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Impact of malt quality parameters on beer filtration optimization process

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Filtration optimization process needs developing a strategy based on observations, empirical determinations, and continuous monitoring in order to ensure efficient filter operation. This objective will be reached by identifying critical malt parameters which will influence filtration efficiency. Yeast and components that came from malt dominate the filtration process. The biggest case of concern, since they are more difficult to remove than yeast, are thenon-microbial particles. Malt is also responsible for the major part of enzymes that impact on beer and wort filterability. Experiments were carried out in pilot and industrial scale. Proteins and polyphenols dominate the filtration process, but if we use filter-aids and centrifugation, carbohydrates will dominate the filtration characteristics. More important carbohydrates include: unmodified starch, dextrins, pentosans and β-glucans. Carbohydrates that have a significant impact on filtration were tested using enzymatic techniques for three different beers.

Keywords: Beer filterability, Enzymes, Malt quality, Stabilization, Yeast.

INTRODUCTION

Mashing is a key step in the beer production process. During mashing, enzymatic degradation of the polysaccharides present in the malt takes place. Fermentable carbohydrates are produced from the degradation of the polysaccharide starch. Such carbohydrates are converted into alcohol in the fermentation step of beer manufacturing. [1], [2]
Nonstarch polysaccharides also degrade during mashing into smaller-chain carbohydrates. Different enzymes catalyze all the involved reactions. Because the activity of the different enzymes is highly dependent on temperature, the manipulation of such variable is the main control mechanism for the mashing process [10]. Proteins are a very important class of organic components in beer. They are long chains or polymers with large molecular weight composed of amino acids, connected to each other *via* peptide bonds. Quality and sustainability of beer depends on its protein content. Proteins play a very important role in many stages of the brewing process. They are essential in malt and wort production, and also have a direct impact on the consistency and the formation of beer foam. Presence of proteins and their derivatives in wort can be associated with several factors that affect the nutritional value of the liquor, turbidity and colloidal stability, microbial nutrition, formation of by-products during fermentation and foam stability. A special class of proteins is called enzymes. Enzymes are catalysts that accelerate chemical reactions without any changes in character or structure, which play a decisive role in malting and wort production. In beer production, the most important spectrum of enzymes includes amylases, proteases and beta-glucanases [16].Starch fraction that is not properly liquefied (such as beta-glucans and other soluble gums extracted during malting) has poor filtering characteristics as a result of thicker mash. Also there may be problems of turbidity in the finished beer. At the same time, insoluble gum or hemicelluloses, which can hold up to 20 times their weight, are present in wort in variable amounts. This will increase the filter mass resistance. [9], [11]. The boiler is intended to reduce the viscosity of beer and wort, as well as to reduce the filter mass resistance in order to improve the time of circulation during boiling process. The most important enzyme responsible for filtration is beta-glucanase.The purpose of filtration is to preserve the beer so that no visible changes occur in the long run and the beer keeps its original appearance. Generally, the filtration steps fulfill two roles: to remove suspended materials from the green beer (the real filtration) and to unhinge potential turbidity formers (stabilization) [3]. Beta-glucanase acts on maltose rubber substances to improve the viscosity (liquefied wort) and the clarity of the beer. The rubber character of beta-glucan increases the viscosity of the wort and results in poor filtration and poor clarity of wort.

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Beta-glucans tend to dissolve in hot water but are insoluble in cold beer thus contributing to cold turbidity. Consequently, it is necessary to ensure the continued activity of beta-glucanase during mashing, since the release of beta-glucan will continue through the activity of beta-glucan solubilase which is more heat-stable than the malt beta-glucanase which breaks down the beta-glucan structure. [13] The high molecular weight beta-glucans released by beta-glucan solubilase contribute to wort viscosity and poorer extract recovery. Most brewers are very careful in selecting malt with low beta-glucan levels, and beta-glucan degradation occurs during malting. However, most initial mash temperatures are at or above the maximum stability temperature of the malt beta-glucanase enzymes, and it is common practice in many breweries to add exogenous beta-glucanase to decrease wort and beer viscosity and to improve filterability [12]. The objective of this paper is to provide information for identification of potential critical parameters of malt that have a significant impact on beer filterability. Wort production is the most significant process related with the amount of NMP in beer. [14], [15] An understanding of how milling, mashing, mash filtration, boiling and cooling (whirlpool) affect particle formation and removal will allow us to more easily control the process and to achieve a consistent and optimum level of beer particles in wort and beer. [16]

EXPERIMENTAL

This work was performed on "Stefani & Co" brewery (Albania), in pilot and industrial scale. Testing methods were taken from Analytica EBC and Analytica-EBC Microbiologica [7], [8]. The results were statistically analyzed according toAnalytica-EBC, Section 14, Statistics, Method 14.1. The minimum number of experimental trials was eight and each trial was performed in duplicate. In a pilot plant built in the laboratory was measured the maximum filtration volume, the viscosity, the time of filtration of the wort produced from two different types of malt.[4], [5] Low-quality malt and high-quality malt were used and differences were noticed between them. The performance of malt enzymes used in industrial scale for brewery has been studied in 2013, 2014,2015.

