WORT PRODUCTION OPTIMISATION BASED ON PHYSICO-CHEMICAL MALT PARAMETERS

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ABSTRACT

The quality of the beers is directly related to the quality of wort produced in brewing. Raw material used for the production of beer is malt, barley seed partially sprouted, previously heated and dried. To optimize the wort production is necessary to monitor the physical and chemical parameters of the malt. Malt has direct impact on flavor (taste, aroma, sensation in the mouth), surface, (color, clarity, foam), colloidal stability and stabilization of oxidative flavor. Physical characteristics of malt are very important and affect the technological process of brewing. The most important parameter is malt extract. Wort composition depends on the quality and type of raw materials used, in the control of the various processing steps and on the concentration and profile of nitrogen compounds (proteins, polypeptides and amino acids). The quality and stability of beer depend on its protein content. In this paper are presented the results of physical and chemical analyses performed on samples of malt also is studied the impact of these results in the quality of wort. This study gives the results of protein content in wort, at different stages. Stability and life expectancy of beer is studied depending on protein content. The parameters studied in thia paper are friability, extract content, malt moisture and enzymatic content in wort at various stages of production, Hartong index, viscosity, and filterability.

Keywords: Exctract, friability, malt, nitrogen compounds, physical analyse, wort.

INTRODUCTION

A malt analysis will typically list three types of data: physical analysis, wort analysis and chemical analysis. While each attribute uniquely impacts the brewing process or finished beer, some have a greater impact and significance than others. The physical analysis include: glassy of malt, rate of crystallization, friability and size of malt grains. These tests are very important because through them we know the physical characteristics of malt, which will be used for wort production (Briggs et al., 2004).

The most important chemical analysis are malt extract and protein content. Smaller changes in malt analysis may have consequences in different boiling, especially when mixing varieties. These changes, especially the changes in color, moisture, malt extract content, can seriously affect the preparation of boiling recipe. Malt after milling is mixed with water and forms the mash. The mash heats to dissolve valuable substances in the water. The purpose of this process is to obtain an extract content as high as possible by milling malt. If mashing process is correct will take only 10-15% of the extract, while with the help of enzymes, which breakdown complex substances insoluble in simple substances soluble in water. The higher the malt extract is the more soluble it will be the dry material. A malt which is well modified and appropriate for an infusion method will have an FG / CG extract difference 0.5-1.0%.

Difference extracts % FG/CG (Fine Grind / Coarse Grind) of fine milling and coarse milling shows malt modification and is often used as the main parameter to determine the quality of the malt.

A parameter that affects the extract's content is malt moisture. The closer to 1.5% is the malt moisture, the less the risk to be touched by the mold and the smaller loss of smell will be. For this purpose dark malt should not have a moisture content greater than 4%. The upper and the maximum limit should be no more than 6%. Moisture content is often taken as a factor in determining the quality of a malt. Malt with high moisture content may be a product obtained from poor malting, or by a poor drying process during malting.

During malting process occurs hydrolyzing of barley proteins, while barley contains proteins which make the beer turbid. Proteins are among barley components that are essential for the quality of malt and beer. First, high-protein contents decrease available carbohydrates, with a negative influence on the brewing process [Peltonen J, Rita H, Aikasalo R, Home S, 1994]; [Fox GP, Onley-Watson K, Osman A, 2002] and second, proteolysis (protease hydrolysis producing amino acids and peptides from hordeins) during malting and mashing is necessary for yeast metabolism [Moll M, 1979]. Finally, soluble proteins are important in beer head retention and stability. They are necessary in enzymatic processes of malting, wort production and affect directly the consistency and foam.

The boiler is intended to reduce the viscosity of beer and wort, as well as 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) (Eblinger, 2009). Beta-glucanase acts on maltose rubber substances to improve the viscosity (liquefied wort) and the clarity of the beer.

MATERIAL AND METHODS

The data on which this paper is performed are obtained from the analyses that are made for different samples of lager malt. The period analysed in this study was 2014-2015-2016.

Friability indicate if malt is easy milled and is related with mealy character of grains. In this test which indicates the level of modification, malt is crushed using a friability instrument. The friability is the percentage (by weight) of material that passes through the sieve. Investigation of material remaining on the sieve can be informative and can indicate if the malt corns generally contain unmodified material or if a substantial proportion of wholly unmodified grains are present.

Determination of the malt extract is performed according to the procedure given in the EBC manual. For each samples of malt get in the study, the moisture content and extract content are measured. Is studied the dependence of extract content on malt moisture.

In order to evaluate protein degradation during the wort production Kolbach gave an assessment, the so-called boiling intensity. The Kolbach index is calculated as the protein soluble amount / total protein amount, or as SN / TN (soluble nitrogen / total nitrogen). IK is

a very important indicator of malt modification. The higher this value, the more modifiable it will be the malt.

