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Abstract. Beer production passes through those steps: malting, wort production, fermentation, and filtration. Filtration is used to remove yeast, proteins and other unwanted substances. Filtration is carried out by candle filters with kieselguhr, diatomaceous earth in a form of silica. In this study there are used three types of kieselguhr (DIF, CBL, CBL3). There are used different kieselguhr quantities for the same beer volume and is measured filtration time, turbidity and beer color. Experiments showed that a good filtration is ensured by using all three types of kieselguhr. It is important to set a sufficient first layer from 800 to 1000 g/m^2 kieselguhr and continues dosage depending on beer quality and quantity. Based on level of beer turbidity and color after filtration results that optimal doses of kieselguhr for first layer and optimal doses during dosage process are: DIF 67%, CBR 16.5%, CBL$_3$ 16.5% and CBR 40%, CBL3 60%, respectively.

Keywords: kieselguhr, optimal doses, beer, filtration

INTRODUCTION

Beer represents a complex colloidal system. Bad conditions of beer storage cause integration of colloidal particles by their condensation and polymerization. Formed deposit cause colloidal instability of beer and problems with its appearance and shelf life. Chemical, physical, fermentative and mechanical ways of impact on colloidal system of beverages are widely used in modern brewing production for the purpose of product stability increase. Some chemical ways reduce oxidizing processes speed in beer. For this purpose, brew masters use antioxidants, interacting with oxygen from air and preventing oxidation of phenolic beer compounds. Physical and chemical ways are making it possible to remove colloids of various natures by means of adsorbents. In particular, silica gels remove the haze forming proteins and polyvinylpyrrolidone (PVPP) decreases the concentration of phenolic compounds. Besides, such technological operations as separation and filtration could increase colloidal stability of beer. [1]

Filtration of beer, in one form or another, has been practiced for over one hundred years. The process of filtration is a very important step during beer production. The consumer expects a bright and well clarified beer. Turbidity is perceived as a shortcoming in quality, except for unfiltered beers, wheat beer or some other traditional beers.

Kieselguhr is the most important and most widely used filter aid. Haze particles in beer are divided into three groups. Particles >1 μm (e.g., yeasts, coagulated protein and microorganisms) generate a macroscopic visible haze. Colloidal particles <1 μm, which consist of protein, protein tannin complexes, tannins or gums (e.g., β-glucanor hop resins) and which are only visible through refracted light. Particles <0.001 μm, which are not visible and are still in solution.[2]

Over the time filtration technology for beer changed from the old plate and frame filters over horizontal leaf filters to candle filters, which are the most used by breweries. The candle filter is a vertical tank filter with candles. Filter cake is formed on the outside of the candles and filtrate flows up through the tube into the head and out. The candles are cleaned by high rate backwashing often assisted by a hydraulic pump. Filtration is either depth filtration or surface filtration. During surface filtration, the haze particles cannot enter or pass the filter media's pores and are retained on the surface of the filter media. They form a layer which becomes denser during filtration. Because of this, the separation rate is increased. However in contrast, the flow rate decreases.[3]
Depth filtration is based on two complementary effects. On the one hand there is the sieve effect. The haze particles enter the pores of the filter media until a pore reduction stops them. In this case the particle size is larger than the pore size. On the other hand there is the effect of adsorption. Especially small particles are retained through a positive/negative charge.[4]
The grade of particle size and the porosity of the used filter aid influence the flow rate. The finer the filter aid and the higher its porosity, the more accurate the separation and the filtration rate, but the lower the filtration flow rate. Coarse filter aid will produce the opposite result.[4]
The inner porosity of filter aids tends to benefit filtration performance as well as the sieve effect. Kieselguhr is the most important filter aid on the market because of its high inner porosity. However, its crystalline components are the reason for the health hazard of the kieselguhr powder. [5]
Particle removal is dependent on the properties and dosing rate of filter aid, the beer brand and the suspended solids distribution in the green beer. Characterization of filter cake structure should enable prediction of bright beer clarity and thus facilitate the authoritative selection of filter aids. [6]

MATERIALS AND METHODS

Experiments for determination of optimal doses of kieselguhr used as aid filters were carried in an Albanian brewery. Evaluation of filtration tests were performed in laboratory and in brewery. The beer used for the filtration experiments was an unfiltered cold storage bottom-fermented (at 10–12°C) lager with an original gravity of 11.5°Plato, 7.78 EBC color units, turbidity was 7.345 EBC units, and 4.8–5.0% alcohol by volume. All analyses were carried on by the standard work of analytical laboratory methods issued by the European Brewery Convention. [7]