RESULTS AND DISCUSSION

Carbohydrates that have a significant impact on filtration were tested using enzymatic techniques for two different beers (Beer A) 100% bad malt beer, (Beer B) 100% good malt beer. The filterability of a beer was represented by the maximal filtrate volume, V_{max} at a given differential pressure. All the worts for these trials were produced by infusion and the enzymes were used one by one [6].

Table 1. Impact of enzymes on beer filterability (n = 8)

Enzymes used in wort production	Carbohydrate attacked	Vmax	
		Beer A	Beer B
Noenzymesused	-	80	120
Alpha-amylase	Starch, oligosaccharides.	100	150
Amyloglucosidase	Dextrins	100	150
Xylanase	Pentosans	130	150
β-glucanase	β-glucans,cellulose, hemicelluloses	180	190
Allenzymes	Manycarbohydrates	260	290

Fig. 1. Pilot scale apparatus and centrifuge used for beer filterability monitoring in experimental scale.

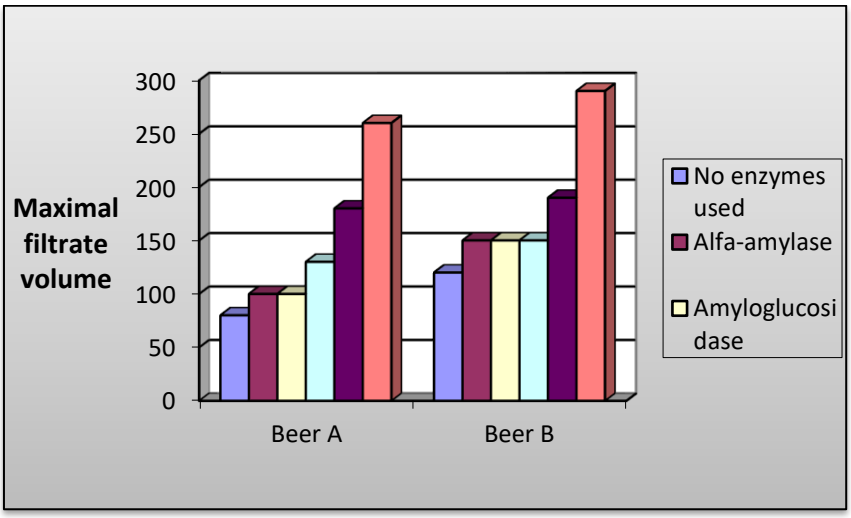

Fig. 2. Impact of enzyme on beer filterability

Figure 1 represents the foto of the pilot scale apparatus used to measure the filterability in laboratory for two tipe of beers. The results of V_{max}, measured in pilot scale for the beer A and beer B using different enzymes are shown in table 1, in all cases the beer B has a V_{max} higher then beer A.

If we compare the performance in beer A and beer B, from figure 2 we notice that in all cases the beer produced from malt with good quality presents a maximal filtrate volume higher than the beer A. In both types of beer the highest maximal filtrate volume is obtained when they are treated with all enzymes and the lowest values - if they are not treated with enzymes. If we compare the impact of each enzyme on beer filterability we see that beta-glucanase presents a maximum filtrate higher than other enzymes in both beers A and B. The most important enzyme responsible for filtration is beta-glucanase, which breaks down the beta-glucan structure. If the large viscous beta-glucan molecules are not broken down during malting or mashing other process problems can also occur: reduced extract recovery, high wort viscosity, poor run off performance, beer filtration problems and beer haze problems.

β-Glucanase enzyme was used in wort and beer during maturation. There were no significant differences between filterability of these beers, but the most important fact was that β-glucanase enzyme used in breweriesalso shortens the mash filtration time in the lautertun filter (Figure 3).

In Figure 4 are given the values of the amount of β-glucanases and amylases in the samples. We notice that there is an oscillation of the amount of β-glucanases. None of the samples exceeds the limit value of 15 to 200 mg/ l. β-glucanase acts on maltose rubber substances to improve viscosity and clarity of beer, however, should not exceed 200mg/l because it causes problems in the production process. Amylases decompose strach into simpler sugars, and the samples we have studied have values that provide a satisfactory transformation of amide.