Viscosity is measured in the wort and especially in laboratory worts (congress wort and 65°C wort) as part of the malt analysis, and allows us to draw conclusions from the cytolysis of the malt used. Consists in measuring the breakdown of beta-glucans (endosperm cell walls) during malting. Concerning breweries and processing laboratories, viscosity is monitored in several different stages of beer production (supplied malt quality tracing, malt and wort quality determination, filtration monitoring, and final product evaluation). Viscosity also plays an important role in theory of filtration. A malt in the laboratory with high viscosity above 1.75 cP will present problems in brewing. The higher the viscosity, the less effective will be the boiling process to release the β- glucans.

The Hartong index is a measure of extract used by the Middle European Brewing Technology Analysis Commission. It is acquired by determining the extract obtained isothermally at 45°C. Commonly the Hartong 45° value is expressed as e percentage of the extract value of the Analytica-EBC extract. In this case it isreferred to as the Hartong Index. For malts, values less than 30 are considered to be poor and less than 36 insufficient. Values between 36 and 40 are considered satisfactory and greater than 40 to be good. The determination of the Hartong at 45°C is the most revealing result because at this temperature, the proteolytic and cytolytic activity of enzyme is maximum. The Hartong 45° depends of: the barley variety from which the malt is made, the state of malt disintegration and the process of malting. The numerical value of the Hartong Index is directy proportional to the degree of modification.

RESULTS AND DISCUSSIONS

All of the following tests were carried out by malt samples, which were taken during the 2014-2015-2016 in the different furnishing malt of beer factory. In this study, the analyzes were carried out for various malt 'lager' samples used by our brewery factory and produced at the establishment in Korça. Were analyzed different samples of malt, wort, fermented beer, pre-filtration and final beer. Friability shows if malt mill easly and is recomended a friability about 80%. From the results obtained see that all samples have a friability above 80%, so that these malts can mill easily.

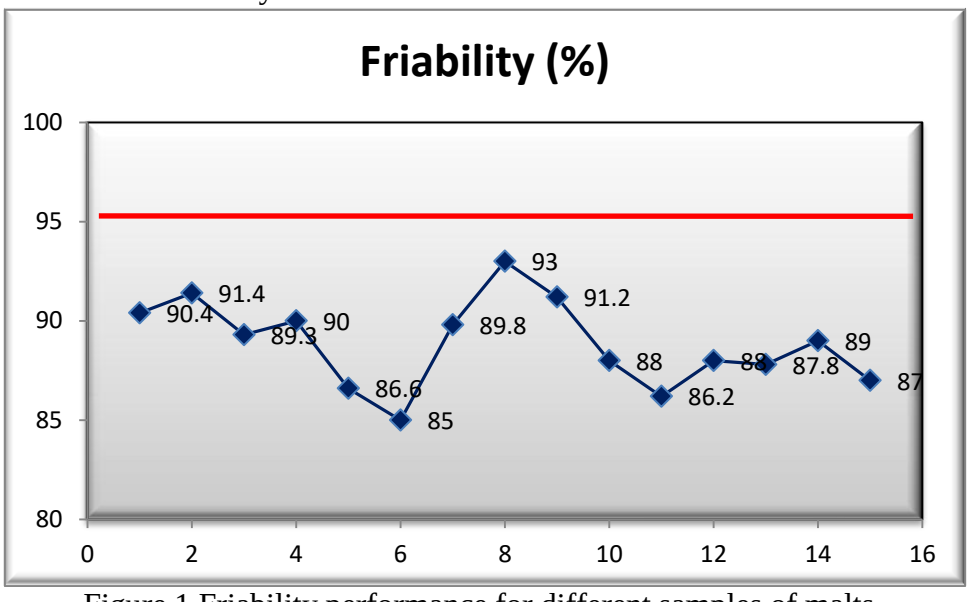


Figure 1.Friability performance for different samples of malts.

From the Figure 1, it is clear that the values of friability for different sample of malt are below the thick red line. Since friability of malt is below 95% is not recommended to work with the infusion method. Friability walks in proportional to extract of wort. The higher friability is, the higher extract of wort is produced.

One of the most important parameters to determine the quality of malt is the difference in the extract. For a normal brewing process this difference should not be greater than two.

