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Impact of malt protein parameters on brewing process optimization

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Abstract

Proteins are a very important class of organic components in beer. They are long chains or polymers with large molecular weight composed from amino acids, connect 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 brewing process. They are essential in the malt and wort production, also have a direct impact on the consistency and the formation of beer foam. This means the protein content in malt affect the quality of the finished product. It is very important to determine protein content before using malt for beer production. Malt is the main source of protein in beer. Proteins are made from compounds with nitrogen bases such as e.g. amino acids; every 1% nitrogen is equal to 6.25% protein. In this paper are the results of malt protein content in 2014,2015,2016 year. The amount of soluble protein or nitrogen, expressed in percentage by weight of malt and this indicator will be used to calculate the amount of nitrogen dissolved. Soluble nitrogen is determine by EBC method. Industrial and experimental yield is calculated based on the values of soluble nitrogen. Is studied the connection between the amount of soluble nitrogen or protein content in malt and the characteristics such as viscosity,turbidity, Hartong Index and enzyme levels. All malt that exceed the protein content over 12% (1,9 TN), cause problems in boiling process or in turbidity of beer. European malt lager or ale type have a protein content below 10%. The amount of dissolved nitrogen is a very important indicator for the modification of malt. The higher this value is, the more the malt will be modifiable. Protein content in malt grow to the extent 9-14% compared with barley.

Keywords: brewing, priteins, malt, soluble nitrogen, turbidity, viscosity, yield.

1. Introduction

Malt is the raw material for beer production. It is barley seed partially sprouted, which had been previously heated and dried. Barley can not be used for the production of beer, because it hasn't a developed enzymatic system, which transforms starch into sugar during the moistening process. During malting process occurs hydrolyzing of barley proteins, while barley contains proteins which make the beer turbid. Grain proteins have been classifi ed either according to their physico – chemical properties as albumins, globulins and prolamines or according to their function as catalysts (enzymes), structural, storage and defense proteins, respectively [3]. 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 [10]; [4] and second, proteolysis (protease hydrolysis producing amino acids and peptides from hordeins) during malting and mashing is necessary for yeast metabolism [7]. 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. Proteins are composed from nitrogen-based compounds such as e.g. amino acids. The nitrogenous constituents of barley are of great interest to maltsters and brewers. As already noted, a barley sample with a high nitrogen or "crude protein" content gives a malt with a lower yield of extract than a "low-nitrogen" sample of the same variety. Barley with a high nitrogen content is sometimes slow to "modify" during malting, has a high respiration rate and its roots grow quickly, so it makes malt at the expense of a high malting loss.

Furthermore the quality of beer (flavour, palate fullness, tendency to form haze) is influenced by the nitrogen content of the malt from wich it is made [2]. Nitrogen compounds present in wort may have different molar mass, and this profile influences the brewing process and the quality of the final product. Proteins with high molar mass ($\geq 10^6$ Da) contribute to beer texture and the formation of foam, although those proteins might be related to haze formation in the product during its storage time [1]. Proteins with medium molar mass and polypeptides derived from malt lead to freshness sensation, CO_2 retention and stability of the foam when they are hydrophobic compounds [13]; [8]. Proteins with low molar mass as well as peptides and amino acides found in wort (molar mass $\leq 10^3$ Da) are fundamental to yeast metabolism during the fermentation stage [1]; [9]; [6]. Since nitrogen content impacts on the brewing process, it is determines the amount of total nitrogen and soluble nitrogen. Total nitrogen values are obtained from the sum of all nitrogenous compounds present. Soluble nitrogen is a very important indicator of malt modification. The higher this value, the more modifiable it will be the malt. The protein content in malt grows up to 9-14% as compared to barley. Industrial and experimental yields are determined based on amount of total nitrogen and soluble nitrogen. Besides this, is studied the relationship between characteristics such as turbidity, viscosity and Hartong index and total nitrogen and dissolved nitrogen content.

