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REGULAR ARTICLE

EFFECT OF TEMPERATURE ON THE PROCESS OF BEER PRIMARY FERMENTATION

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ABSTRACT

Beer is a very popular and widespread drink worldwide. Beer may be defined as a foamy alcoholic drink aerated by carbon dioxide that is formed during fermentation. Sensorial and analytical character of beer is mainly formed during process of primary fermentation. Our work has monitored the influence of temperature of fermentation substrate on the process of primary fermentation during beer production. Obtained values of temperature and apparent extract out of four brews of 10% light hopped wort has been recorded, during the process of primary fermentation carried out in mini brewery of SPU. We have compared our results with theoretical values of primary fermentation process commonly achieved in conditions of industrial breweries. It was found out that our results differ in some ways, moreover they exceed theoretically given values which was caused due to different construction of mini brewery fermentation tank in comparison with industrial brewery technologies. Beer produced in mini brewery of SPU showed in sensorial tests very good quality without any strange odour and any strange taste.

Keywords: temperature, primary fermentation, beer, apparent extract, yeast, saccharization

INTRODUCTION

In brewing, the primary fermentation is one of the longest stages as well as an important aromatic compound production step. Indeed, fermentation has the main impact on process productivity and product quality (**Landaud *et al*., 2001; Davis *et al*., 2008**). The fermentation of beer is an inherently variable process, affected by factors such as the raw ingredients composition and the yeast characteristics. In practice, this means that fermentation times can vary considerably between batches of the same beer quality (**Siebert, 2001**).

The main consideration in primary fermentation is to ferment wort to the desired gravity (degree of attenuation) in the required period of time. This is largely achieved first by accurate pitching of wort and secondly, by controlling the temperature of the process (**Lewis, Young, 2002**). According to **Brown, Hammond (2003)** common practical approaches toward fermentation intensification include use of high temperatures, high yeast pitching rates and high wort gravities. Increases in temperature and pitching rate enhance the rate of fermentation by promoting yeast growth. However, these straightforward approaches have a number of disadvantages including altered beer flavor at the end of primary fermentation and detrimental effects on yeast viability and vitality (leading to poor successive fermentation performance) (**Stewart, 2001; Pratt-Marshall *et al.,* 2002**).

Optimal fermentation temperature during bottom fermentation is in interval 5 to 16°C. Increase of temperature with regard to bottom fermentation could cause increased activity of yeasts, deterioration of foam stability, beer colour, decrease of pH and higher lost of bitter compounds. Optimal speed of fermentation means that decrease of extract within 24 hours should not exceed 1.5% by weight. Temperature should not fall faster than 1°C within 24 hours so that fermentation won’t be interrupted (**Basařová *et al.,* 2010, Basařová, 2002**). Temperature regulation is in practice one of the most effective tool to modify speed of fermentation. If temperature is changed from 10 to 13°C and than it is tempered at 14°C, in the last stage of fermentation, the process of fermentation could be shorten about 28.8 hours, found out **Šepeľová (2004).** This change even improves sensorial properties of beer.

For yeast to live and grow, wort must contain a sufficient supply of nutrients. Yeast needs fermentable carbohydrate, assimilable nitrogen, molecular oxygen, the vitamin biotin, source of phosphorus and sulfur, calcium and magnesium ions, and trace elements such as cooper and zinc ions (**Lewis, Young, 2002**).

The objective of our study was to monitored influence of the fermentation substrate temperature on the process of primary fermentation during beer production.

MATERIAL AND METHODS

Beer preparation

Beer was prepared in mini brewery of Slovak University of Agriculture in Nitra. Light hopped wort with concentration of 10% was prepared using infusion mashing system of brewing and consequently the fermentation process of hopped wort was carried out.

Measurement

Saccharization of initial wort and apparent extract of fermented hopped wort were measured using saccharometer. Saccharometer was dipped into sample of prepared initial wort that was firstly rid off CO_2 bubbles. Sample of wort had 20°C to be measured. Values of saccharization and apparent extract were taken off saccharometer.

Temperature measurements of fermented hopped wort were carried out by thermometer. From results of temperature and apparent extract diagrams of fermentation process were arranged. We have compared our results with theoretical values of primary fermentation process commonly achieved in conditions of industrial breweries (Figure 1).

