Transactions on Science and Technology Vol. 8, No. 3-3, 545 - 551, 2021

Effect of Heat Treatment on Physicochemical Properties of Bambangan (*Mangifera pajang*) Fruit Juice

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ABSTRACT Bambangan (*Mangifera pajang*) is an indigenous fruit that merely cultivated in Borneo Island. This fruit has great potential to be commercialized particularly in food applications such as production of juice and ingredient for functional foods. In this study, the effect of different heat treatment on the physicochemical properties of bambangan fruit juice (BFJ) was evaluated. The BFJ was subjected to three different heat treatment conditions: sterilization at 121°C for 3 min, mild temperature long time (MTLT) pasteurization at 65°C for 15 min, and high temperature short time (HTST) pasteurization at 90°C for 1 min. After heat treatment, the BFJ samples were further analyzed for their physicochemical properties including moisture content, color, total soluble solid, pH and vitamin C. It was found that heat treatment could decrease the BFJ moisture content. Heat treatment has changed the color of juice in terms of lightness (L*), green to red (a*), and blue to yellow (b*). The total soluble solid was increased with heat treatment, but decreased in vitamin C, and no changes in pH. The results provide important information on the physicochemical characteristic of BFJ in different heat treatment conditions.

KEYWORDS: Bambangan fruit; Bambangan fruit juice; Heat treatment; Physicochemical properties
Received 19 October 2020 **Revised** 30 October2020 **Accepted** 4 December 2020 **Online** 2 December 2021

Original Article

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INTRODUCTION

Bambangan (*Mangifera pajang*) is an indigenous fruit endemic to Borneo Island (Sabah, Sarawak, Kalimantan and Brunei). With weight can reach up to 1 kg and more, bambangan fruit is regarded as the largest fruit in the *Mangifera* genus (Mohd Fadzelly *et al*., 2011). In general, bambangan fruit is composed of 10-15% of peels, 60-65% of pulps and 15-20% of kernels/seeds. The pulp has a delightful mango fragrance, juicy with highly fibrous structure, a unique aromatic flavor and strong smell (Mohd Fadzelly & Jeffrey, 2013). Several studies have found great potential health benefits of bambangan fruit which attributed to the total phenolic contents that exhibited a high antioxidant activity (Ibrahim *et al*., 2013; Al-Sheraji *et al*., 2012; Sulaiman & Ooi, 2012).

It is usually freshly eaten making it suitable for production a natural fruit juice or beverages. Nowadays, fruit juices consumption has become more popular because of its nutritional benefits as well as convenience, and ready-to-drink. However, fruit juice is highly susceptible to microbial, enzyme, chemical, and physical degradations thus affect the product quality and shelf-life during storage. Various approaches have been investigated to overcome this problem, but thermal treatment such as pasteurization and sterilization remains the most cost-effective strategy to extend the shelf-life of juice product by inhibiting the growth of micro-organisms that can cause fruit juice deterioration (Aguilo-Aguayo *et al*., 2009; Rawson *et al*., 2011; Jimenez-Sanchez *et al*., 2017).

During the processing of fruit juice, thermal treatment may affect the fruit juice attributes, particularly on physicochemical properties. Various heat treatment techniques have been used for production of fruit juice including ultrahigh temperature (UHT), low-temperature long time (LTLT), mild temperature-long time (MTLT) and high-temperature short time (HTST) (Wang *et al*., 2018). The effect of thermal treatment on the physicochemical properties of fruit products have been investigated in several studies including mengkudu (*Morinda citrifolia*) extract (Maskat & Tan, 2011), white- and red-flesh dragon fruit purees (Liaotrakoon *et al*., 2011), orange juice (Cinquanta *et al*., 2010), and apple juice (Aguilar-Rosas *et al*., 2007). Most studies are focusing on determining the methods that could preserve the quality of fruit juice.

Until recently, there is no study on the physicochemical information is available for juice made from bambangan fruit. Therefore, this study investigates the effect of different heat treatment on physicochemical properties of bambangan fruit juice (BFJ) aiming to determine the suitable heat treatment method that could maintain the physicochemical properties which comparable with untreated BFJ.