2. 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. Various samples of malt, wort (semi-raw material), fermentation beer, pre-filtration and final beer were analyzed. The protein determination was carried out using the Kjeldahl method, in which a small sample of barley is digested with pure boiling sulfuric acid. The amount of ammonia formed is measured. The method according to Kjeldahl is based on a digestion of the sample (oxidation of the nitrogenous organic compounds to H_2O, CO_2 and NH_3), the distillation of NH_3 and the subsequent determination of NH_3 in the distillate by titration. Only nitrogen bound in organic substances and ammonia is detected by this method; other inorganic nitrogens like nitrite and nitrate are not determined.

2.1. Determination of intensity of wort production

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. The intensity of wort production is calculated as follows:

$$IWP = \frac{IPY}{EPY} x100$$

IWP – Intesity of wort production; *IPY* – Industrial protein yield; *EPY* – Experimental protein yield.

$$IPY = \frac{N_{iw}}{N_m} x100$$

N_{iw} – mg nitrogen in wort after boiling of 100g malt; N_m – mg nitrogen in 100g malt.

$$EPY = \frac{N_{ew}}{N_m} x100$$

N_{ew} – mg nitrogen in wort of experimental boiling with lupuli in 100g malt; N_m – mg nitrogen in 100g malt.

2.2. Determination of turbidity

Turbidity is caused by the scattering of light. The occurrence of turbidity limits the shelf - life of beer; hence, prediction of the time until a visible turbidity is detected is of major interest in the brewing industry. The measurement of turbidity is carried out using turbidity photometers, which detect the light scattered by the sample [3].

2.3. Determination of viscosity

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. Mainly insuffi ciently degraded, high molecular β-glucans originating from the cell walls of the endosperm contribute to high viscosity. Viscosity is given in the unit cP or in IOB. Viscosity 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 measured viscosity in the IOB unit should be in the range of 6,3-6,8 (get to 70°C).

2.4. Determination of Hartong Index

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. Values are dimensionless. 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.

3. Results and Discussion

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.

3.1. Determination of intensity of wort production

For each malt load in the beer factory was determined the amount of nitrogen in wort and malt at the industrial level. In the laboratory was measured the amount of nitrogen in wort during the boiling process with lupul and the amount of nitrogen in the malt. Based on their values was calculated the industrial protein yield and the experimental protein yield. Through the above formula was calculated intensity of wort production. The intensity of wort production was calculated in three case of boiling: 1) with decoction method; 2) with infusion method and 3) with adding enzymes (protease and amylase). All these results are summarized in the Table 1.

Table 1. Intensity of wort production for three boiling ways

Number of sample	**1**	**2**	**3**	**4**	**5**	**6**
IWP of boiling with decoction method (%)	97.64	102.2	96.2	106.4	92.8	105.1
IWP of boiling with infusion method (%)	96.3	97.2	92.6	92.6	92	96
IWP of boiling with adding enzymes (%)	101.2	108.6	101.3	106.7	109.5	103.2

In Figure 1. we note that the IWP value is 100% on the average. This is a relatively good value. The IWP value is the function of raw materials, equipment, and the effectiveness of the technological process. The allowed interval is 85% -120%. Since only one malt sample has been worked out, we conclude that the technological process and the equipment used in the process of production are effective. Decoctiom production at industrial scale utilizes the proteolytic enzymes of malt, compared to infusions, therefore we obtain higher performance on the other hand, in any case the use of enzymes guarantees the maximum utilization of dry material in malt.

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.