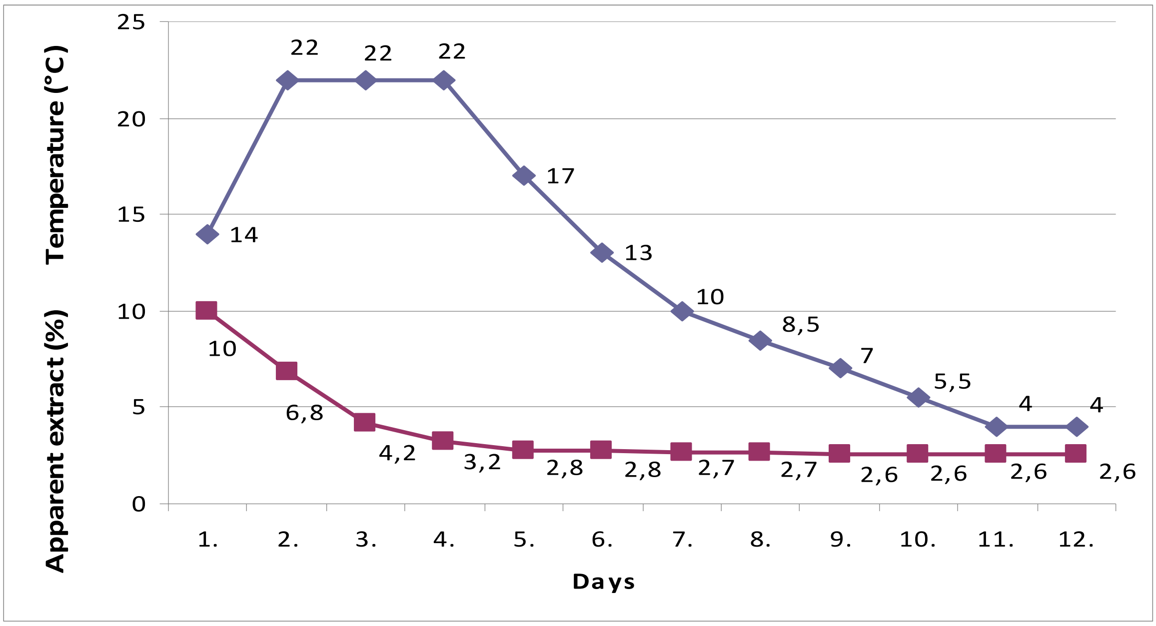

Figure 1 Theoretical fermentation process - development of temperature and apparent extract during boiling of hopped wort

RESULTS AND DISCUSSION

Figure 2 presents fermentation process of 10% light hopped wort. Initial pitching temperature was 14°C and within 24 hours it raised up to 22°C. This temperature stayed at this level within 2 days and value of apparent extract was 3.2%. Due to this temperate we started to cool down the brew thus we regulated whole process to reach value of apparent extract 2.6%. Minimal temperature that was achieved was 4°C. As we compare process of primary fermentation of 10% light hopped wort with theoretical process (Figure 1) we found out some deviations in comparison with theoretical process due to strong temperature cut-down after fourth day that fall from 22 to 12°C. This problem did not affected values of apparent extract which represented 2.8% (figure 2).

