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REGULAR ARTICLE

EFFECT OF KIESELGUHR FILTRATION ON OPTICAL PROPERTIES OF BEER

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ABSTRACT

Looks of beer is an important factor which is associated with high clarity. Clarity of beer is a basic precondition of its good marketability and consumer satisfaction. Beer filtration is ideal tool to create required optical properties. There is a high accent on this operation in brewery and minibrewery. The process of filtering removes unwanted haze-active substances in order to increase clarity and overall stability of beer. Objective method to expressing clarity of beer is nephelometric determination of turbidity, which is highly sensitive and achieved by reliable results directly in the units used to express the turbidity values in beer. The objective of our study was to measure haze before and after filtration in various types of beer with different length of lagering. Kieselguhr was used as filtration material. Haze of beer was measured by haze meter in determination under 2 angles and values were expressed in European Brewery Convention units directly.

Keywords: beer, filtration, kieselguhr, nephelometry

INTRODUCTION

Beer is very popular for thousands of years and it belongs among the most consumed low-alcoholic beverages. Additionally beer can make a substantial contribution to the diet in respect of certain B vitamins, minerals, antioxidants and perhaps fiber. It contains compounds that are associated with positive effects on the human body, than antioxidants, minerals, fiber, vitamins, proteins and amino acids that affect nutritional value, but also taste and stability of beer (**Gallignani *et al*., 1994; Bamforth, 2002; Engelhard *et al.*, 2004**).

An important index of beer stability is the visual appearance of the product. With the exception of a few well-known examples, such as Weiss beer, consumers associate a star-bright product as a mark of freshness. While a beer is likely to deteriorate in terms of flavor before the appearance of haze, most consumers will probably notice the latter first. (**O`Rourke, 2002**). 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 beer and to unhinge potential turbidity formers (**Lindemann, 2009**). Filtration is an important process step whereby haze-active substances (proteins, tannins, yeasts, etc.) are removed and thus biological and colloidal stability can be achieved (**Fontana a Buiatti, 2009; Clemens, 2010**). Filtration of beer can not to reduce its foaming, to deliver oxygen into beer, metal ions which catalyzing oxidative reaction during storage also the other compounds, which would be negative, affect chemical composition and organoleptic properties of beer (**Basařová *et al*., 2010**).

Yeast, bacteria and colloids are almost completely removed from beer depending on the selected filtration plate. Filtration plates consist of cellulose fibers from different types of wood, kieselguhr, perlite, synthetic fibers and resins that increase stability of filters. Large surfaces serve optimum adsorption of turbidity substances (**Bamforth, 2003; Briggs *et al*., 2004**). Filtrations can be classified as surface and depth filtration depending on the place of solid separation. In surface filtration, the particles to by separate are retained on the surface of the active media but in depth filtration, the separation process takes place inside of the filter material. This process is called a cake filtration. An important representative of cake filtration is kieselguhr filtration (**Lindemann, 2009**).

Kieselguhr is diatomaceous earth, which is mined from Miocene period deposits in Europe and North and South America. It consists of skeletons of marine algae containing silicon dioxide. Kieselguhr powders for use in brewing are prepared by drying and milling on size of particles 5 – 20 µm (**Briggs *et al*., 2004; Basařová *et al*., 2010**). The conventional dead-end filtration with filter-aids (kieselguhr) has been the standard industrial practice for more than 100 years and will be increasingly scrutinized from economic, environmental and technical standpoints in the coming century (**Hrycyk, 1997; Knirsch *et al*., 1999**). Kieselguhr filtration uses 90 % of the world's brewers. Its addition from 50 to 220 g.hl^{-1} can be found in practice (**Benešová, 2000; Briggs *et al.*, 2004; Lindemann, 2009**).

One of the methods of controlling the filtration efficiency is monitoring its optical properties and thus determination of haze in beer with using devices called haze meter. The most common haze meters works on turbidimetry or nephelometry principle. Turbidimetry is based on the measure of light beam loss in sample (**Dienstbier *et al.*, 2010**). The nephelometry is an analytical method based on the measure of light intensity scattered by hazy solutions. It finds various applications in the quality control of beverages in which the untimely appearance of haze or sediments causes serious marketing problems. The angle at which the scattered light is measured relatively to the light beam plays an important function. The most used angle is centered on 90°. An angle of 13° (forward) relatively to the emergent beam is sometimes used to favour the large particles (over 0.4 µm) (**Chapon, 1993**). There are a different unit to express amount of haze in the Europe (EBC) and the USA (ASBC). 1 EBC unit (European Brewery Convention) is 69 ASBC units (American Society of Brewing Chemists) (**Briggs *et al.*, 2004**).