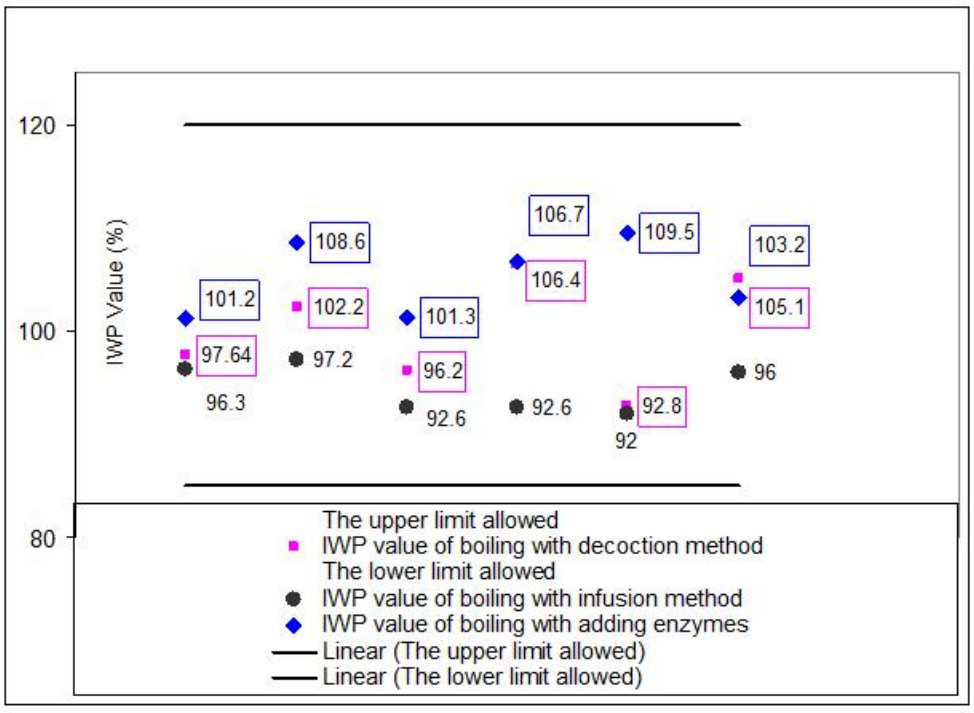

Figure 1. The determination of the Intensity of Wort Production

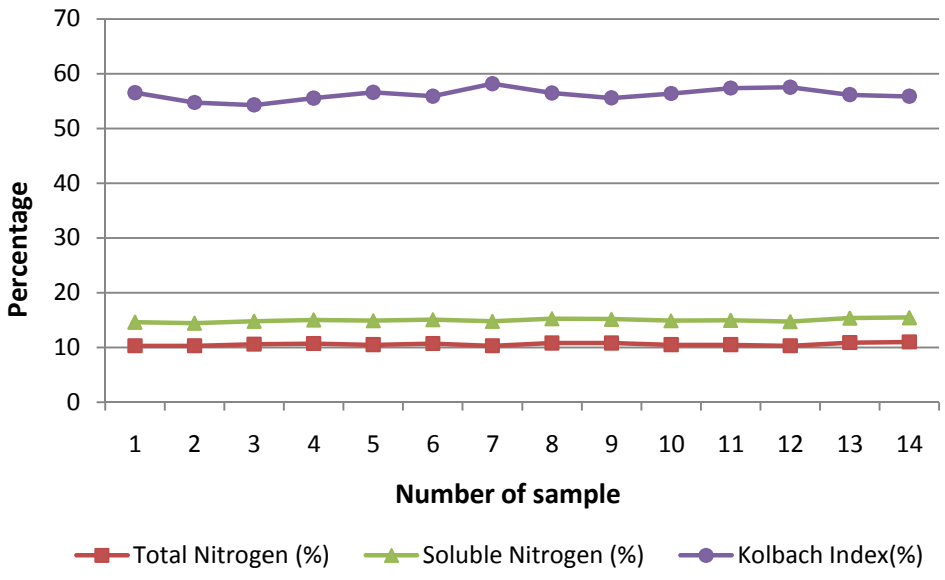

Figure 2. The relation of the Kolbach Index with the amount of nitrogen

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 2 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.

3.2. Determination of turbidity

The protein dissolved in beer is responsible for the turbidity. Were analyzed beer with different protein contents, for each of them was measures the turbidity. The Figure 3 gives the protein content and the turbidity values in beer samples. It is noticed that despite the fact that protein growth is linear, the turbidity is exponential.