SAMPLE PREPARATION

Beer samples have been degassed prior to be filtered. There is used magnetic stir until
all gas has been released. Beer color was measured with Spectrophotometer and results were expressed in EBC unit. There is used Nephalometer Models 800 and 800P to measure beer turbidity. The instrument was standardized according to Beer-Analytica-EBC 2010 with formazin suspension in EBC units (EBC u.). [8] The amount of turbidity was measured in NTU units and was expressed in EBC unit (1 EBC is equal to 4 NTU). [9]

RESULTS AND DISCUSSION

The purpose of this work was to demonstrate the performance of filter aids in removing particles from beer. Particle removal is dependent on the properties and dosing rate of filter aid, the beer brand and the suspended solids distribution in the green beer. Characterization of filter cake structure should enable prediction of bright beer clarity and thus facilitate the authoritative selection of filter aids.[6]

Green beer was filtered on laboratory and also on candle filter in brewery. There were used three types of kieselguhr for beer filtration: DIF-rough-size kieselguhr, CBR- middle-size kieselguhr and CBL_3 -fine-size kieselguhr

Table 1. The data obtained by filtration of beer with three types of kieselguhr

Kieselguhr	Filtration time(minute)	Turbidity (EBC)	Volume (ml)	Color (EBC)
Kieselguhr amount 2 gr				
CBL_3	24’	0.6051EBC	92 ml	7.8250 EBC
CBR	23’	0.8281 EBC	89 ml	8.00 EBC
DIF	10’	0.9492 EBC	85 ml	8.175 EBC
Kieselguhr amount 5 gr				
CBL_3	24’	0.460 EBC	88 ml	7.325 EBC
CBR	20’	0.556 EBC	86 ml	7.5750 EBC
DIF	11’	0.649 EBC	84 ml	8.550 EBC
Kieselguhr amount 7 gr				
CBL_3	27’	0.3087 EBC	80 ml	8.1750 EBC
CBR	20’	0.4620 EBC	79 ml	8.3250 EBC
DIF	13’	0.5463 EBC	78 ml	8.8500 EBC
Kieselguhr amount 15 gr				
CBL_3	30’	0.4655 EBC	60 ml	8.025 EBC
CBR	22’	0.5218 EBC	57 ml	8.25 EBC
DIF	13’	0.7114 EBC	54 ml	10.475 EBC
Kieselguhr amount 20 gr				
CBL_3	29’	0.6615 EBC	50 ml	7.8500 EBC
CBR	19’	0.7644 EBC	45 ml	8.3000 EBC
DIF	**7’**	0.8673 EBC	42 ml	10.3500 EBC

FILTRATION TRIALS ON LABORATORY CONDITIONS

For each types of kieselguhr used for filtration we weight 2, 5, 7, 15, 20 gr. We added in beaker with 100 ml unfiltered beer the amounts of kieselguhrs, respectively. Filtration of appropriate quantities was performed after a well mixing.

Filtration quality was estimated by determination of filtration time, volume of collected filtrate, turbidity and color of filtrate.

All tests were carried out in the same beer sample. Laboratory tests were performed by five replicates for each amount and types of kieselguhr used for filtration.

The Table 1 show the average values for each experiment performed.

Turbidity of unfiltered beer was in level of 7.3452 EBC units and the color was 7.78 EBC units.

In Figure 1 was noticed that filtration realized with rough –size kieselguhr was approximately twice as fast as middle –size kieselguhr and about three times faster than fine-size kieselguhr filtration time.
It was noticed that difference in filtration time was increased significantly with the addition of kieselguhr.

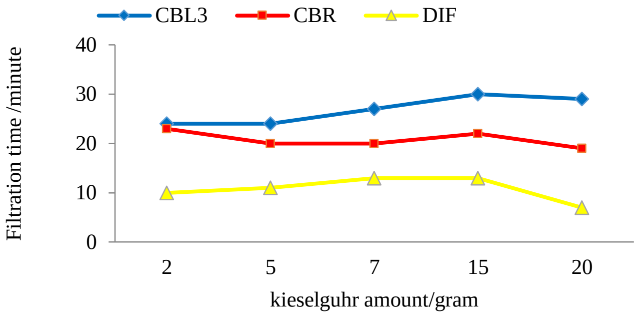

Fig 1. Filtration time for each type of kieselguhr and quantities

Filtrate volume was an important parameter in order to calculated flow rate. The optimal values of filtrate volume were achieved when 7 grams of each type of kieselguhr were used. As shown in Figure 2, the addition in kieselguhr quanties increased losses in filtrate volume.