The objective of our study was to compare filtration effect of different types of kieselguhr. Kieselguhr was used independently and as a mixture in specific ratio. On the basis of gained results the best type of kieselguhr for filtration process was selected.

MATERIAL AND METHODS

Beer and filtration material

Beer was prepared in mini brewery of Slovak University of Agriculture in Nitra. It was prepared using infusion mashing system of brewing. Length of lagering was 15 and 30 days at 8°C in cylinder conical tank. 300 ml of unfiltered samples of unpasteurized beers tempered on 20°C were used for filtration process. As the filter material 3 types of kieselguhr with different particle size (F4 -fine, F10 - semi-fine, F50 gross) were used.

Table 1 Amount of kieselguhr in percentage used for filtration

		amount of kieselguhr (%)												
filtration		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
	F50	100	0	0	50	50	0	33.33	66.66	16.66	16.66	83.33	10	10
kieselguhr	**F10**	0	100	0	50	0	50	33.33	16.66	66.66	16.66	10	83.33	6.66
	F4	0	0	100	0	50	50	33.33	16.66	16.66	66.66	6.66	6.66	83.33

Amount of each filtration material was 1, 2 and 3 grams. Kieselguhr was used individually but also as a mixture in specific ratio (tab. 1). Filtration was carried out without pressure of beer on the filter septum that was filter paper (300 mm circles, grade 1289).

Measurement

Efficiency of filtration was analyzed by laboratory haze meter MZN 2002. The measurement was carried out under two angles of light scattering - nephelometry angle (90°) and forward angle (13°). Calibration of haze meter was realized according to Analytica EBC no. 9.29 using formazin standard suspension. The values of haze of each sample were expressed in EBC units.

RESULTS AND DISCUSSION

Haze values of unfiltered beer taken after 15 days of lagering period expressed high haze level of 15.40 EBC units, measured under angle 90° and 26.52 EBC units under angle 13°. In comparison with beer with lagering period of 30 days are these measured values higher. This fact is understandable due to shorter time of natural sedimentation process of individual beer compounds, mainly yeasts. Beer with longer time of lagering expressed haze values only of 5.12 EBC units measured under angle of light scattering detection of 90° and 10.20 EBC units under angle 13°.

Beer filtration with lagering time of 15 days

Based on the measured results and values introduced in figures 1 and 2 could be point out that effectiveness of filtration in beer sample with lagering time 15 days increased with increasing amount of filtration material.

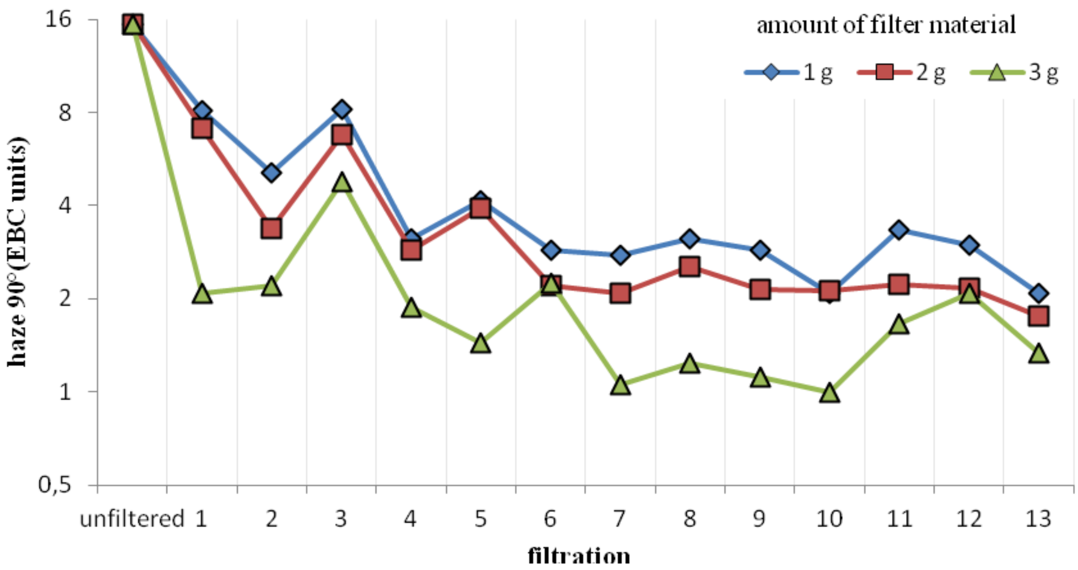

Figure 1 Haze of 15 days old lagering beer detected under angle 90° before and after filtration using different types of kieselguhr.