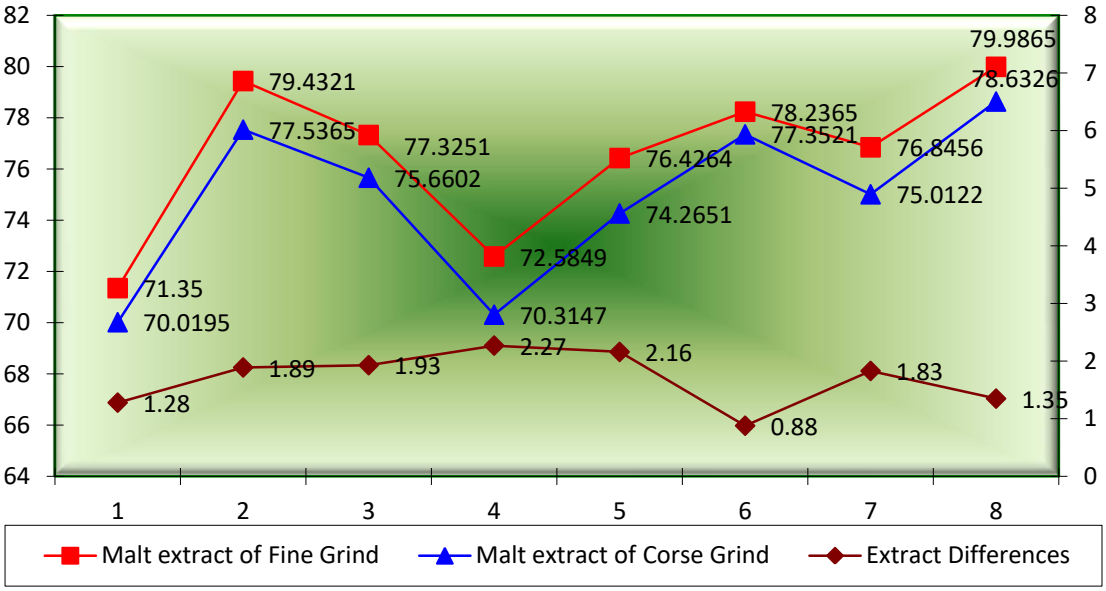


Figure 2. Extract diference of malt

The performance of the malt extract of fine grind and corse grind is given through two lines that almost walk in parallel with each other as is shown in Figure 2. Regardless of the obtained extract values (good or not), the difference between the two extracts is generally acceptable. The maximum limit of this difference is 1.8-2, given in the figure with a straight red line. Is given very clearly that the difference in the malt extract is not proportional to the amount of extract in the fine and corse grind. So we have high extracted malt, close to the standard, which have the same margin difference as the middlesee standard, such as point 1 and 8.

In order to determine the influence of malt moisture in the wort extract, successive experiments were conducted directly on the industrial scale. It was worked with the same boiling method and the same load of malt. Considerations were taken only on tests where there was no change of parameters and fluctuations in the production process.

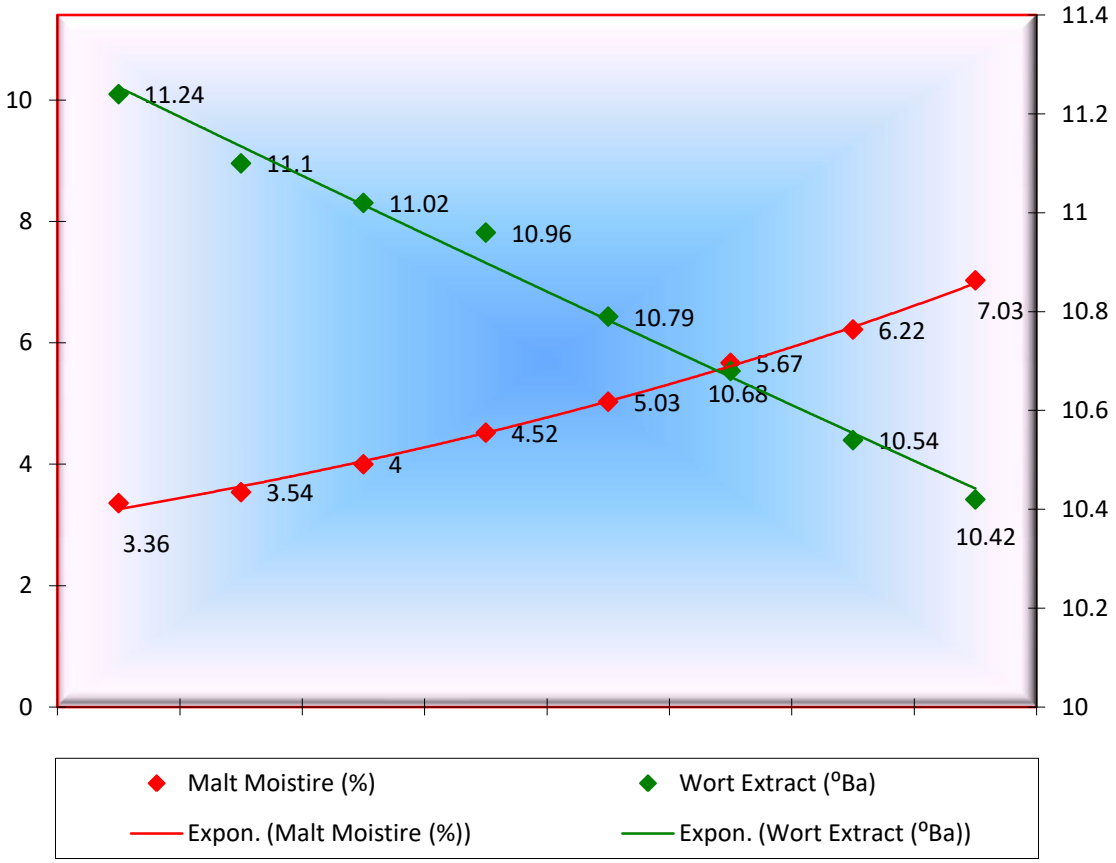


Figure 3. The influence of malt moisture in the wort extract

We determined the amount of total nitrogen and soluble nitrogen for 14 samples of malt and for each of them the Kolbach index was calculated.

