ABSTRACT

As science progresses, brewing technology continuously changes. The industry introduces numerous modifications (pertaining raw materials, the process itself, as well as the machinery), making the production process suitable for the current needs of the market. Changes in the properties of semi-products impact the quality of the final product, hence the need for research.

Beer wort should have such properties and parameters, so that its fermentation process is correct, and the resulting beer is of the right quality. The clarity and the correct ion content, both of which are analyzed in this paper, are crucial for the correct yeast metabolism, therefore impacting the quality of the product.

This paper aims to determine the impact of the amount of the chosen non- malted raw materials (barley and spelt), as well as the impact of water's mineral content on selected fundamental physicochemical parameters and ion content of beer worts. Technological aspects of beer wort clarification for each variant were verified by the effectiveness of hot trub sedimentation. Innovative structural solutions have been designed, aiming to improve the currently used methods of hot trub separation in a cycling vat.

The aim of the research was to determine the impact of the non-malted raw material content on the beer wort clarification process using a cycling vat. Special attention was directed towards the concentration of selected metal ions (Ca^{2+}, Mg^{2+}, Zn^{2+}, Mn^{2+}), physicochemical parameters (ph, colour, extract, turbidity, the worts' volume, approximate effectiveness of the brewery as well as the mass of the separated hot trub). The secondary objective of the PhD dissertation was to determine the effectiveness of the introduced structural modification of the cycling vat's tank in relation to the improvement of the flow during the separation process. The modification was supposed to allow to make better use of the beer wort and hot trub separation process.

The research done as part of the PhD was performed in three stages. The first one used a laboratory to produce laboratory malted beer worts (control tests) with deionized water and technological water from a brewery, as well as with water with different amounts of non-malted material (barley and spelt). On different stages

of the production (mashing, filtration, boiling and hot trub separation) physicochemical parameters of the beer worts were determined (pH, colour, extract, turbidity). An approximate effectiveness of the brewery was determined based on the volume of the worts after filtration. The clarified worts as well as the hot trub removed from them were analyzed for the concentration of selected metal ions (Ca^{2+}, Mg^{2+}, Zn^{2+}, Mn^{2+}).

The second stage was the experimental research using PIV (Particle Image Velocimetry). It used a research method which included laser-illuminated seeding particles in order to analyze flow's velocity field. Separation cycles were performed for 7 different baffle geometry variants. The variables were the filling rate of the separator as well as the position of the baffle in relation to the feeding inlet's placement. The most advantageous solutions were recognized after performing all separation cycles and obtaining maps of velocity vector field and its distribution.

The next stage involved experimental research with tanks in half-technical scale. The cycling vat had a baffle chosen on the basis of the previous stage of research. Only worts with malted barley, and 30% non-malted material content (barley) were used for the clarification process.

Based on the obtained results it was determined that using non-malted cereal raw material (barley or spilt), especially with more than 15% contribution, caused an increase of the time needed for the mash solidification and filtration, a decrease of the beer worts' volume after filtration and smaller approximate brewery effectiveness in comparison to tests with 100% contribution of malted barley. Another drawn conclusion was that use of non-malted raw material (barley or spilt) in the load (15 to 30%) causes an increase of the hot trub sedimented in wort during boiling, in comparison to solely using malted barley. Beer worts produced with technological water had almost two times smaller concentration of Mg^{2+} ions, in comparison to worts with deionized water (irrespective of the non-malted material content). The Mn^{2+} ions concentration in the wort depends on the type of used water (in the case of the technological water it was higher than in the deionized water). The addition of non-malted barley in the load caused an increase of manganese ions concentration in the wort (regardless of the type of used water). A substantial amount

of wort's zinc ions is lost with hot trub – both in the case of technological and deionized water, and irrespective of the non-malted raw materials' contribution in the load.

Using the baffle as a cycling vat tank's structural modification helped to reduce the time during which the primary flow was present, which has higher velocity values, and is located closer to the tank bottom's center. The most advantageous structural design helped to improve beer wort clarification in a cycling vat. It allowed to achieve a more focused hot trub cone in the central part of the tank.