EFFECT OF ADDITIONAL MANGO PUREE RATIO ON CRAFT BEER FERMENTATION

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ABSTRACT

The study was conducted to investigate the effect of the additional mango puree ratio to malt (30, 45, 60 and 75%, w/w) on the quality components of craft beer. The quality components including the content of bioactive compounds, total sugar, total acid, protein, ethanol, color parameters and sensory values of the product were analyzed. Results showed that the optimal additional mango puree ratio was 60% w/w. At this optimal condition, the product had the most harmonious sensory values in terms of taste, color and preference level. In addition, the product contained polyphenol 1.22 g GAE/100g dry matter-DM, flavonoid 0.85 g QE/100g DM, carotenoids 1.19 mg/g DM, protein 1.91% DM, total sugar 70.01% DM, total acid 0.43% DM and ethanol 5.49% v/v. The color parameters such as L*, a*, b* and ΔE were 40.31, -4.33, 1.45 and 53.32, respectively.

Keywords: *Bioactive compounds, craft beer, chemical components, color parameters, mango puree, sensory value.*

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1. INTRODUCTION

Beer is the most consumed alcoholic beverage in the world and the third most popular beverage after water and tea [1]. Craft beer is a fermented beverage produced from dried germinated grains (malt), water, yeast, and hops. Over the past decade, consumer interest in craft beer has increased globally, especially traditional and low-alcohol beers with distinctive flavors, quality values, and unique sensory characteristics [2]. Today, consumers are looking for authentic, unique, differentiated, and high-quality products. Craft brewers have responded to this by incorporating raw or germinated grains, and have modified the taste of beer by adding fruits, aromatic herbs, and health-promoting properties. Consumer's interest in craft beer has emerged in some countries and sales of this type of beer have increased faster than industrial beers [3]. In Vietnam, craft beer has also recently attracted the attention of consumers, especially young people in big cities.

Mango (*Mangifera indica* L.) is a fruit which is rich in fiber, vitamins A and C, essential amino acids and many bioactive phytochemicals such as polyphenols, terpenoids, carotenoids and phytosterols that are found in the leaves, bark, fruit pulp, peel and seeds with antioxidant, anti-inflammatory, immunoregulatory, antibacterial, antidiabetic and anticancer effects [4]. Nutritional compositions in 100g of mango (edible part) include water 82.6%, lipid 0.3%, glucid 14.1%, protein 0.6%, ash 0.6% and cellulose 1.8%. Mineral and vitamins content include Ca 10mg, P 13 mg, Mg 9 mg, Fe 0.4 mg, K 114 mg, Na 2 mg, Zn 0.56 mg, Se 0.6 µg, beta carotene 445 µg, vitamin C 30 mg, vitamin K 4.2 µg, vitamin E 1.12 mg, folate 14 µg, vitamin B3 0.3 mg, vitamin B5 0.16 mg, vitamin B5 0.13 mg [5]. Three-color mango (Taiwanese mango) is popularly cultivated in Cho Moi district, An Giang province. The fruit flesh is thick with little fiber, thin flat seeds and light sweet taste. Mango is consumed not only in fresh, but also in processed types such as mango jam, dried mango, mango juice [6].

This study focuses on investigating the effect of added mango puree ratio in the craft beer production process on the sensory value, color parameters, content of bioactive compounds, chemical components, and ethanol concentration of the wort after five days fermentation. The results of the study will contribute to improve the mango craft beer production process.

2. MATERIAL AND METHOD

2.1. Sample preparation and experimental setup

Preparation of mango puree: Three-color mangoes were directly collected from farmers in Cho Moi district, An Giang province (fruit weight ranged from 0.5 ÷ 1.0 kg) and let to ripe for 4 days at room temperature. Ripe mangoes were peeled, the pulp was extracted, and then blended with water at a 1: 1 weight ratio for 5 minutes to produce mango puree, which was then frozen for use as the study's raw material. The brix and pH of Mango puree are 9.5 and 6.2, respectively.