METHODOLOGY

Preparation of Bambangan Fruit Juice (BFJ)

Bambangan fruits (*Mangifera pajang*) were bought from Ranau market, Sabah and brought to the laboratory. Upon arrival at laboratory, the fruits were washed, and the peel was manually removed to get the pulp. The pulp maturity was evaluated according to the total soluble solid (°Brix) using refractometer (Atago, Germany) with the matured bambangan fruit was considered approximately around 15°Brix of total soluble solid. The pulp was then cut into smaller pieces followed by blending using a food processor (Dito Sama, Italy) and filtered to get the juice. The juice was prepared with a ratio of 1:1 (water and flesh) and then placed in 500 mL Schott bottle.

Heat Treatments of BFJ

The bambangan fruit juice (BFJ) was treated at three different heat treatment conditions denoted as high temperature short time (HTST) pasteurization (90°C, 1 min), mild-temperature long time (MTLT) pasteurization at (65°C, 15 min) (Pareek *et al*., 2011; Wang *et al*., 2018) and sterilization (121°C, 3 min) using horizontal retort (CY-3000H, China) (Chen *et al*., 2015). BFJ without treatment were used as control. All samples were placed in a cold room at -20°C until further use.

Moisture Content Analysis

Moisture content was analysed based on the AOAC method (2010). Briefly, about 5 g of samples was weighed into the petri dish and heated at 105 °C in an oven for 5 h. After that, the sample was placed in a desiccator followed by weighing with analytical balance. All measurements were performed in triplicate. The following equation was used to calculate the moisture content:

$$\text{Moisture content, (\%)} = \frac{A-B}{C} \times 100 \qquad (1)$$

where A and B is the weight of the sample with petri dish before and after drying, respectively (g), and C is the original weight of sample (g).

Physicochemical Analysis

Color Determination

Determination of the color of bambangan juice is determined using Colorflex EZ Colorimeter (Hunter Lab, USA). Color values are measured through the CIE scale L*, a*, b*. L* value represents a measure of lightness, a* value represents the chromatic scale from green to red, and b* value represents the chromatic scale from blue to yellow. The instrument calibration step is performed before starting to determine the color of the sample. Firstly, standard black glass is placed into the sample holder space to set the bottom scale (zero). Next, standard white tiles with values L *: 93.87, a *: -0.73 and b *: 2.06 were placed in the sample holder space followed by OID standard placement with values L *: 51.23, a *: -25.32 and b *: 15.14. A total of 70 mL of juice sample was measured using a cylinder gauge and poured into a sample glass followed by the placement of the sample lid. This step is performed to obtain the color value of the sample. All measurements were taken in triplicate.

Total Soluble Solids Determination

Total soluble solid (°Brix) in the samples were measured with a hand refractometer (ATAGO, Germany). The glass surface of the refractometer is cleaned with a specific tissue to ensure that the surface does not have any dirt every time before measuring the value of the brick. Two drops of the sample are taken and dropped to cover the entire surface of the refractometer glass. The value of total soluble solid is displayed in the refractometer. All measurements were performed in triplicate.

pH Determination

Eutech Instrumental pH meter (Malaysia) was used to determine pH of the fruit juice. The instrument was calibrated prior to determine the sample pH. The calibration step involves rinsing the glass electrode with distilled water followed by pH 4.0, 7.0 and 10.0 buffer solutions. After that, a total of 10 mL of sample will be measured with a cylinder gauge and transferred into a 25 mL beaker and the pH value was measured using pH probe. All measurements were performed in triplicate.

Vitamin C Determination

Titration method was used to measure the Vitamin C content following the method established by Strong & Koch (1974). Briefly, 1% oxalic acid solution (10 g of oxalic acid in 1 liter of distilled water) and 2,6-dicloroindofenol (DCPIP) solution (0.5 g of 2,6-dichloroindofenol sodium salt in 975 mL of distilled water) were prepared. 25 mL phosphate buffer was then added to the solution. Phosphate buffer solution was prepared with 3.55 g of in-sodium hydrogen phosphate and 3 g of sodium hydrogen phosphate. Standard ascorbic acid solution (0.1 mg / mL) was prepared by diluting 50 mg of ascorbic acid with 500 mL of 1% oxalic acid in a 500 mL volumetric flask. 25 mL of standard ascorbic acid (0.1 mg / mL) was poured into a burette and a 50 mL beaker was filled with 2 mL of DCPIP dye. The standard ascorbic acid solution is titrated to a beaker containing the dye until the pink color turns colorless. The quantity of ascorbic acid that dissolves DCPIP was recorded. Titration of ascorbic acid was performed triplicates and the average reading value was taken. The same procedure was performed for samples. The content of ascorbic acid dioxide with 2 mL of dye and vitamin C content were calculated by using Equation (2) and (3), respectively:

