Effect of cherry products addition on beer fermentation

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Abstract. Fruits has been used in brewing as a source of sugars, colour and flavour. Cherry (Prunus avium L.) products such as juice and pomace can be used in brewing in order to increase beer biological value. In this study, cherry juice and pomace in concentration of 15% were added at first and seventh day of beer fermentation. The effect of cherry products addition was investigated by measuring the content of yeast metabolites (ethanol, aldehydes, higher alcohols, esters, and vicinal diketones) in cherry beers and control sample without cherries. The alcohol content in all the cherry beers was higher than the control sample. The cherry juice addition at the beginning of fermentation led to the formation of more secondary metabolites than the control. Cherry juice addition at the seventh day of fermentation resulted in a decrease in higher alcohols and esters concentration, but in an increase in carbonyls concentration compared to the control. Cherry pomace addition led to a significant increase in esters and vicinal diketones concentration. Aldehydes concentration was not affected by cherry pomace addition. Higher alcohols were influenced only by pomace addition at the seventh day of fermentation. Sensory evaluation was also made because yeast metabolites affected beer flavour and aroma.

1 Introduction

Fruit beer is a special beer, produced with fruit addition during fermentation, maturation, or the refermentation process [1]. Fruits has been used in brewing as a source of sugars, colour and flavour [2]. Various fruits can be added to beer, such as drupes (cherries, peaches, mangoes, etc.), pome fruits (pears, apples, etc.), tropical fruits (pineapples, bananas, etc.), and berries [3]. They can be added directly, as a fruit extract, and as fruit-flavoured additives [4].

Sweet cherries (Prunus avium L.) can be added in beer production as a whole fruit, fruit juice or puree [5-7]. Sweet cherries contain simple sugars and analogues (glucose, fructose and sorbitol), organic acids (malic and succinic acids), dietary fibers, carotenoids, melatonin, quercetin and other valuable elements. Furthermore, they have vitamins C, B, A, E and K. Cherries also include minerals (calcium, magnesium, phosphorus and potassium) [8].

The chemical composition of cherries can affect brewer’s yeast metabolism. Brewer’s yeast produce big spectrum of secondary metabolites, which form beer flavour profile. Some of them as higher alcohols and esters are desirable volatile constituents of beer but others as vicinal diketones and aldehydes contribute to flavour defects of beer [9]. During beer production, it is important to assure that the active substances contributing to beer flavor are kept within certain limits as modifications to one or more compounds can directly affect the flavor profile [10].

The aim of this study is to investigate the effect of cherry juice and pomace addition on first and seventh day of fermentation on yeast metabolism. Therefore, the concentration of ethanol, higher alcohols, esters, aldehydes, and vicinal diketones in the final beer were measured and compared to control samples without cherry products addition. Sensory evaluation of beer was also made because secondary yeast metabolites contributed to beer flavour and aroma.

2 Materials and methods

2.1 Raw materials

Pilsner malt (Weyermann, Germany) and Perle and Cascade hops (Bulhops, Bulgaria) were used for wort production. Wort was fermented with dry yeast Saccharomyces pastorianus Saflager W 34/70 (Fermentis, France). The sweet cherries (Prunus avium L.) were purchased in a frozen state from Bullfrukt Ltd., Bulgaria, and kept at -18°C.

2.2 Wort production

Coarsely ground Pilsen malt (15 kg) and 55 L water were mashed in Home Brew 50 (all-in-one 50 L brewing system (TM INOX, Bulgaria)). Mashing was conducted by increasing the temperature by 1°C/min and maintaining rests at the following temperatures: 20 minutes at 60°C, 20 minutes at 65°C, 25 minutes at 72°C, and 1 minute at 78°C. Lautering, sparging and boiling were carried out in the same Home Brew 50. Hopping was carrying out by adding 20 g Perle at the beginning of boiling and 17.14 g Cascade at the end of the boiling in order to achieve 60 mg/L α-bitter acids. After hot trub removal the wort with extract 14±0.5°P was cooled to the fermentation temperature.

2.3 Beer fermentation

The wort was aerated and transferred into a stainless steel cylindroconical fermenter (TM INOX, Bulgaria). After yeast pitching according to manufacturer’s instruction wort was divided to 5 equal parts, transferred to small fermenters, where cherry juice and pomace were added in concentration of 15% according to Table 1.

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2.5 Sensory evaluation

Sensory evaluation of the beverages was performed by a trained 5-member tasting panel. The samples were evaluated 14 days after bottling using a “beer gun” (Blichmann Engineering, USA).

2.6 Statistical Analysis

The results are the mean values of at least three analytical determinations, and the coefficients of variation expressed as the percentage ratios between the standard deviations and the mean values were found to be <5% in all cases. The means were calculated with Microsoft Excel™ at a 95% confidence level. One-way ANOVA and Scheffe’s multiple range test as described by Donchev et al. [14] at p < 0.05 were used too.

3 Results and discussion

The results for main beer characteristics are presented in Table 2. The addition of cherry products led to an increase in beer original extract with 0.4% (w/w) regardless of the cherry product type. According to [15] total soluble solids (TSS) in sweet cherries varied between 14 and 20% (w/w). The fermentable sugars by brewer’s yeast (glucose, fructose and sucrose) represented between 60 and 80% of TSS. The added sugars from cherry products were fermented, which resulted in an increase in alcohol content in beers with cherries (Table 2).