Preparation of research samples: Malt (Base malts, Château Munich Light) is is ground with each sample of 1 kg of malt was used with water/malt ratio of 4/1 (v/w). The pH value of the mash was adjusted to 5.5 with lactic acid and $CaCl_2$ at 85 mg/L [7]. Mashing was carried out at 50 ÷ 55°C for 30 minutes; 60 ÷ 65°C for 30 minutes and 70 ÷ 75°C for 30 minutes [8]. Hops were added at ratios of 0.15% (w/v) and boiled for 60 minutes. Then, mango puree was added at different ratios (30, 45, 60 and 75% (w/w) compared to original malt and heating at 95°C for 5 minutes. When the temperature of the mixture of malt, hops and mango puree dropped to about 40°C, it was put into a fermentation tank, ratio of yeast (Fermentis Saflale-S04) was added at a concentration of 0.2% and fermented at room temperature (25 ÷ 30°C) for 5 days. Samples were collected by cold centrifuge method and the following parameters were analyzed: sensory evaluation (color, taste and preference); measures color parameters (L*, a*, b*), content of bioactive compounds (polyphenols, flavonoids and carotenoids), chemical composition (total sugars, total acids and proteins) and ethanol concentration.

2.2. Analytical methods

- Sensory evaluation (color, taste and liking level) according to the descriptive scoring method [9]. Color parameters (L^*, a^*, b^*) were measured using a Chroma Meter (Konica Minolata, CR-400, Japan) and ΔE represents the total color difference compared to the white blank plate [10]. The ΔE value was calculated according to formula (1):

$$\Delta E = \sqrt{(L_0 - L^*)^2 + (a_0 - a^*)^2 + (b_0 - b^*)^2}$$

In which: L_o, a_o, b_o are the measured values of the blank sample and L*, a*, b* are the measured values of the experimental sample.

- Analysis of biological compounds: Polyphenols were determined by the Folin-Cioaclteu method [11], the results were expressed as grams of gallic acid equivalent per 100 grams (gGAE/100g); flavonoids were determined by the Aluminum Chloride Colorimetric method [12], the results were expressed as grams of quercetin equivalent per 100 grams (gQE/100g); carotenoids were determined by the method described by Singh (2014) [13], the results were expressed as mg/g DM.

- Chemical composition: Protein content was determined by the method described by Talreja (2011) [14], the results were expressed as g/100g DM; Total acid was determined by titration with 0.1N NaOH standard solution [15]; Total sugar was determined by the phenol method [16]; Ethanol content was determined by the method described by FSSAI (2015) [17].

2.3. Statistical analysis

Microsoft Excel software was used for calculation collected data, combined with Statgraphic Centurion XVI software for ANOVA analysis, testing the significance level of the treatments through LSD (Least Significant Different).

3. RESULT AND DISSCUSION

3.1. Effect of supplied mango puree ratio on bioactive compounds in five days fermented wort

Bioactive compounds found in plants and edible foods are important for human health. These natural compounds, as part of the whole diet, ingredients or supplements, can modulate many aspects of human health and well-being [18]. Phenolic compounds include terpenoids (carotenoids and phytosterols), polyphenols, alkaloids and other nitrogen-containing components (glucosinolates), which account for the majority of bioactive compounds and are found in foods and beverages such as tea, fruit juices, wine, chocolate and beer [19]. In this study, mango puree was added and fermented together with wort to enhance the flavor, while also increasing the nutritional quality of the product. The results of the study showed that when the ratio of mango puree supplemented from 30 ÷ 75% to malt, the content of polyphenols, flavonoids and carotenoids in the product all tended to increase and were statistically different at the significance level of $P \leq 0.05$ (Figure 1). Specifically, polyphenols increased from 0.94 to 1.24 g GAE/100g dry matter (DM), flavonoids increased from 0.70 to 0.85 g QE/100g DM and carotenoids increased from 0.84 to 1.25 mg/g DM. However, the content of polyphenols and flavonoids between samples with the ratio of mango puree supplemented from 60 and 75% had no statistical difference (Figures 1a and 1b); the content of carotenoids increased and had statistical difference between samples (Figure 1c). There was an increase in polyphenols, flavonoids and carotenoids in the product with increasing mango puree addition ratio due to the presence of polyphenols, flavonoids and carotenoids in mango puree [20]. According to Elechi *et al.* (2022) [21], fermentation increased the content of vitamin C and carotenoids in mango flour samples.