$$2 \text{ mL dye} = \text{mL ascorbic acid} \times 0.1 \text{ mg / mL} \quad (2)$$

$$(\text{Ascorbic acid content} \times 100)/(\text{Sample volume} \times \text{sample dilution}) = (\text{mg vitamin C}) / (100 \text{ g}) \quad (3)$$

Statistical analysis

Statistical Analysis was performed using a Statistical Package for the Social Science (SPSS) version 25 software. Mean and standard deviation were determined based on triplicate measurement. One-way analysis of variance (ANOVA) followed by Tukey's B test was used to evaluate the differences among treatment. Value of $p < 0.05$ is considered as statistically significant.

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RESULT AND DISCUSSION

Moisture Content of Bambangan Juice Formulation

Bambangan fruit juice (BFJ) was conducted with three different thermal treatment conditions; mild temperature-long time (MTLT), high temperature-short time (HTST), sterilization and no heat treatment as control. As shown in Table 1, it was found that the moisture content for untreated BFJ was 94.45%. As the BFJ was subjected to heat treatment, significant ($p < 0.05$) reduction on the moisture content was observed. BFJ subjected to MTLT shows the highest moisture content (94.03%), followed by HTST (93.21%) and sterilization (92.60%). However, the percentage of reduction in moisture content for all heat treatments are relatively low with ranging from 0.5 to 3%.

Table 1. Moisture Content of BFJ with Different Heat Treatment

Treatments	Moisture Content (%)
No heat treatment	94.45 ± 0.02^{a}
Mild Temperature Long Time (MTLT)	94.03 ± 0.03^{b}
High Temperature Short Time (HTST)	93.21 ± 0.03^{c}
Sterilization	92.60 ± 0.05^{d}

Values are reported as mean ± standard deviation (n = 3).
Values in column followed by different superscript letters indicate significant difference ($p < 0.05$).

Physicochemical Properties
Color

Color is a crucial factor in the appearance of food. Consumer acceptance is influenced by color as it is an indicator of the quality of freshness and taste. Color changes are often associated with other quality changes such as nutritional composition and sensory values. In general, different thermal treatments on BFJ caused the L*, a* and b* values to decrease significantly, as indicated in Table 2.

The L* value between the untreated BFJ and heat treated BFJ is significantly different ($p < 0.05$). The untreated BFJ had brightest color (59.31), followed by the HTST (55.68), MTLT (52.81) and the sterilization (51.71) samples. This indicates that HTST treatment could give closest brightness to the untreated BFJ. Darker appearance of the BFJ sample after subjected to MTLT compared to HTST might be due longer heat treatment which cause pigment component deterioration to occur in BFJ. In addition, sterilization treatment at high temperature (121°C) could promote Maillard reaction, thus reduced the brightness value. According to Bharate *et al*. (2012), intermediate compounds were formed when the carbonyl group in the reducing sugar react with the free amino group in the amino acids. These intermediaries will undergo subsequent reaction that produce brown pigments and cause unwanted discoloration. Aguiló-Aguayo *et al*. (2009) reported a similar tendency when watermelon juice was treated at a temperature of 90 °C for 60 seconds, where the color value decreases due to the Maillard reaction leading to the formation of compounds such as 5-hydroxymethyl furfural (HMF) resulting in the juice becoming darker.

A similar trend was found for the a* and b* values where HTST treatment shows the closest value with untreated BFJ, followed by MTLT and sterilization. According to Maskan (2006), high temperature could accelerate the carotenoid isomerisation and resulted in a reduction in b* value. Ahmed *et al*. (2004) conducted a study to investigate the effect of thermal treatment (50, 60, 70, 80 and 90°C) on colour changes of plum puree. They observed a reduction in both the L* and b* values with time, while the puree color has changed to reddish brown. This suggest that high temperature and long duration of heat treatment can cause degradation of color pigment which consequently affected the redness (a*) and yellowish (b*) color of BFJ.

