Central Mindanao University
Journal of Science
ISSN Print: 0116-7847 ISSN Online: 2704-3703

EFFECT OF BOILING TIME AND STORAGE CONDITION (FROZEN AND UNFROZEN) ON THE PHYSICO-CHEMICAL PROPERTIES OF FLACOURTIA JANGOMAS (LOUR) RAUESCH FRUIT

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ABSTRACT

Flacourtia jangomas, locally known as *Seriales* is an indigenous fruit tree in the Philippines. It potentially contains important nutrients and bioactive compounds, but it is a less known commodity, with no economic value. Moreover, the fruit is highly prone to enzymatic browning reaction, resulting to undesirable discoloration once exposed to air. Hence, this study was conducted to determine the changes in the physico-chemical properties of ripe *Seriales* fruit as affected by boiling time and storage conditions. Ripe *Seriales* fruits of known weight were exposed to upto 10 minutes of boiling water. Representative samples from each treatment were analysed of its color, total soluble solids, pH, and % titratable acidity. The same procedures were done to samples that had been stored for 19 days in the freezer. The results of the experiment revealed that storage conditions (frozen and not frozen) only affected the b* of the skin of the ripe Seriales fruits, while boiling time affected all other parameters, excepts pH, %TTA, and b* values of the fruit flesh.

Keywords: Flacourtia jangomas, physico-chemical, frozen, unfrozen, boiling

INTRODUCTION

Seriales is the local name for *Flacourtia jangomas* in the Visayas and Mindanao, and is one among other less-known native fruit commodities in the Philippines. It is a plant that belongs to the family of Flacourtiaceae grown in various parts of the world. It is commonly known as Indian coffee plum (Hossain and Sisodia, 2011; Kumar et al., 2018, Sasi et al., 2018), Indian sour cherry (Kumat et al., 2018), Indian cherry (Hossain et al., 2011), Paniala (Hossain and Sisodia, 2011; Sasi et al., 2018), Chinese plum (Hossain and Sisodia, 2011), among others.

The plant is considered underutilized, with little use such as food for birds and by some people leaving in the rural areas where it is mostly found growing. It can also be utilized as lumber, and is considered important in India due to its medicinal properties. The ripe fruits have high fibre content together with good protein content, low fat and higher amount of monosaturated fatty acids as compared to polysaturated fatty acids. It contains significant amount of β-carotene followed by lutein and zeaxanthene, retinol and phylloquinone (vitamin K) which are important in the regulation of haemoglobin and fibrinogen in human body (Srivastava et al., 2009).

Specifically, fruits are used for treatment of biliousness, fever and digestive disorder (Kitikar and Basu, 1993 as cited by Kumar et al., 2018). The medicinal capability of the commodity is attributed to the chemical components and its bio-functional properties. Parvin et al. (2011) reported that extracts from plant and plant parts are effective against both gram-positive and gram-negative bacteria, which is comparable with the standard antibiotic called Amoxicillin. The fruit itself has a diverse array of compound classes including terpenoids, alkaloids, flavonoids and tannins, lignans and flavanolignans, glucosides, coumarins and isocoumarins; as well as xanthones, quinones, limonoids and phenazines (Parvin et al., 2011). Specifically, the ripe fruits contain alkaloids, flavonoid, phenolic compounds and tannins which is proven to have high antioxidant potential (Neeharika and Pandey, 2013; Sinha et al., 2018). However, some of these components and other unmentioned components may have been degraded during its processing. For example, Cimafranca (2017) reported that different pre-treatments on *Seriales* fruit were noted to have significant variation in terms of bioactive compound content as well as on physico-chemical attributes. In terms of boiling and time of exposure, many studies had proven significant effect on many quality parameters of the commodity. For instance, boiling the Bactrijasipaes for 30 minutes did not affect total carotenoid content of the commodity (Jatunov et al., 2010), but in eggplant, it causes dry matter loss (Scalzo et al., 2016). PassoTsamo et al. (2015) reported that total phenolics decreased after boiling of whole banana fruit. These patterns serve to illustrate that