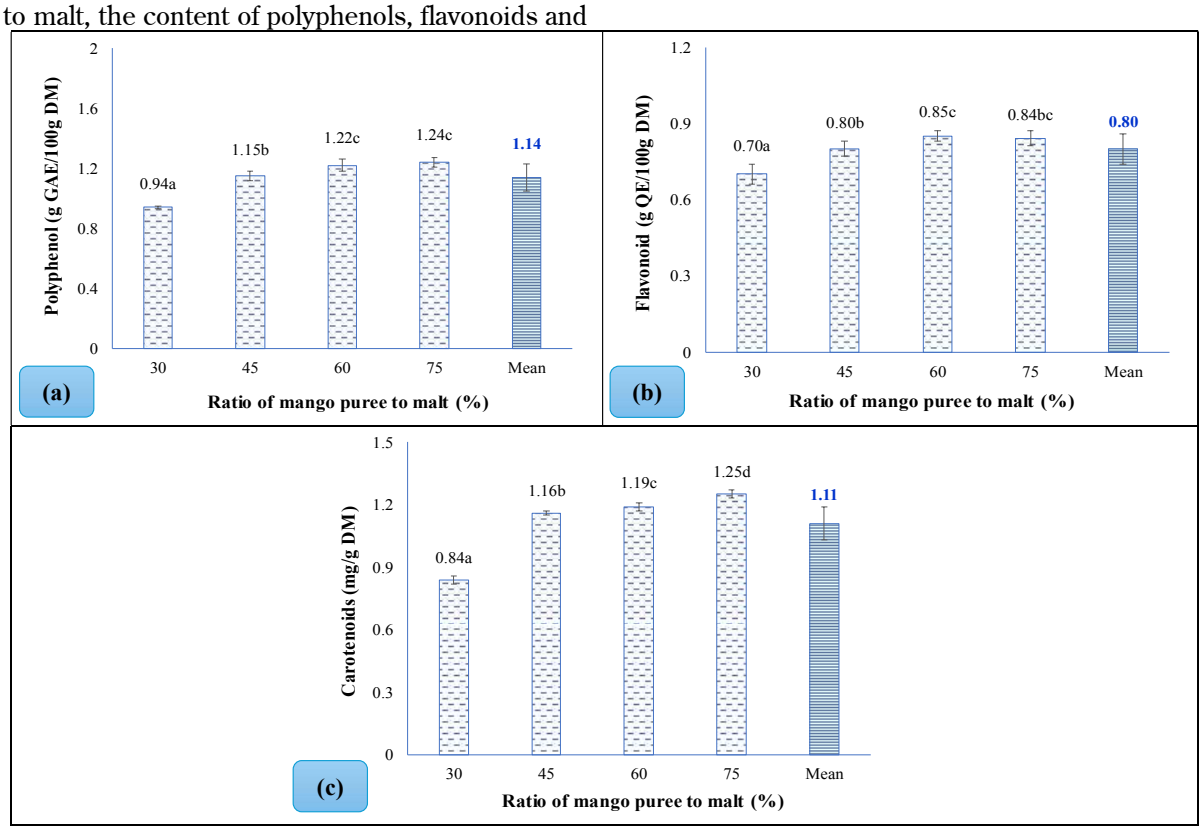

Figure 1. The content of polyphenols (a), flavonoids (b) and carotenoids (c) in the product according to different added mango puree ratios

Notes: a, b,c represent statistical differences with significance level P≤ 0.05.