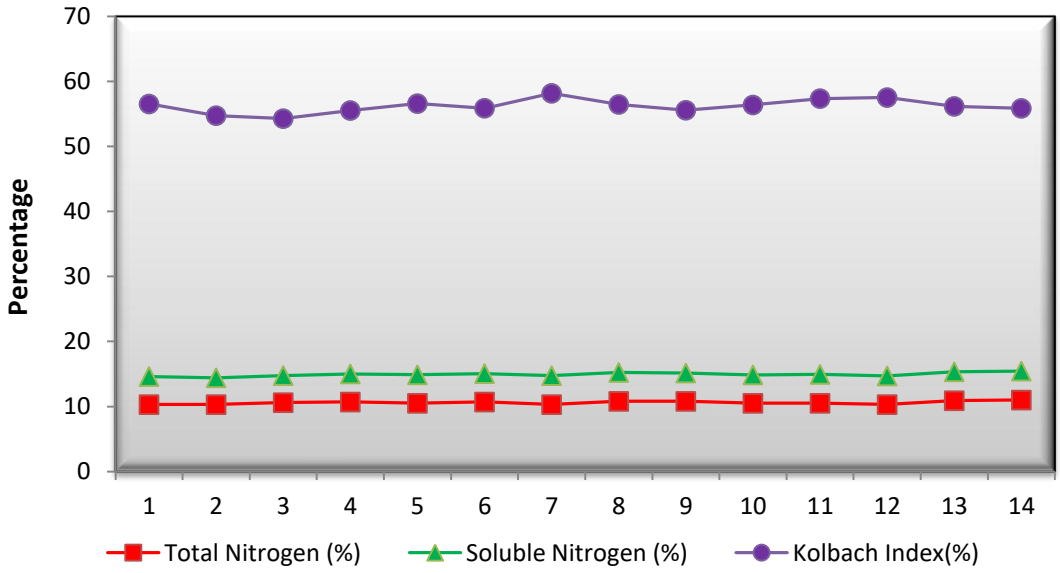
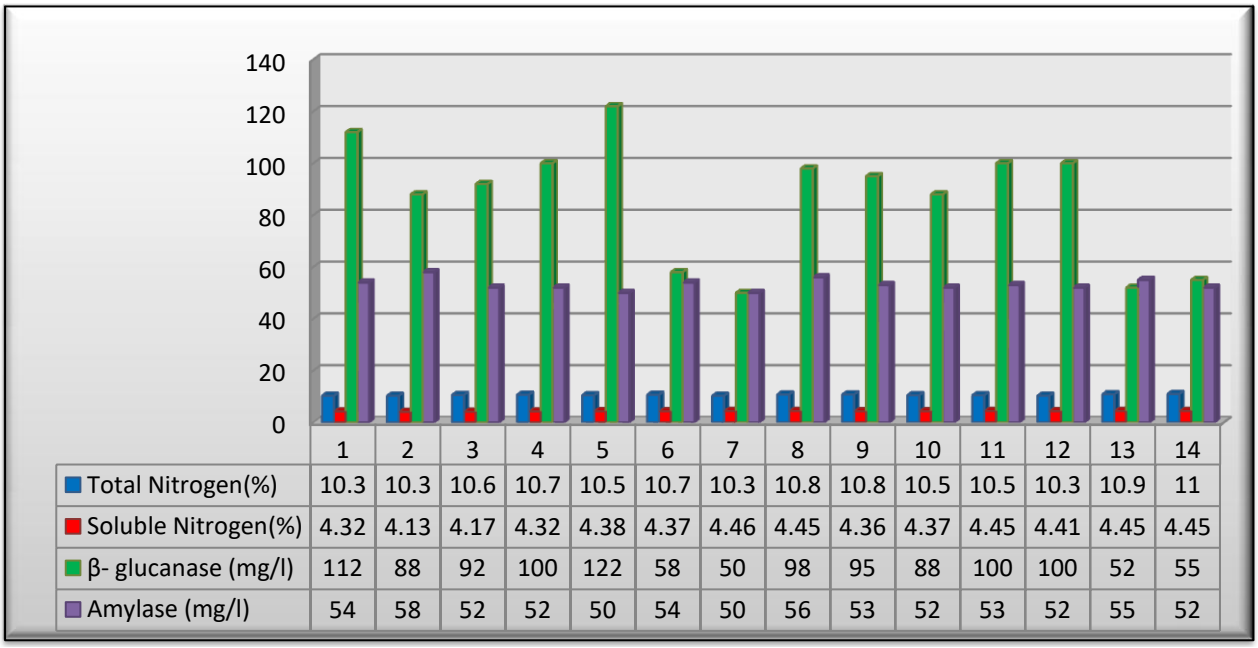


Figure 4. The relation of the Kolbach Index with the amount of nitrogen

All of the analyzed samples have satisfying values of Kolbach index. The values 30-33% indicates poor malt modification and the values 37-40% indicates very strong malt

modification. In Figure 4 we see that sample number 7 has the highest Kolbach index in value 43.4%. This malt is appropriate for diffusion method. If the value of Kolbach Index is higher than 45%, the beer will have low consistency. In any of the samples this value is not exceeded All samples have a degree of modification suitable to produce a final product with quality.