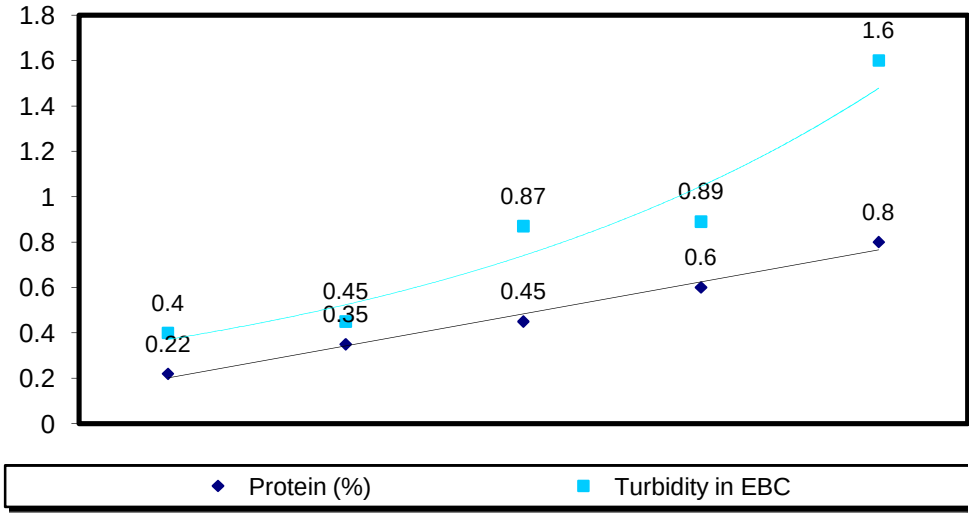

Figure 3. The performance of protein content and turbidity in beer

3.3. Determination of viscosity

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.

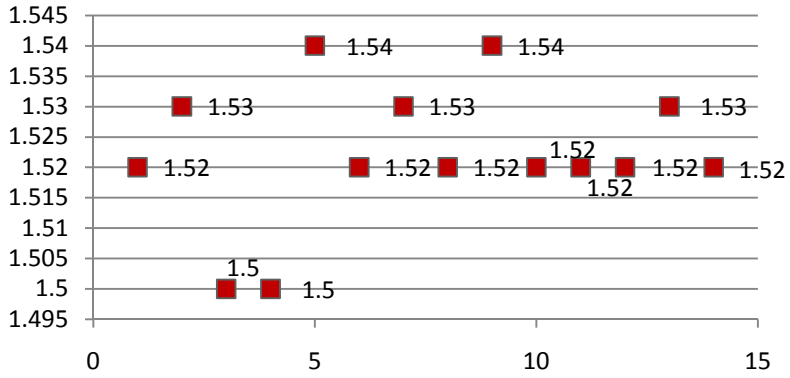

Figure 4. Viscosity value in the wort.

3.4. Determination of Hartong Index

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 5 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.

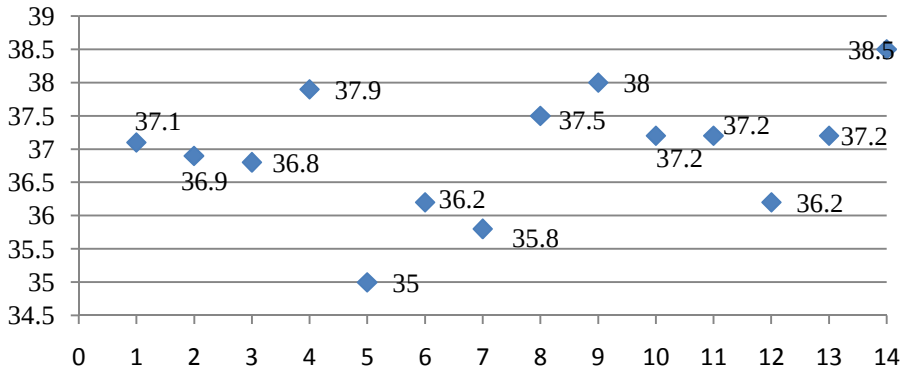

Figure 5. Hartong Index values of the samples

4. Conclusions

The quality and stability of beer depends on its protein content. The protein in beer comes mainly from malt. Since the technological process and the equipment used in the process of wort producing the are effective, the IWP value should be between 85% and 120%. For lower values it is necessary to use the decoction method with a temperature of 50°C, for better disintegration of the protein fraction. 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%.

5. References

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