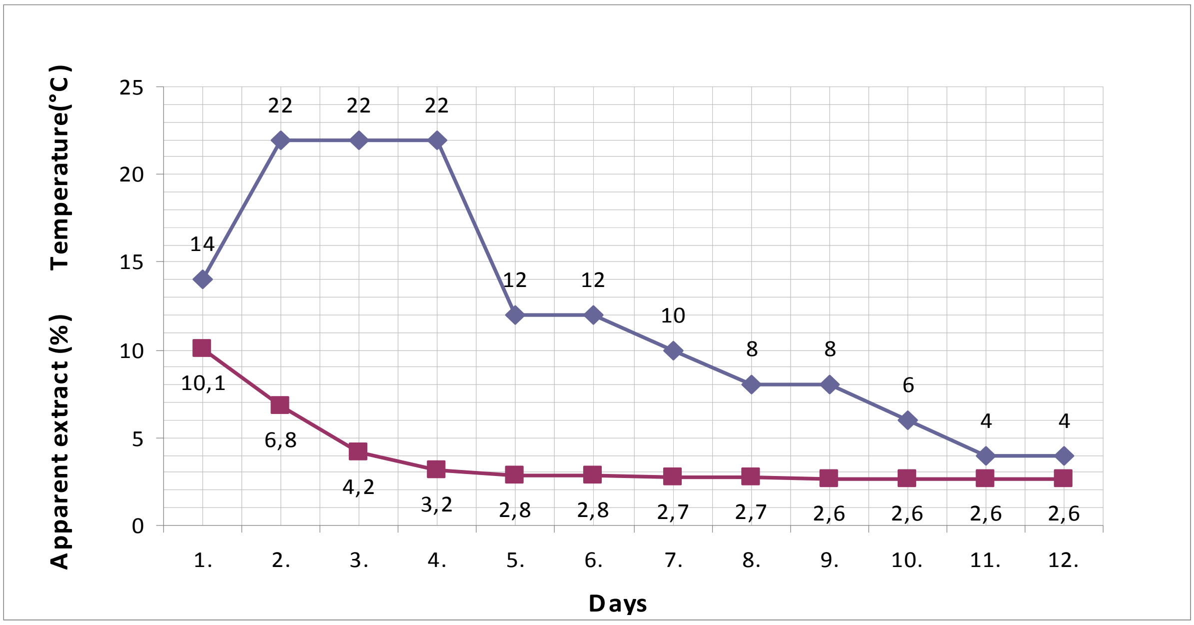

Figure 2 Development of temperature and apparent extract during hopped wort boiling – the first brew

Form figure 3 we can observe that pitching temperature represented 12°C. By spontaneous fermentation process without cooling, the temperature reached 20°C in 24 hours. We could see that lower initial fermentation temperature affected the whole process of fermentation. In comparison with theoretical fermentation process, the pitching temperature was about 2°C lower. Values of apparent extract were not affected. According to **Brown, Hammond (2003)** increases in temperature and pitching rate enhance the rate of fermentation by promoting yeast growth. However, these approaches have a number of disadvantages including altered beer flavor at the end of primary fermentation.

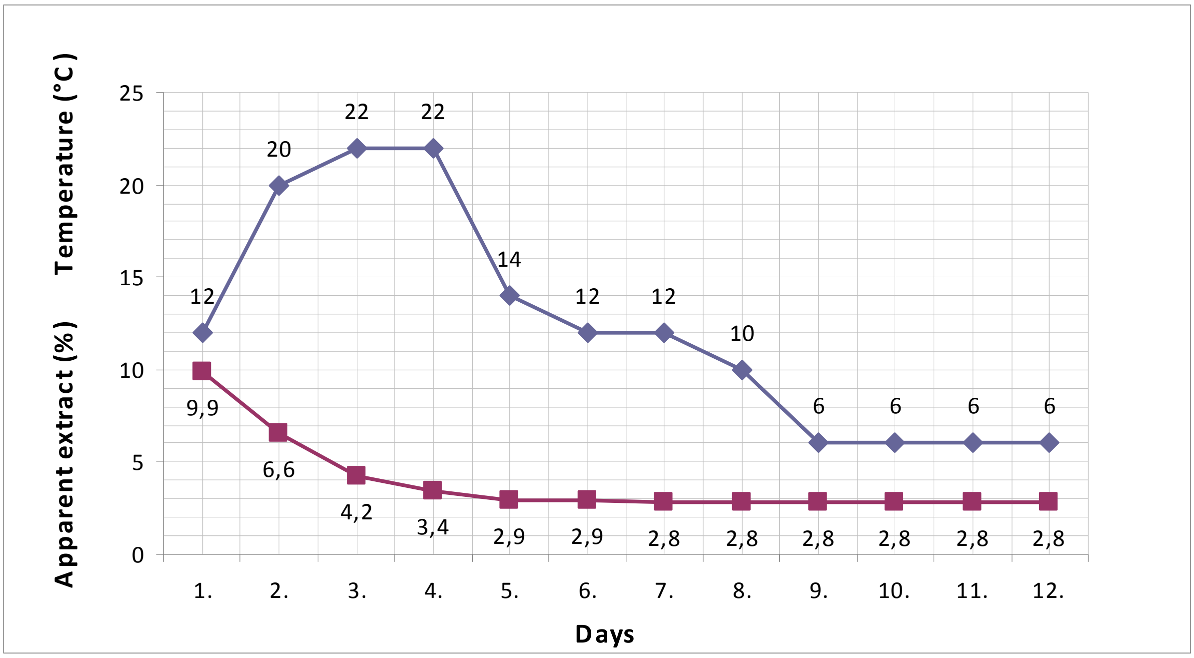

Figure 3 Development of temperature and apparent extract during hopped wort boiling – the second brew