In Figure 5, are given the values of enzymatic content of the -β-glucanase and amylase in the samples studied above. We notice that there is a fluctuation in the amount of β-glucanases. None of the samples exceed the value limit of 15 to 200 mg / l. β-glucanases acts on maltose rubber substances to improve viscosity (beer liquor) and clarity of beer, however, should not exceed 200 mg/l because it causes problems in the production process. Amylases decompose strach into simple sugars and in the samples we have values that provide a satisfactory transformation of strach.



	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Total Nitrogen(%)	10.3	10.3	10.6	10.7	10.5	10.7	10.3	10.8	10.8	10.5	10.5	10.3	10.9	11
Soluble Nitrogen(%)	4.32	4.13	4.17	4.32	4.38	4.37	4.46	4.45	4.36	4.37	4.45	4.41	4.45	4.45
β- glucanase (mg/l)	112	88	92	100	122	58	50	98	95	88	100	100	52	55
Amylase (mg/l)	54	58	52	52	50	54	50	56	53	52	53	52	55	52

Figure 5. The amount of the β-glucanase and amylase enzyme

Degradation of protein fractions during malting is achieved through proteinases and peptides. The balance of protein content in the filtered wort is given in Figure 6. Melt temperature and enzymes have a very important effect on the content of coagulated nitrogen in the wort.

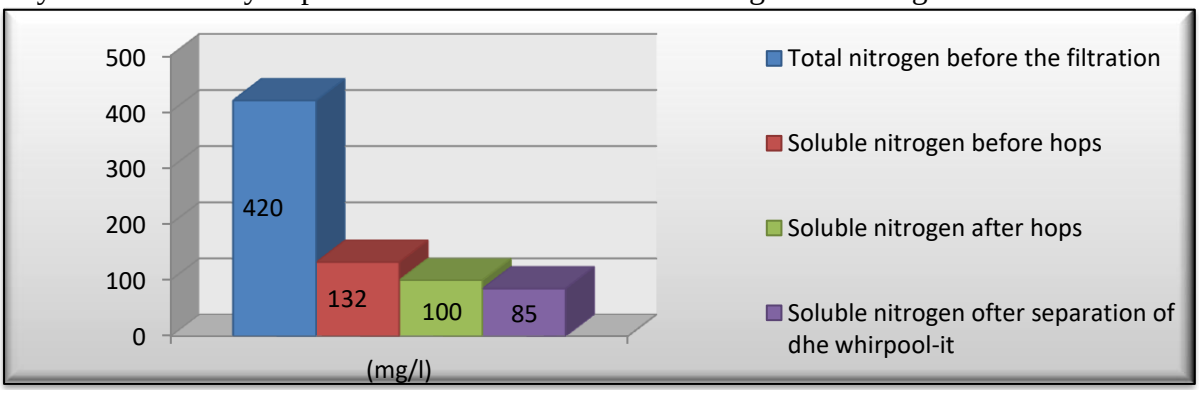


Figure 6. Protein content in wort during various stages of production

We measure the viscosity of the wort obtained from 14 malt samples for which we have previously determined the amount of total nitrogen and soluble nitrogen. The results obtained are summarized in the Figure 4. For a good filtration is recommended viscosity of wort less than 1.75 cP. Worts that have viscosity higher than 1.75 cP, the filtration time is over one hour caused from a bed filtration. In this case is necessary the addition of β-glucanase in mashing process that reduces the viscosity of the wort. In all analyzed samples the viscosity does not exceed 1.7 cP, so So it is not necessary to add enzymes to the boiling process.

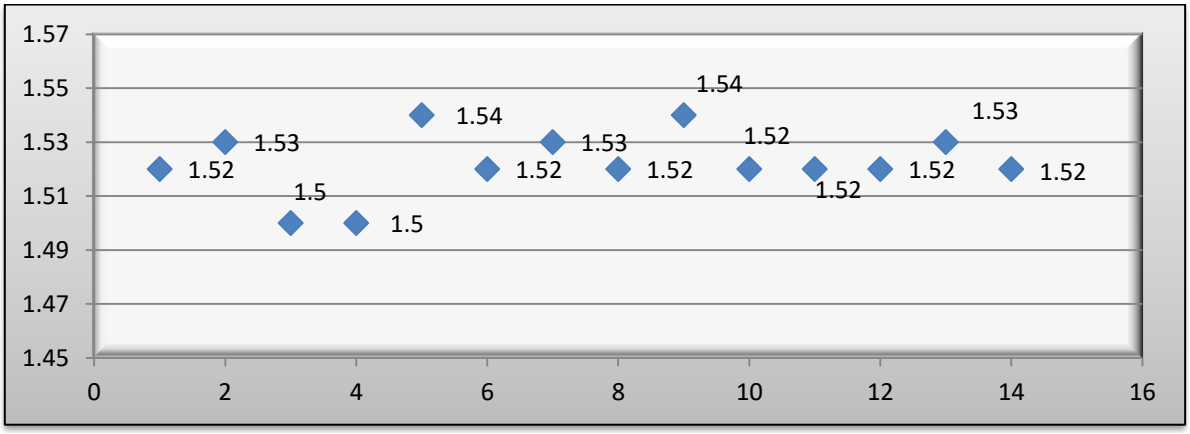


Figure 7. Viscosity value in the wort.