Table 2. Color values L*, a*, b* for Bambangan juice formulations with different heat treatments.

Treatments	Formulation Samples		
	L* (Lightness)	a* (Green/red)	b* (Blue/Yellow)
No Heat Treatment	59.31 ± 0.33[a]	16.83 ± 0.09[a]	64.71 ± 0.29[a]
MTLT	52.81 ± 0.12[c]	11.12 ± 0.49[c]	53.58 ± 0.31[c]
HTST	55.68 ± 0.27[b]	12.28 ± 0.17[b]	62.23 ± 1.18[b]
Sterilization	51.71 ± 0.51[d]	8.07 ± 0.01[d]	51.89 ± 0.03[d]

Values are reported as mean ± standard deviation (n = 3).
Values in column followed by different superscript letters indicate significant difference (p <0.05).

Total Soluble Solids

The total soluble solids in the untreated and treated BFJ are presented in Table 3. All the heat-treated (MTLT, HTST and sterilization) samples have significantly higher total soluble solids than without heat treatment. However, the difference between total soluble solids for the heat-treated samples is not significant.

Table 3. The Percentage of Total Soluble Solid, pH and Ascorbic Acid Content for Bambangan Juice Formulation with Different Heat Treatment.

Treatments	Formulation Sample (%)		
	Total Soluble Solid (°Brix)	pH	Vitamin C (mg/100g)
No heat treatment	6.03 ± 0.06[b]	3.22 ± 0.03[b]	127.07 ± 7.31[a]
MTLT	7.03 ± 0.06[a]	3.19 ± 0.03[b]	95.69 ± 0.52[b]
HTST	7.03 ± 0.06[a]	3.20 ± 0.00[b]	94.65 ± 0.22[b]
Sterilization	7.03 ± 0.06[a]	3.10 ± 0.00[b]	88.99 ± 1.30[b]

Values are reported as mean ± standard deviation (n = 3).
Values in column followed by different superscript letters indicate significant difference (p <0.05).

pH

pH is an important measurement for fruit juice where it can influence the flavor or taste of the product. pH has an important role especially in the microbiology safety during the storage period because the acidic pH value can be an additional barrier to the growth of microorganisms and can ensure food stability (Barba *et al*., 2012). The pH value of the BFJ decreased when subjected to heat treatment (Table 3). However, the reduction did not show any significant with untreated BFJ. This indicates that the pH of BFJ does not affect by the heat treatment. According to Amit *et al*. (2017), fruit beverages are high-acid products (pH 4,6 or less) thus it does not require high temperature treatment because the high-acid characteristic help to inhibit the growth bacteria, fungi, and yeast.

Vitamin C

The vitamin C content for BFJ is shown in Table 3. It was found that untreated BFJ has 127.07 mg/100g of vitamin C content. When BFJ was subjected to heat treatment, the vitamin C content were significantly decreased to the range of 89 – 96 mg/100g but there is no significantly difference among treatments. MTLT samples had higher vitamin C values than HTST samples and sterilization due to relatively low temperature consumption and vitamin C degradation were also relatively low. Sterilization samples have a lower vitamin C content than HTST samples simply because the sterilization temperature is higher than the HTST temperature and the treatment time used was also longer. According to Lee & Kader (2000), heat processing and treatment causes vitamin C degradation. Besides that, high dissolved oxygen content in the sample may also promotes degradation of vitamin C as reported by Alwazeer *et al*. (2003).

CONCLUSION

The effect of pasteurization (MTLT and HTST) and sterilization on the physicochemical properties of bambangan fruit juice (BFJ) was successfully elucidated. HTST is the most suitable heat treatment because it gave a closest physicochemical property with original BFJ as compared to other heat treatment (MTLT and Sterilization). This indicated that HTST could maintain the physicochemical properties of bambangan fruit juice. The findings obtained from this study provide a useful information for the juice manufacturers in production of juice.

ACKNOWLEDGEMENT

This project was funded by Universiti Malaysia Sabah through Acculturation Grant Scheme (SGA0019-2019), and is greatly acknowledged.

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