Obviously, this is largely due to the weak amylolitic enzyme activity of the malted einkorn, the incomplete starch hydrolysis and its poor utilization.

This fact largely influences another significant indicator, namely the dynamic viscosity of the wort. It is well known that this indicator is directly related to the malt mash filtration speed. As demonstrated from the data presented in **Figure 3**, the values of the indicator follows persistent trend of growing.

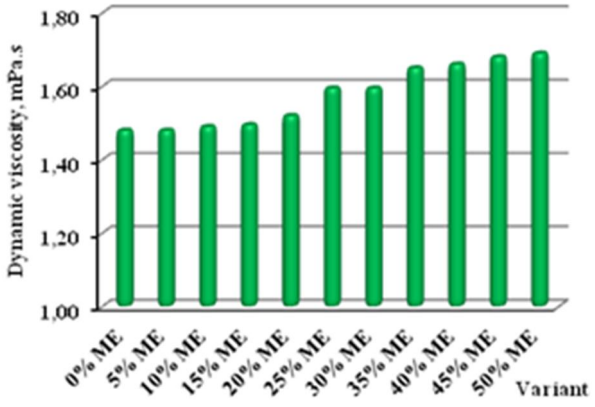


**Figure 3.** Changes of dynamic viscosity of the wort

When substituting the barley malt up to 25%, a significant deterioration of the dynamic viscosity has not been observed and its values linger at around 1,50 mPa. s i.e. as usual. However, together with the growing share of the malted einkornt, a negative trend towards deterioration of the viscosity has been noticed. The indicator accepts value of 1,69 mPa in the sample with 50% participation of the malted einkorn. It has already been considered as an inadequate value, and difficulties in the filteration of the malt mash may be expected using such proportion of the raw materials. This problem can be particularly emphasized due to the lack of flakes in malted einkorn. Their absence leads to poorly structured malt clums with poor permeability.

The results of the analysis of the wort regarding the concentration of α-amino acids also show a negative trend. Data presented on **Figure 4** shows that the increasing share of the malted einkorn in total malt grist leads to a gradual decrease in the content of α-amino nitrogen..

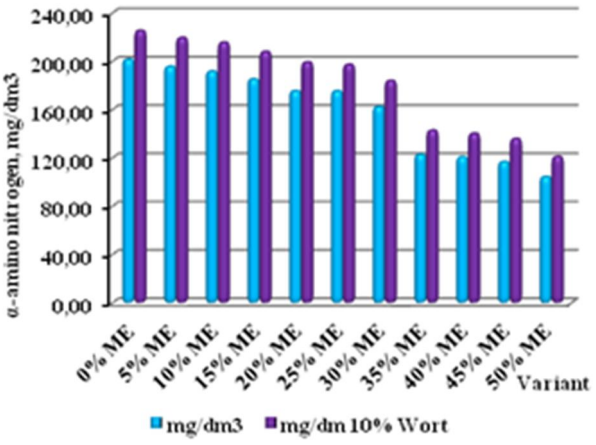


**Figure 4.** Changes of α-amino nitrogen

Despite the steady trend in declining of α-amino acids, it should be noted that the obtained values are relatively good. This is largely due to the high quality of the barley malt, as well as the high content of general proteins in the malted einkorn that exceeds 15%.

The most significant decrease in the values of the index have been observed when the malt einkorn share is up to 35%. For this reason, these and even higher ratio has to be considered and even avoided. When using a low-quality barley malt, the negative effects would be even more emphasized.

Since the use of wheat and / or varieties of wheat often leads to a reduction in the wort color, the index has been determined in all experimental variants. The results are presented in **Figure 5**.

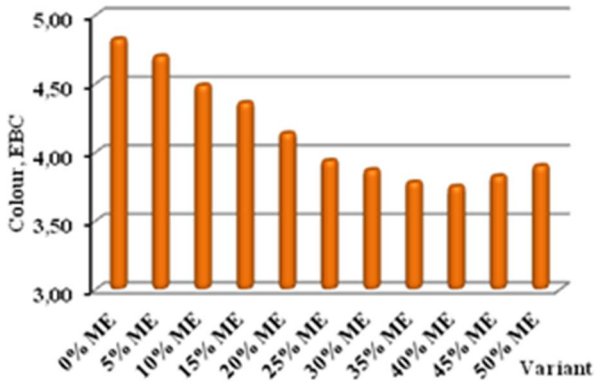


**Figure 5.** Changes of colour of the wort

Although the data shows a steady reduction in the color of the wort, the values of the indicator are relatively acceptable. It is obvious that despite the conducted malting of the einkorn and its subsequent drying, there has been no significant change in the color.

However, when the share of the malted einkorn is over 25% some negative effects can appear, especially in combination with barley malt with a lighter colour than the one used in the experiments.

**Conclusion**

The study has been conducted using a standard method of mashing, as the objective is to establish the influence of malted einkorn on the most important quality indicators of laboratory wort.

Some changes in the key wort indicators have been experimentally established at gradually increasing participation of the malted einkorn in the total mash.

The following conclusions can be highlighted based on the carried out experiments:

1. The application of malted einkorn in mashing using a standard method of EBC does not lead to a significant change in the wort extract content, despite the lack of flakes in the einkorn. An insufficient amylolytic enzyme activity has been observed, which was proved by gradually increasing of the time for saccharification. The deterioration of the indicators has been most distinct when the share of the malted einkorn is over 25%.

2. Within the increasing share of the malted einkorn of over 25% of the total malt grist, undesired growth in the dynamic viscosity of the wort has been observed. This fact, together with the lack of flakes in the malted einkorn could lead to undesired delay and obstruction of the filtration of the malt mash in real production conditions.

3. A decrease in α-amino nitrogen has been observed, despite the higher content of proteins in the malted einkorn. It is possible a decreased activity of the amino and carboxypeptidase of the malt to appear.

Similar tendency toward a decrease can be noticed in the wort color. The negative effect in these indicators is particularly noticeable in einkorn participation of over 30%. It is generally recommended to add not more than 25% to 30% malted einkorn under the particular conditions of the experiment.

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