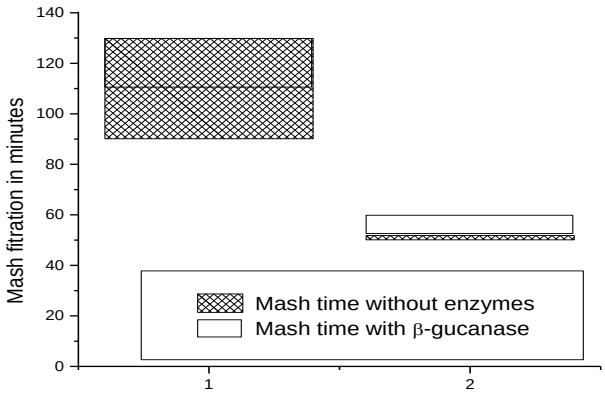

Fig. 3. Impact of enzyme β-glucanase on wort filtration time (n = 18)

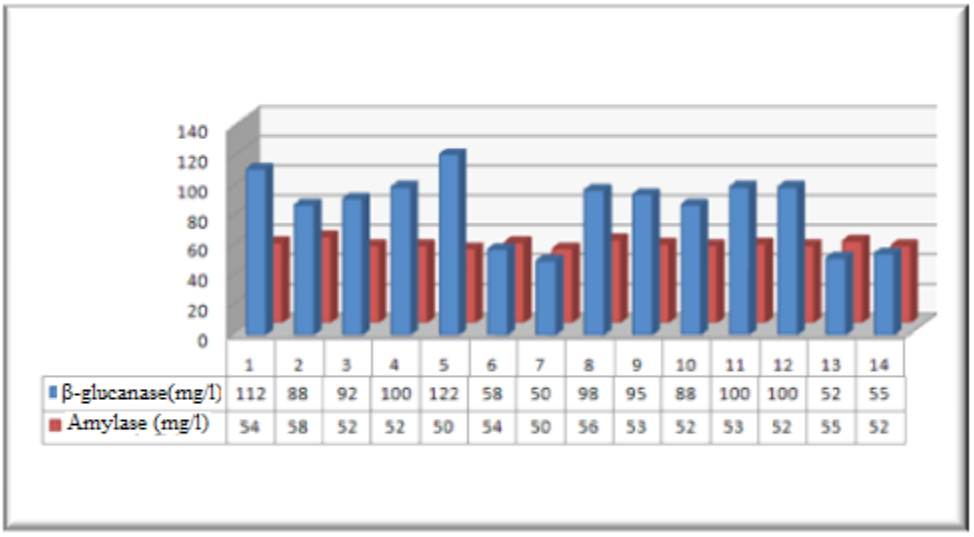

Fig. 4. Values of β-glucanase and amylase in industrial mash.

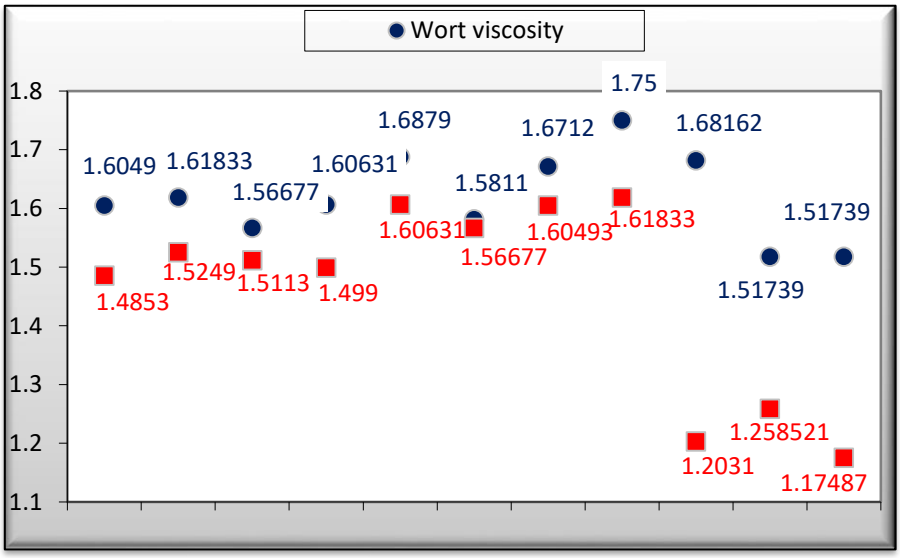

Fig. 5. Dynamicviscosity (mPa s) monitoringinwortandbeer (100% badmaltbeer)