The best results were achieved by amount of 3.0 g of used kieselguhr. The best filtration material was filtration mixture no. 10 which was mixture of coarse (F 50) 16.66 %, semi-soft (F10) 16.66 % and soft kieselguhr (F4) 66.66 % by which were determined values of haze of 1.00 EBC units under angle 90°and 1.12 EBC unites under angle 13° (figure 1, 2).

In conclusion, better filtration effect could be achieved by mixing soft kieselguhr with bigger size of kieselguhr particles (F50).

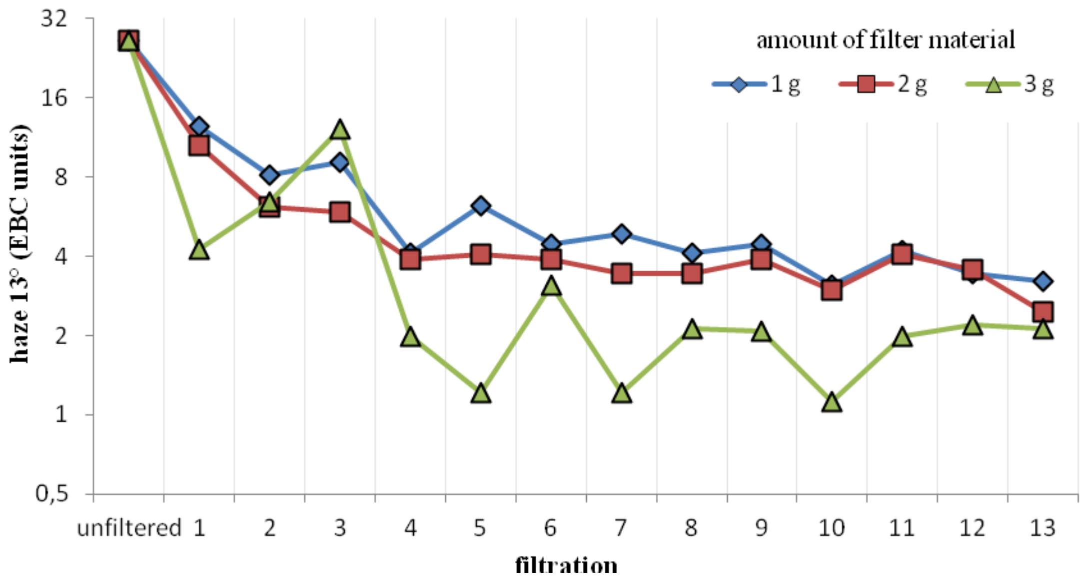

Figure 2 Haze of 15 days old lagering beer detected under angle 13° before and after filtration using different types of kieselguhr

Individual use of soft kieselguhr in higher amounts turned up to be unsuitable mainly in connection with increased hazes under angle 13°. This detection angle detects compounds bigger than 1 µm analogous to results of **Gabriel *et al.* (1994)**.

This refers to formation of low quality filtration cake and moreover consequential transfer of filtration material into produced beer. Clarity of fresh beer is within the limits 0.3 and 0.6 EBC units. Even in longer stored beer it should not exceed 1.0 EBC units (**Čejka, Kellner, 2000**). In case of beer filtration with regard to beer with 15 days period of lagering, haze value until 1.0 EBC was achieved only in one sample of kieselguhr mixture.

Beer filtration with lagering time of 30 days

The best filtration effect in case of beer with lagering time of 30 days (Figure 3, 4) was achieved by using the amount of kieselguhr 1.0 g. The higher amount of filtration material however achieved comparable results but in the frame of filtration effectively and the amount of used material for optimal doses represented 1.0 g.