Initial fermentation temperature (16°C) of boiled and cooled hopped wort presents figure 4. During 24 hours the temperature of fermentation medium increased to 22°C. This temperature remained stable 48 hours and during this time value of apparent extract reached 3.2%. This value is considered as optimal value because after finalization of fermentation process the value of 2.6% of apparent extract should be reached. In our case the value of apparent extract represented 2.7% that is about 0.1% higher as theoretical process even if temperature of fermentation was 6°C. However, this difference is minimal. As we compare process of primary fermentation of figure 4 with theoretical process, we could notice only minimal deviation in comparison with theory. Despite this fact, the final product (beer) achieved very good qualitative parameters. According to **Basařová *et al.*, (2010)** temperature regulation is in practice one of the most effective tool to modify speed of fermentation and final sensorial properties of beer.

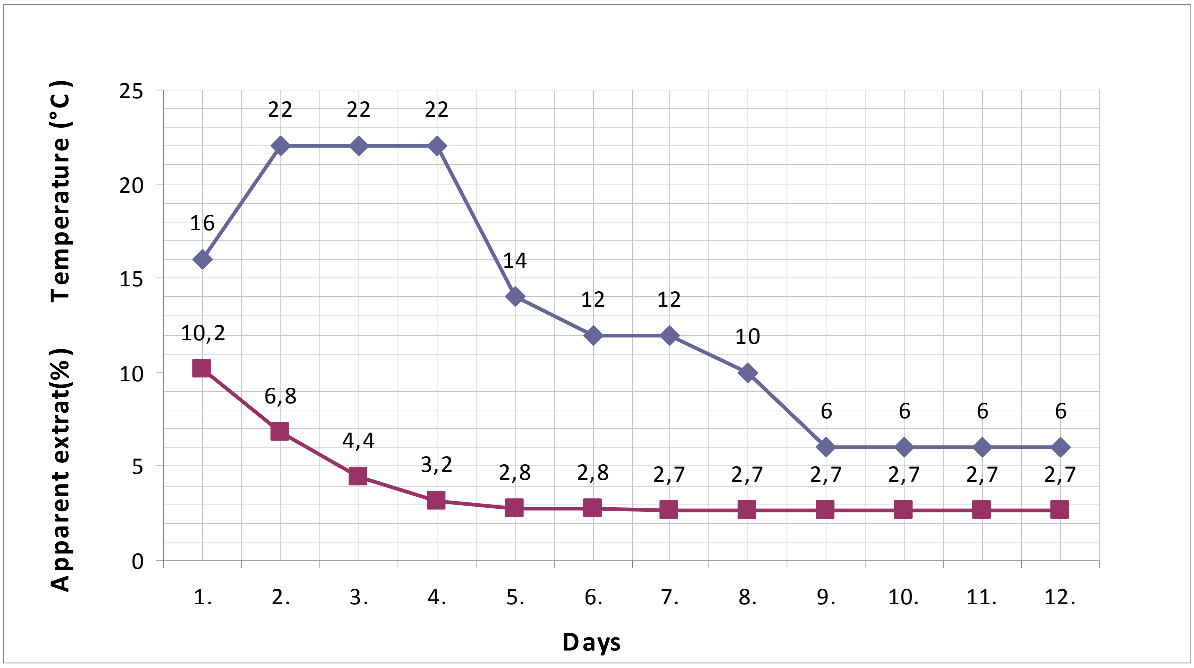

Figure 4 Development of temperature and apparent extract during hopped wort boiling – the third brew

Next brew fermentation process presents figure 5. Initial fermentation temperature was 15°C and second day it raised, without cooling the fermentation medium, up to 22°C. During next two days it reached 23°C. Value of apparent extract was 3.3%. Next day we started with cooling down the hopped wort.

If we spontaneously leave temperature to increase, in the first phase of primary fermentation, we could reach the value of 23°C. One of the arrangements to protect against pressure collision is to open the tap on blocking device that assure outflow of generating CO_2 into space and this prevent against increase of pressure in tank. On the other hand we can confirm findings of **Kelner *et al.* (2000)** who claims that amount of vicial dicetons expressed by limited value of diacetyl 0.1 mg.dm^{-3} decreases by using such higher temperatures. This value of diacetyl is given by threshold sensitivity of human body to feel its presence in evaluated samples. Also according to **Kosař and Procházdka (2000)** an important element that lowers number of diacetyl during fermentation is the temperature.