For the same malt samples analyzed above, we determined the Hartong Index. Above is said that for malts, values less than 30 are considered to be poor and less than 36 insufficient. Values between 36 and 40 are considered satisfactory and greater than 40 to be good. In the Figure 8 we see that the samples 5 and 7, Hartong Index is less than 36, so this malts are considered insufficient. All the other samples of malts have values between 36 and 39 of Hartong Index, with means that these malts are considered satisfactory. None of the samples analyzed has a Hartong index higher than 40.

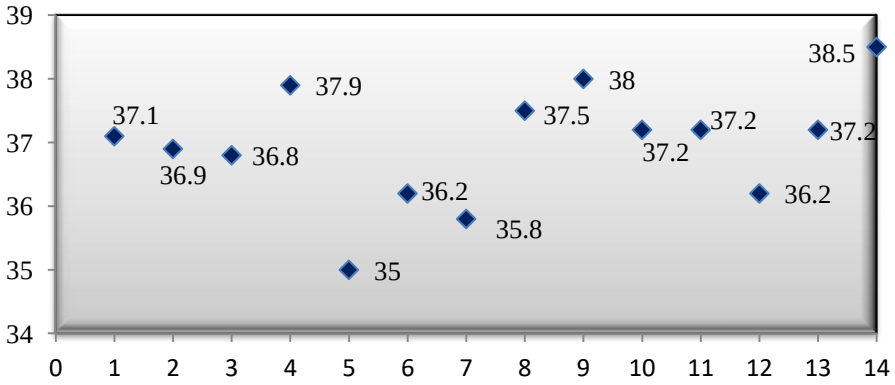


Figure 8. Hartong Index values of the samples

Carbohydrates that have a signicative 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} in a given differential pressure. All the worts for these trials were produced by infusion and the enzymes were used one by one. (European Brewery Convection. 2000)

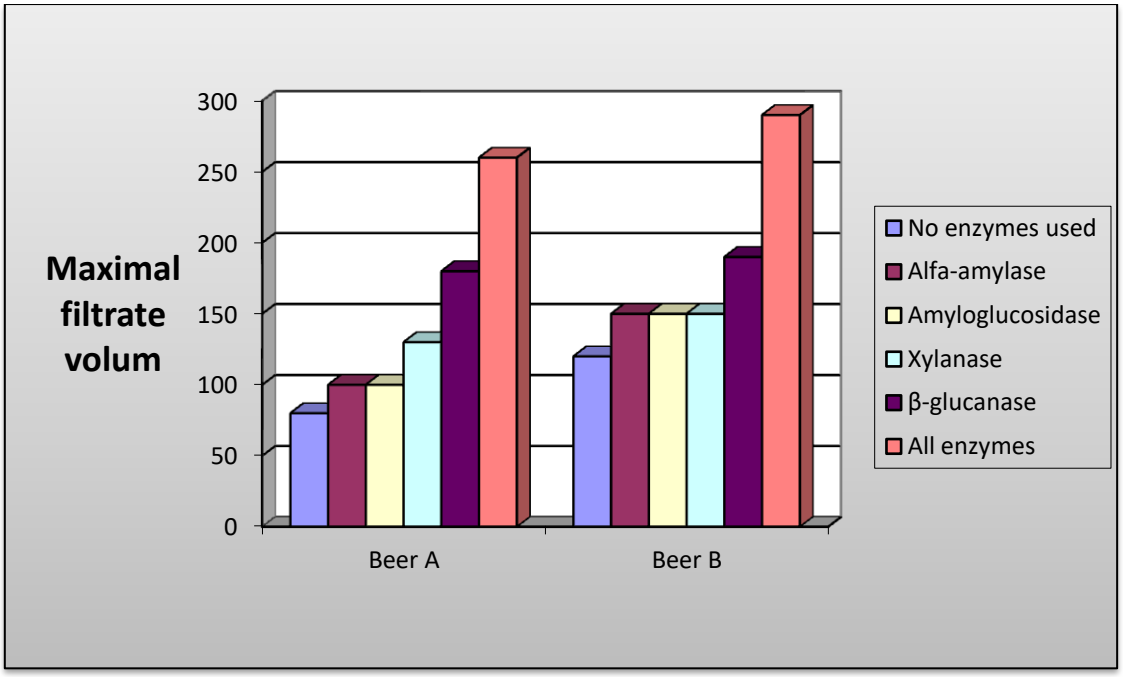


Figure 9. Impact of enzyme on beer filterability

If we compare the performance in beer A and beer B, from Figure 9 we notice that in all cases the beer produced from malt with good quality represent the maximal filtrate volume higher than the beers B. In both types of beer the highest maximal filtrate volume is obtained when they are treated with all enzymes and lowest values if they are not treated with enzymes. If we compare the impact of each enzyme in beer filterability we see that beta-glucanase represents a maximum filtrate higher than other enzymes in both beer 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 not significative differences between filterability of these beers, but the most important fact was that β-glucanase enzyme used in brewhouse shortens also the mash filtration time in the lauter tun filter (Figure 10).