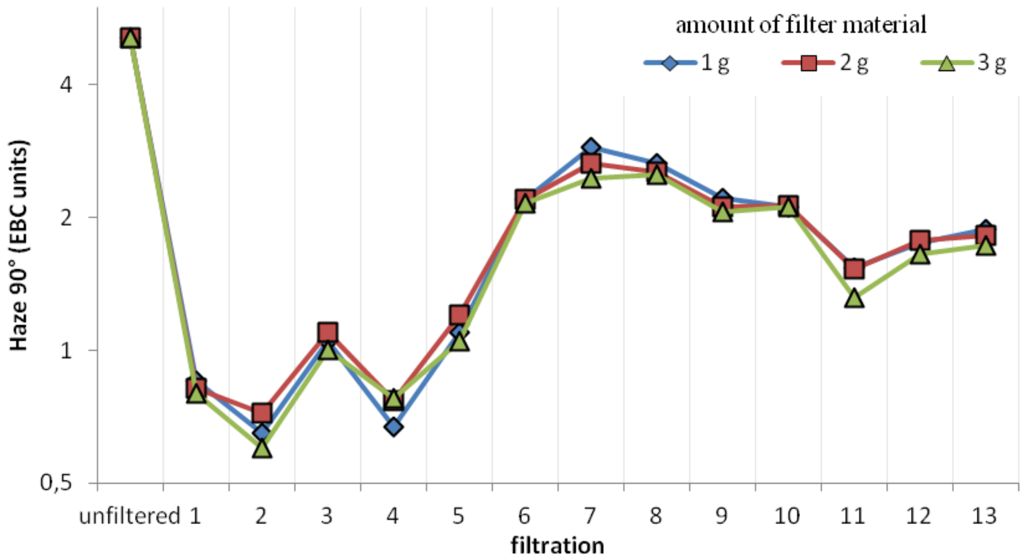

Figure 3 Haze of 30 days old lagering beer detected under angle 90° before and after filtration using different types of kieselguhr

According to **Basařová (1993)** it is possible to divide beers according to their haze values: clear beer – under 0.4 EBC unites, almost clear beer – 0.4 up to 0.9 EBC unites, slightly turbid beer - 1.0 up to 2.0 EBC units, turbid beer – over 2.0 EBC units.

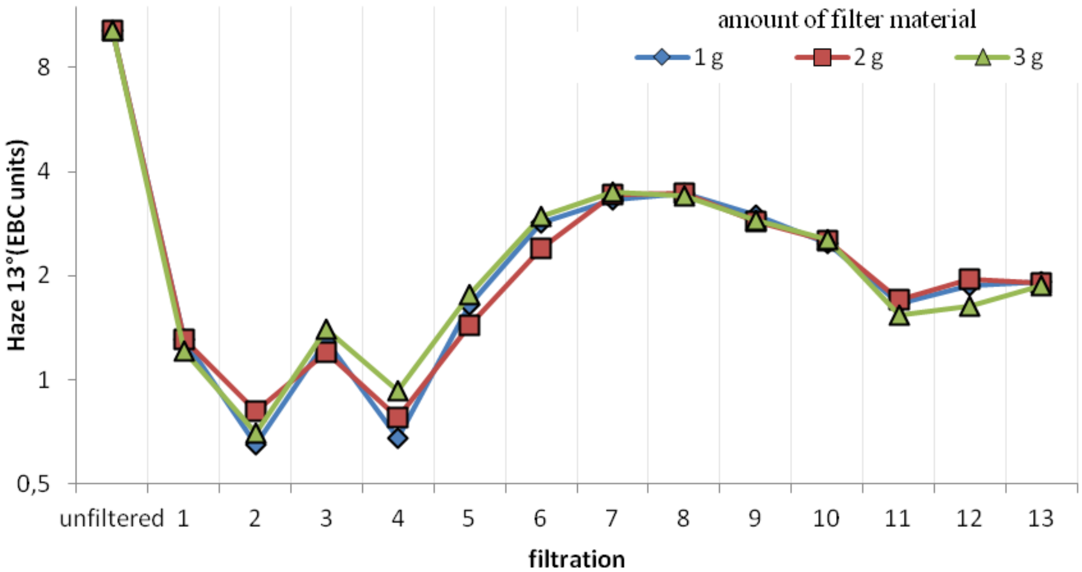

Figure 4 Haze of 30 days old lagering beer detected under angle 13° before and after filtration using different types of kieselguhr

In term of type of used kieselguhr the best quality showed semi soft kieselguhr (F 10), by means of which the haze value of filtrated beer was 0.60 and 0.65 EBC units under measured angles 90°and 13°. In any case of filtration we did not reached haze vale of max. 0.4 EBC units that represents the level of clear beer. The level of almost clear beer was managed to reach only in two cases (filtration no. 2 and 4). Values of filtrated beer hazes were high due to fact that for process of filtration there was not used pressure method that could lower values of haze as it is mentioned in results of **Voborský, Šruma (1996).** However testing such filtration method is difficult for the amount of filtered beer but in future it would be the subject of our further research.

CONCLUSION

Optimal value of haze of filtered beer is the first assumption to ensure its suitable shelf life as well as good sensorial parameters. Objective measurement of haze by use of nefelometric devices enable to control optical properties of beer in the frame of whole technological process and also could serve as suitable tool for choice of optimal materials and devices that serve to improve its quality.

Even the final beer filtration in industrial breweries is conducted by pressure method that increases its speed and effectiveness, our results give values that could be used as primary information before filtration process for small and mini breweries.

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