3.2. Effect of supplied mango puree ratio on chemical components of fermented wort

Chemical components such as protein, total acid, total sugar and ethanol are very important components related to the quality of beer. Proteins and amino acids present in beer have various functional roles such as color, flavor and stability. Determination of nitrogen compounds in beer is necessary to predict the amino acid and biogenic amine composition of the finished beer [22]. Protein (amino acid), sugar and acid contents are formed by hydrolysis of protein, starch in malt and added mango puree, as well as during fermentation. The analysis results showed that the protein, total acid and ethanol contents tended to increase, while the total sugar content tended to decrease when increasing the proportion of added mango puree from 30 to 75% and there was a difference between samples with a statistical significance level of $P \leq 0.05$ (Figure 2). Specifically, the protein content increased from 1.58 to 1.93 g/100 g DM but there was no statistical difference between the 45, 60 and 75% samples (Figure 2a). The total acid content increased from 0.40 to 0.45% and there was a difference between the samples (Figure 2b). The ethanol content increased from 5.18 to 5.56% v/v and there was no significant difference between the 45, 60 and 75% samples (Figure 2c). The total sugar content decreased from 73.05 to 68.60 g/100 g DM and there was a significant difference between the samples (Figure 2d). According to Maldonado-Celis *et al.* (2019) [23] Mango puree contained about 15% total sugar, of which sucrose is 6.97%, glucose is 2.01% and fructose is 4.68% and this was a good substrate source for yeast to use to ferment and form ethanol during the fermentation process. Therefore, the total sugar content would decrease and the ethanol content in the craft beer product would increase. Besides, according to Lebaka *et al.* (2021) [24], mango puree contains protein, amino acids, organic acids and vitamin C, as well as the fermentation process increased the protein content in mango powder [21], which of would increase the protein and total acid content in the craft beer product when increasing the amount of added mango puree.