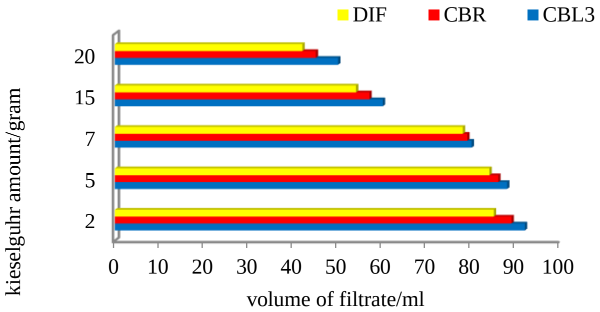

Fig 2. Volume of filtrate for each types of kieselguhr and quantities

In Figure 3 were noticed good results of beer color filtered with fine-size kieselguhr. As shown in figure 4, usage of 7 gram of fine-size kieselguhr gave us turbidity in optimal value. There were obtained high values of beer turbidity during rough –size kieselguhr filtration.

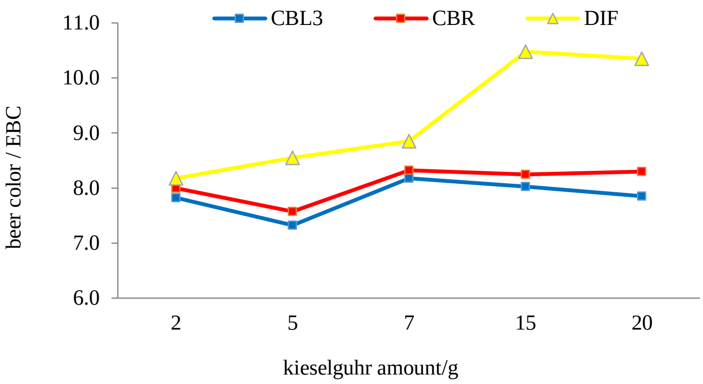

Fig 3. Beer color for each type of kieselguhr and quantities

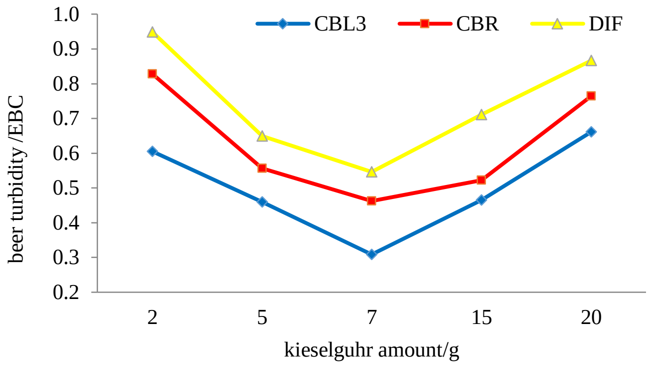

Fig 4. Beer turbidity for each type of kieselguhr and quantities

Lower turbidity values and shorter filtration time the better beer filterability. [10] To determinate the optimal quantities of kieselgurs used for filtration should be taken account both results of Figures 1 and 4. They showed clearly that shortest filtration time was followed with higher turbulence values, while the lowest turbidity values were obtained in relatively long filtration time.

FILTRATION TRIALS BY MIXING THREE TYPES OF KIESELGUHRS

There were conducted three experiments by mixing all kieselguhr types in the same green beer and volume sample. During those experiments were prepared the filter cake and a mixture of kieselguhrs for dosage during filtration.

For each experiment was determinate filtration time, volume of filtrate and beer turbidity. As lower turbidity level and shorter filtration time the better beer filterability. There were taken into account beer turbidity and filtration time because both are most important factors to determinate filterability. As results, we selected experiment 1 as best one which gave optimal values.

Filtration trials in brewery were conducted based on experiment 1.

Table 2. The data obtained by filtration of beer with mixing of kieselguhrs

No	Filter cake	Filtration dosage	time (min)	volume (ml)	turbidity (EBC)
Exp 1	2g CBR + 2g DIF	2g CBR + 2g CBL_3	18	78	0.432
Exp 2	2g CBR + 2g DIF	4g CBL_3	24	84	0.378
Esp 3	2g CBR + 2g DIF	4g CBR	16	82	0.643

Table 3. Kieselguhrs rate in precoating and dosage used in candle filters

	Precoating	
Kieselguhr	Filtration I	Filtration II
DIF	67,0%	47,0%
CBR	16,5%	16,5%
CBL_3	16,5%	36,5%
	Dosage	
Kieselguhr	Filtration I	Filtration II
CBR	40%	20%
CBL_3	60%	80%

Table 3 show two filtration trials with candle filters in brewery. First filtration was considered better then second one because it provided a flow rate as much as optimal value of filter flow (4 $HL/m^2/h$), difference pressure remained within working parameters and beer turbidity was about 0,345EBC unit during all filtration period.

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