Higher alcohols, also known as fusel alcohols, contribute to beer flavour by intensifying alcoholic perception and imparting a warm mouthfeel. The major higher alcohols are produced via two pathways: the anabolic pathway (Harris) that catalyzes glucose through intermediates (α-keto acid) and the catabolic (Ehrlich) pathway which uses branched-chain amino acids (valine, leucine, isoleucine) and aromatic amino acids (phenylalanine)[16,17]. The results for higher alcohols concentration in beers produced are presented in Figure 1a. Cherry juice addition at the beginning of fermentation led to almost 1.5-times increase in higher alcohols concentration but the results for beer produced with cherry pomace at the beginning of fermentation were similar to the control. It can be explained by higher concentration of fermentable sugars in cherry juice than the pomace, which can be transformed to higher alcohols by anabolic pathway. The latter predominates when medium contains more sugars than aminoacids [18]. The results for higher alcohols in beers with cherry juice and pomace at seventh day of fermentation were similar and were lower than the control. This is due to the fact that over 90% of the higher alcohols have been built at the end of main fermentation [19].

Esters contributes to the fruity/flower characteristics of beer flavour. They are usually produced by enzymatic condensation of higher alcohols with active fatty acyl-CoA [19]. Figure 1b shows the data for ester concentration in beers produced. As a whole, the addition of cherry products affected ester synthesis positively. The main reason is the large amounts of reducing sugars which are served as precursors for the synthesis of esters [3, 15]. Moreover, esters are synthesized not only during main fermentation but also during maturation [19]. The exception was beer with cherry juice added at the seventh day of fermentation. It is interesting to note that the same trend was observed in higher alcohol synthesis. Therefore, it can be assumed that there were not enough available higher alcohols for ester synthesis.

Carbonyl compounds significantly affect beer flavour and aroma because their low threshold and unpleasant aroma. The most important compounds are aldehydes and vicinal diketones. Aldehydes concentration can increase due to the large amounts of reducing sugars which contribute to beer flavour by intensifying alcoholic perception and imparting a warm mouthfeel. The major higher alcohols are produced via two pathways: the anabolic pathway (Harris) that catalyzes glucose through intermediates (α-keto acid) and the catabolic (Ehrlich) pathway which uses branched-chain amino acids (valine, leucine, isoleucine) and aromatic amino acids (phenylalanine)[16,17]. The results for higher alcohols concentration in beers produced are presented in Figure 1a. Cherry juice addition at the beginning of fermentation led to almost 1.5-times increase in higher alcohols concentration but the results for beer produced with cherry pomace at the beginning of fermentation were similar to the control. It can be explained by higher concentration of fermentable sugars in cherry juice than the pomace, which can be transformed to higher alcohols by anabolic pathway. The latter predominates when medium contains more sugars than aminoacids [18]. The results for higher alcohols in beers with cherry juice and pomace at seventh day of fermentation were similar and were lower than the control. This is due to the fact that over 90% of the higher alcohols have been built at the end of main fermentation [19].

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The results of aldehydes concentration in beer produced are shown in Figure 1c. Cherry juice addition affected significantly aldehydes content in beer. The increase was higher when the juice was added at the beginning of fermentation. The aldehydes concentration in beers with cherry pomace was almost equal to the control one. Higher aldehydes concentration in beers with cherry juice can be explained with higher sugar concentration of cherry juice than pomace.

From the group of vicinal diketones only diacetyl (2,3-butanedione) and 2,3-pentanedione affect significantly beer flavour and aroma. They are formed during beer fermentation as byproducts of amino acid synthesis (valine and isoleucine, respectively) in Saccharomyces yeast and are responsible for the butter- or butterscotch-like flavour [21]. Data for vicinal diketones in beer produced are presented in Figure 1d. The vicinal diketones concentration in all the beers with cherry products was higher than the control one. Although it is generally considered an off flavour and unwanted in beers, the sensory perception of diacetyl is highly dependent on the beer matrix and style, being particularly detectable in lager beers [22].

This can be confirmed by the sensory evaluation of beer. Although its highest vicinal diketones concentration, the sample with pomace added at the beginning of fermentation was preferred by the 5-member tasting panel. The reason was the more pronounced fruity notes in the aroma which were attributed to the highest ester concentration. These fruity notes appeared in all the beer with cherry products addition. However, all the beers with cherry pomace received higher marks for the aroma/taste balance, and had more harmonious aroma and taste, compared to those with cherry juice addition. Also the beers with pomace possessed more freshness, because of the higher sour taste and aftertaste.

4 Conclusion

The effect of cherry juice and pomace addition at first and seventh day of fermentation on the amount of some brewer’s yeast metabolites as ethanol, higher alcohols, esters, aldehydes, and vicinal diketones was investigated. The results showed that the higher ester concentration in beers with pomace made them preferable to the tasting panels than beers with cherry juice. Although the highest concentration of vicinal diketones in beer with cherry pomace added at the beginning of fermentation, this beer received the highest score from the panel. Therefore, it can be concluded that synergism of yeast metabolites produced during fermentation affected significantly beer flavor.

This research was funded by the University of Food Technologies, Plovdiv, Bulgaria (research grant 05/19-H).

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