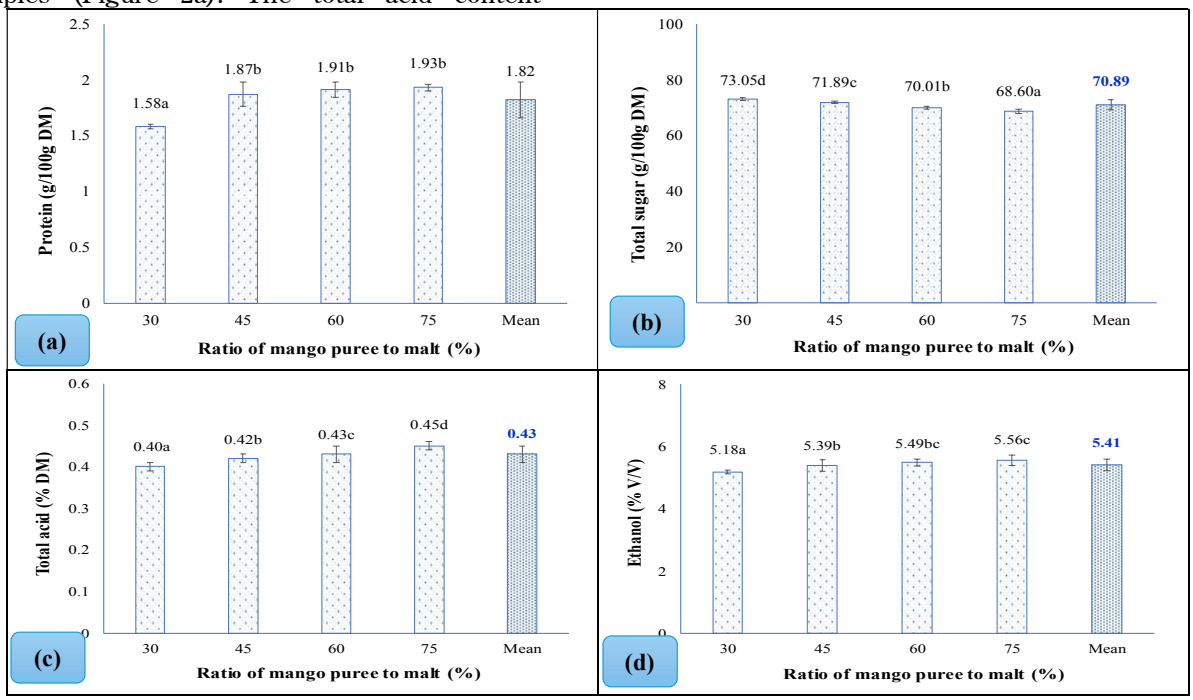

Figure 2. The content of protein (a), total sugar (b), total acid (c) and ethanol concentration (d) in the product according to different added mango puree ratios

Notes: a, b,c represent statistical differences with significance level P≤ 0.05

3.3. Effect of supplied mango puree on color coordination of craft beer product

Color is an important quality attribute in the food industry and it influences consumer choice and preference. Food color was determined by chemical, biochemical, microbiological and physical changes that occur during growth, maturation, post-harvest handling and processing. In the food industry, the CIELAB color scale (L*, a*, b*) is commonly used to measure the color parameters of foods. L* values represent light and dark colors (ranging from 100-0); a* values represent red (a*+) and green (a*-); b* values represent yellow (b*+) and blue (b*-) [25]. The results of color parameter analysis (L*, a*, b*) of craft beer product after fermentation are presented in table 1.

Table 1. Color coordination value of product following different added mango puree ratioes

Mango puree (%, w/w)	Color coordination			
	L^*	a^*	b^*	ΔE
30	40.88 ± 1.25	-4.20 ± 1.05^{a}	1.12 ± 0.14^{a}	52.80 ± 0.75
45	41.34 ± 0.82	-4.26 ± 0.04^{ab}	1.32 ± 0.56^{b}	52.34 ± 0.61
60	40.31 ± 1.53	-4.33 ± 1.89^{bc}	1.45 ± 0.15^{c}	53.32 ± 0.75
75	40.82 ± 1.18	-4.41 ± 0.06^{c}	1.53 ± 0.11^{c}	52.81 ± 0.69
Mean ± SD	40.84 ± 0.52	-4.30 ± 0.04	1.35 ± 0.04	52.82 ± 0.24
Significance level P	0.2516	0.0081	0.0000	0.2707

Note: mean value (n = 6) ± standard deviation, values with letters a, b, c represent statistical differences with significance level P ≤ 0.05.

The results of Anova analysis in Table 1 show that the L* value ranged slightly from 41.33 to 40.31 when the mango puree ratio increased from 30 to 75%; however, this difference was not statistically significant P > 0.05. Similarly, the total color difference value ΔE also ranged slightly from 52.34 to 53.32 when the mango puree ratio increased and this difference was also not statistically significant P > 0.05. Meanwhile, the a* value tended to decrease from -4.20 to -4.41; the b* value tended to increase from 1.12 to 1.53 and there was a statistical difference P ≤ 0.05; however, between the two samples with mango puree ratios of 60 and 75%, this change was not statistically different. This shows that the light and dark color values (L*) and total color difference (ΔE) of the samples are not different. There was only a slight decrease in the red color value (a*) and an increase in the yellow color value (b*) of the product sample. Because mango puree contains many different chemical components such as proteins, amino acids, sugars, polyphenols and carotenoids [20], they can participate in the color reaction during the heating and fermentation process, which will slightly change the color parameters of the craft beer product.