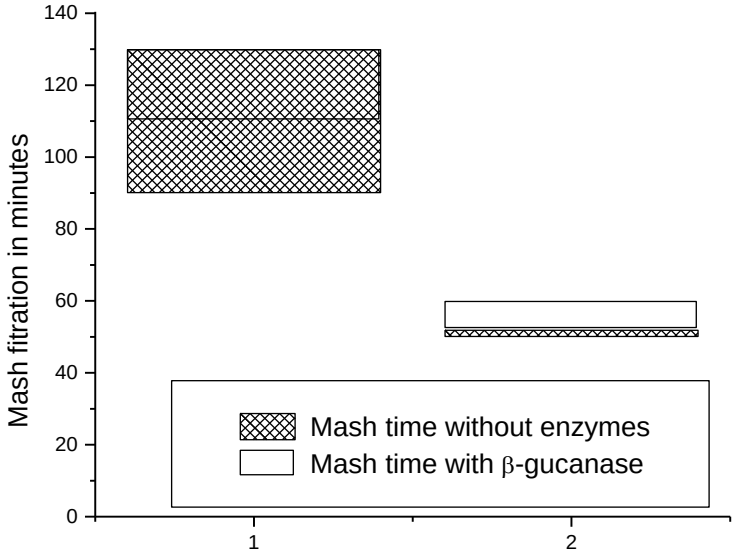


Figure 10. Impact of enzyme β-glucanase on wort time filtration (n = 18)

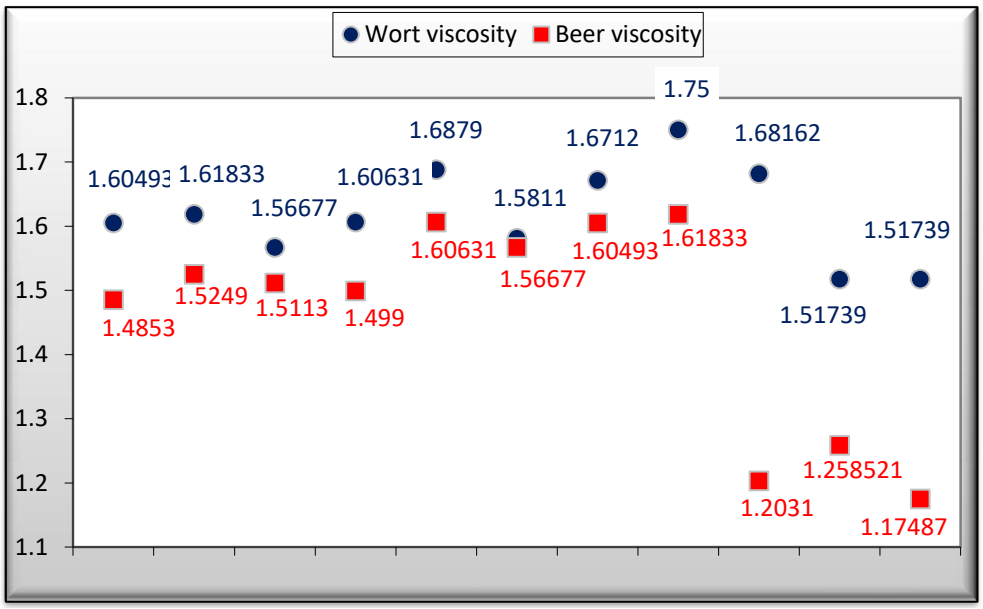


Figure 11. Dynamic Viscosity (mPa s) monitoring in wort and beer (100% bad malt beers)