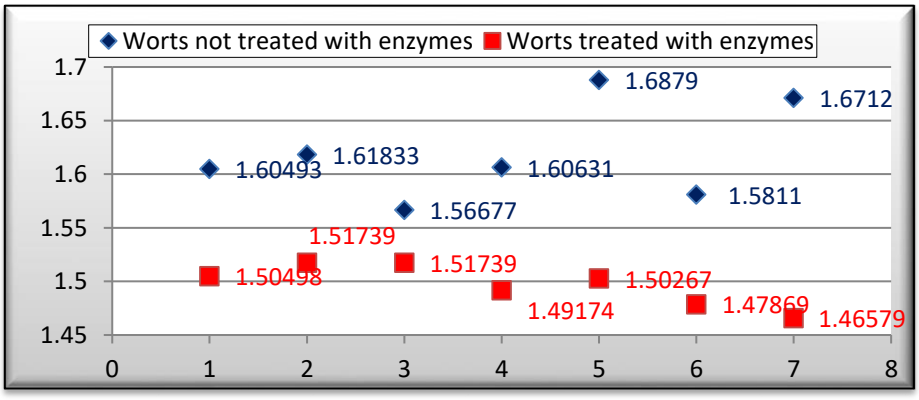

Fig. 6. Dynamicviscosity (mPa s) inwortstreatedandnottreatedwithenzymes

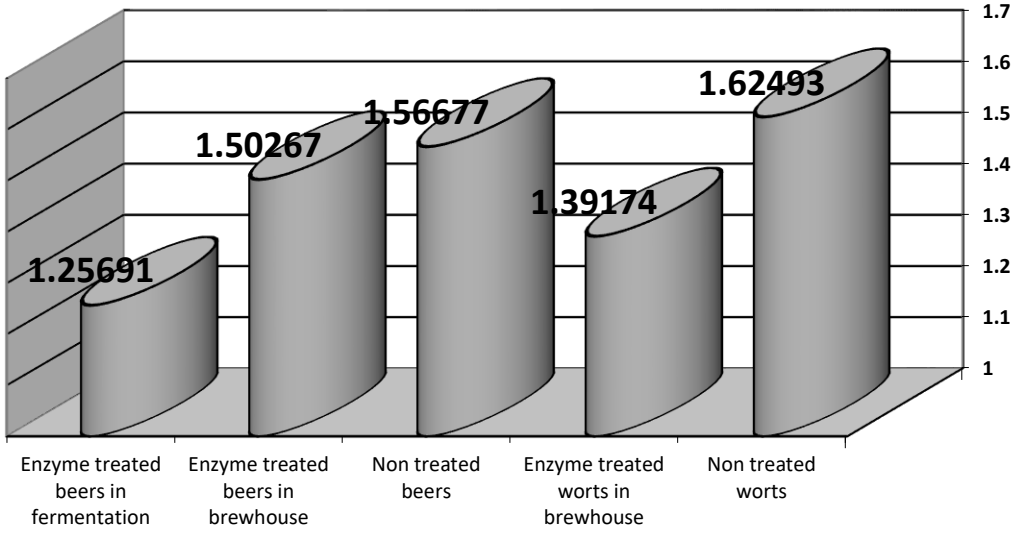

Fig. 7. Viscosity in worts and beer treated in different manner with enzymes

Viscosity was determined in wort and beers. We see in Figure 5 that in all samples studied the wort has a higher viscosity than the final product, beer. Sample 8 of wort has a viscosity of 1.75 that presents difficulties in filtering. So in this case the addition of β-glucanse in the mashing process is necessary.

In Figure 6 are given the viscosity values measured in the wort treated with enzyme and in wort not treated with enzyme. The lowest values of viscosity are obtained in the case of wort treated with enzyme. Although the wort not treated with enzyme does not exceed 1.75 viscosity, enzyme treatment is needed to avoid filtering problems.

In Figure 7 are given the viscosity values measured in worts and beers not treated with enzyme and the viscosity in worts and beers treated in different manner with enzyme. The lowest value of viscosity are obtained in the casa of enzyme treated beers in fermentation. To obtain a viscosity of less than 1.55 cP it is necessary for worts and beers to be treated with enzymes.

CONCLUSIONS

Filtration optimization process needs developing a strategy based on observations, empirical determinations and continuous monitoring in order to ensure efficient filteroperation. This objective will be reached by identifying critical factors which will influence filtration efficiency, by monitoring and recording all parameters surrounding these factors, determining any transgression from the norm, for what ever reason.

Beer filterability strongly depends on malt quality, especially β-glucans and gommacontent. If worts are characterized by high viscosity and a gomma structure, it is strongly recommended to use enzymes to control carbohydrates that dominate filtration characteristics suchasun modified starch, dextrins, pentosans, and β-glucans.

When dynamic viscosity is higher than 1.55 cP, poor beer filterability is noticed. Beer filterability was improved using β-glucanase enzyme in brewery or in fermentation. Using this enzyme in the brewery is more efficient because it simultaneously improves wort filterability, protein coagulation and it needs less energy for wort boiling.

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