3.4. Effect of mango puree ratio on sensory value of fermented wort

Sensory evaluation is applied in most food fields, especially in product development research and there are many sensory evaluation methods applied. In this study, the descriptive sensory evaluation method was used to score (0 - 5 points) on color and flavor indicators, and the general preference level (GPL) was based on the Hedonic scale (1 - 9 points). The number of selected people

to participate was 10 final year students of food technology, who were trained before participating in product evaluation. The results of the sensory evaluation score analysis are presented in Figure 3. Specifically, the sensory score for color tended to increase from 3.3 points to 4.6 points when the added mango puree ratio increased from 30 to 60%, when it increased to 75% the sensory score for color decreased to 4.3 points, however, the sensory score between the samples supplemented with 30 and 45% mango puree as well as the samples supplemented with 60 and 75% mango puree had no statistical difference. The sensory score for taste tended to increase from 3.6 points to 4.5 points when the added mango puree ratio increased from 30 to 45%, when the mango puree ratio continued to increase to 60 and 70% the sensory score decreased, however, there was no statistical difference in the 45 and 60% samples; in the sample supplemented with 75% the sensory score decreased to 3.9 points. This was due to adding the appropriate ratio of mango puree, it will create a harmonious flavor characteristic of the product. If adding a high ratio of mango puree, it would create a flavor of fermented mango juice that overwhelms the flavor of beer. Similar to the sensory score of taste, the sensory score of general liking reached 6.2 and 6.5 points in the samples supplemented with 30% and 75%; the samples supplemented with 45 and 60% mango puree had a sensory score of general liking of 7.2 and 7.7 points, however, there was no statistical difference between these two samples at the significance level of $P \leq 0.05$. According to Yahia *et al.* (2023) [20], mango puree contains volatile compounds, carotenoids, polyphenols, sugars, amino acids, etc., so when mango puree added at 75%, it created an inharmonious flavor and darken the color of the product.

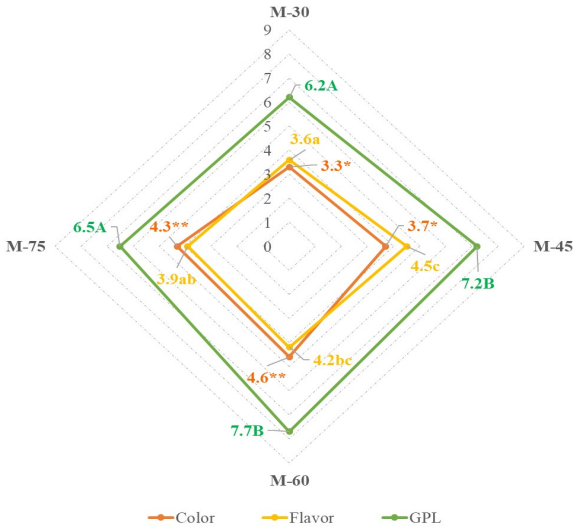

Figure 3. Sensory scores for color, taste and general preference level (GPL) of the product according to different added mango puree ratios

*Notes: M-30, M45, M60, M70 are samples with the ratio of added mango puree, respectively; *, **; a, b,c and A, B represent statistical differences with significance level P≤ 0.05*

4. CONCLUSION

Results showed that the additional mango puree ratio of 60% is considered suitable for the production of craft beer. At this ratio, the five day fermented product has the most harmonious sensory value in terms of taste (4.2 points), color (4.6 points) and general preference level (7.7 points). The product sample contained polyphenol 1.22 g GAE/100g dry matter-DM, flavonoid 0.85 g QE/100 g DM, carotenoids 1.19 mg/g DM, protein 1.91% DM, total sugar 70.01% DM, total acid 0.43% DM and ethanol 5.49% v/v. The color parameters such as L*, a*, b* and ΔE were 40.31, -

4.33, 1.45 and 53.32, respectively. The obtained data contributes to further research for making mango craft beer.

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