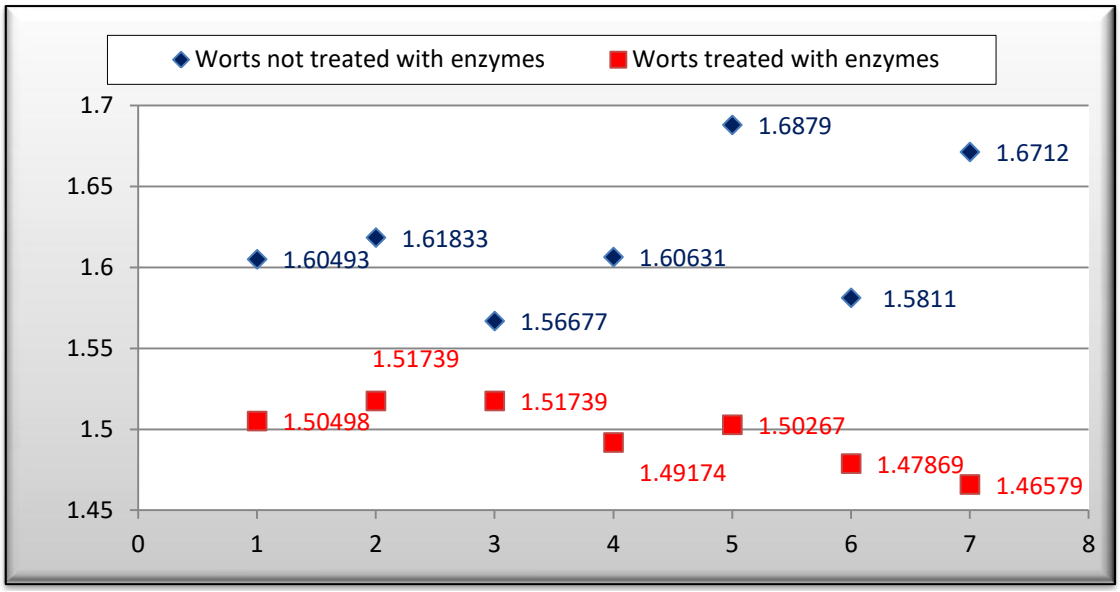


Figure 12. Dynamic Viscosity (mPa s) in worts treated and non treated with enzymes

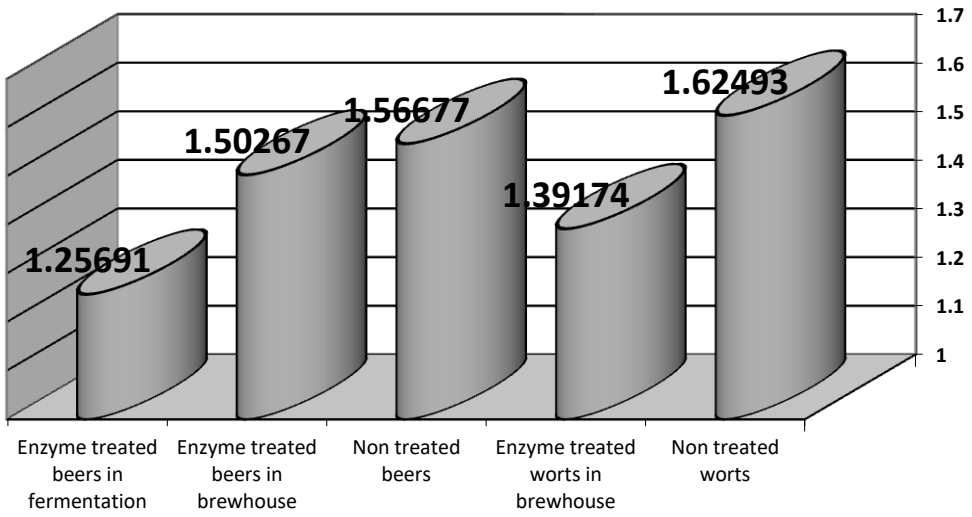


Figure 13. Viscosity in worts and beer treated in different manner with enzymes

Viscosity was determined in wort and beers. We see in Figure 11 that in all samples studied wort has a higher viscosity than the final product, beer. Sample 8 of wort has a viscosity 1.75 that and presents difficulties in filtering. So in this case is necessary the addition of β-glucanase in mashing process.

In Figure 12 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

CONCLUSIONS

Friability is the characteristic that is related with the mealy character of barley grains. Malt should have a friability about 80%. When we use the infusion method, malt should have a friability at least 95% or higher.

The higher the DBFG extract, the more soluble will be the dry matter and will have less protein. The base malt that does not yield at least 78% DBFG extract will be under standard. The DBCG extract gives a better indication of the degree of modification of the strach during malting. The DBCG level significantly affects the quality of the boiling process.

The qality and stability of beer depends on its protein content. The protein in beer comes mainly from malt. Infusion method should be used only for malts with Kolbach Index greater than 36% (over 45% the consistency is very low). The more protein substances are present in malt, the more enzymes it will have. For the production of lager beers malt should have a protein content of about 10%, the reasons relate to the formation of an optimal foam head, the production of a consistency beer, the development of a healthy fermentation and a lower risk of the formation cold turbidity. For a good filtration is recommended viscosity of wort less than 1.75 cP. Worts that have viscosity higher than 1.75 cP, the filtration time is over one hour caused from a bed filtration. In this case is necessary the addition of β-glucanase in mashing process that reduces the viscosity of the wort. Malts using in brewing should have values of Hartog Index more than 36%.

Beer filterability is strongly depended by malt quality, especially β-glucans and gomma content. 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 such as unmodified starch, dextrins, pentosans, and β-glucans. When dynamic viscosity is higher than 1.55 it is noticed bad beer filterability. Beer filterability was improved using β-glucanase enzyme in brewhouse or in fermentation. Using this enzyme in brewhouse is more efficient because in the same time it is improved wort filterability, protein coagulation and it needs less energy for wort boiling.

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