In comparison with theoretical process, during first days of fermentation, we recorded small increase in temperature just about 1°C and moreover values of apparent extract were higher only about 0.1%.

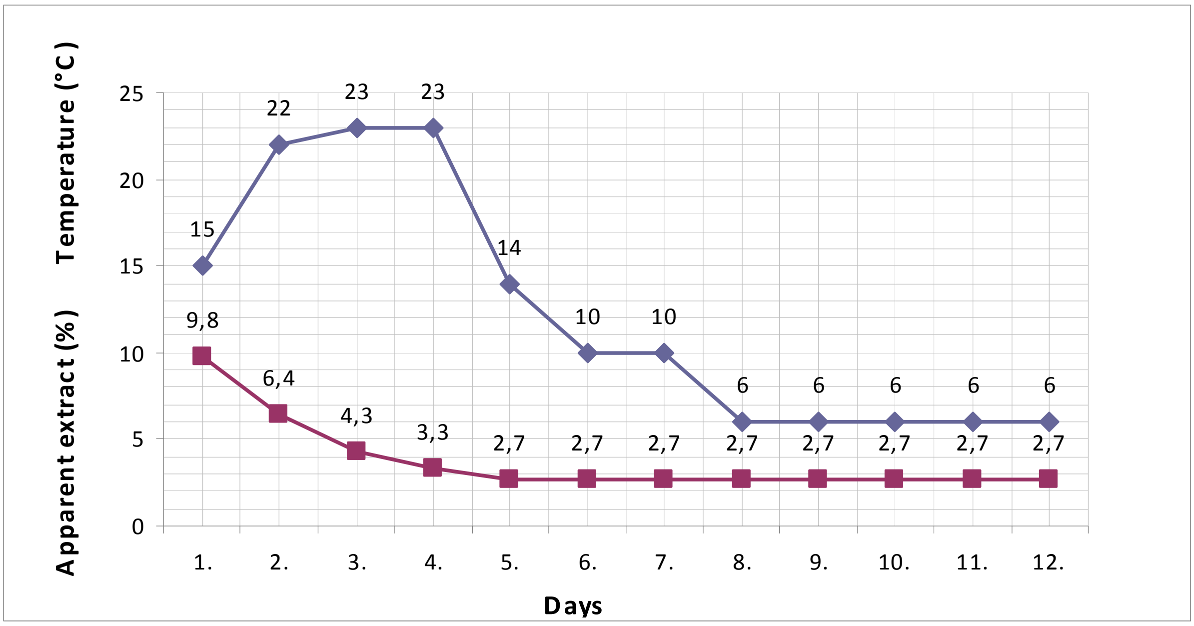

Figure 5 Development of temperature and apparent extract during hopped wort boiling – the fourth brew

According to obtained results, if we compare real process of primary fermentation with theoretical process we can observe that increase of pitching temperature just about 1 or 2°C means increase of maximal value of whole fermentation process about 1°C. At the end of fermentation process it was reached 23°C instead of 22°C. This little deviation did not have any influence on the fermentation process whereas values of apparent extract relatively to great extent mapped values of theoretical fermentation process. According to **Basařová *et al.*, (2010)** optimal speed of fermentation means that decrease of extract within 24 hours should not exceed 1.5% by weight. Temperature should not fall faster than 1°C within 24 hours so that fermentation won't be interrupted.

Form our results we can state that recorded deviation not even affected final sensorial and analytical quality of beer made in mini brewery of SPU. Presented fact needs to be constantly controlled mostly by sensorial evaluation of produced beer which is an important criteria of its quality.

CONCLUSION

With development of new technologies in brewing industry it is important to care about quality that relates to yeast nutrition as well as to fermentation. Therefore it is necessary to provide standard wort for the fermentation process with balanced amount of positive compounds entering the process of primary fermentation.

From our results we can conclude that even maximal value of pitching substrate (14°C) that is limited for industrial breweries was not kept, we manage to create new (different) technological diagram. This diagram was arranged by approach to keep maximal temperature mostly in the first stage of fermentation. We managed to produce final product (beer) with very good sensorial quality which was one of the most important goals of our work. At the base of hopped wort fermentation process we created theoretical diagram of fermentation process (10% hopped wort) that could be used as pattern for future brews produced in conditions of SPU mini brewery due to different construction of mini brewery fermentation tank in comparison with industrial technologies.

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