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Received: Jan 7, 2020; Accepted: June 29, 2021
DOI: https://doi.org/10.52751/vacr1044

there is no applicable trend when it comes to the effect of heat treatment. Meanwhile, storage duration may also cause significant effect to crops. In apples for example, an increase in the total soluble solid, total sugar, pH and TSS/Acid ratio was evident according to Jan and Rab (2012). It shall be noted that known quality parameters sometimes are dependent on specific commodities. Hence, this study aimed to determine the effect of boiling time on the physico-chemical properties of Seriales fruit, as well as the difference due to variation on storage conditions.

METHODOLOGY

Experimental Material

Seriales fruits were obtained from Brgy. Igang, Baybay City, Leyte. The whole batch of fruits were sorted, and only the good quality ripe fruits were used. These purplish-red skin colored fruits were washed thoroughly and then drained.

Heat Treatment

The boiling method employed in the experiment was adopted from the report of Ahmed and Ali (2013), with modifications. Distilled water (3000 ml) was poured into a stainless steel vessel with cover, and was heated to boiling. Seriales fruits (whole) weighing 650 g were submerged into the boiling water. The fruits were boiled at varying time of exposure (2, 4, 6, 8, and 10 minutes) (Table 1). After desired exposure time, samples were taken out quickly from the heat, drained in a stainless sieve, and air cooled for 30 minutes. Treatment samples labelled T1 to T6 were subjected to analyses, while the rest (T7to T12) were packed and sealed in polyethylene bags, stored in the freezer (Biobase BDF-40H200) for 19 days, and were analysed thereafter.

Experimental Design

The study was a six (6) treatment experiment arranged in a Completely Randomized Design (CRD) with varying time of exposure to boiling temperature (Table 1). Separate studies were conducted for freshly heat-treated Seriales samples, and the frozen heat-treated fruits.

Physico-chemical Analyses

Color Determination

Color of samples (skin and flesh) was measured using Lovibond LC 100 Spectrocolorimeter, and measurements were recorded as L, a and b values. Color values were gathered and computed from means of three (3) measurements of the skin color and the color of flesh exposed after the fruit was mashed.

Total soluble solids (TSS)

Representative fruits were mashed to fine pieces, placed it in a filter paper, massaged gently by hand until the juice was extracted. A drop of extracted juice from the fruit (25°C) was placed onto the prism of calibrated digital refractometer (ATAGO ATC-IE model, Japan), and TSS reading was taken.

pH

Determination of pH was carried out using a digital pH meter (pHeps) that was calibrated with pH 4 and 7 buffer solutions. The sample for pH determination was prepared from a 2:1 ratio of sample and distilled water that was blended with the aid of an Osterizer blender. The sample was then placed in a clean and dry plastic cup container, mixed with a plastic spoon, followed by submersion of the pH meter electrode onto the prepared sample. The stable pH reading from the display of the meter was taken and recorded. Three replications were made per treatment sample.

Total titratable acidity (TTA, expressed as % citric acid)

Total titratable acidity was determined by employing standard titration method using 0.1 N NaOH

Table 1

Different time exposure of Seriales fruit to boiling temperature

TREATMENTS	BOILING TIME (mins)	STORAGE CONDITION
T_1	0	No freezing
T_2	2	No freezing
T_3	4	No freezing
T_4	6	No freezing
T_5	8	No freezing
T_6	10	No freezing
T_7	0	Frozen
T_8	2	Frozen
T_9	4	Frozen
T_{10}	6	Frozen
T_{11}	8	Frozen
T_{12}	10	

solution following AOAC (2010). Percent citric acid was computed using the formula:

$$\%\ \text{citric acid} = \frac{\text{Volume of titrant used (mL) x Normality (N) of titrant x mEq.Wt. of acid (0.064 for citric acid)}}{\dfrac{\text{Fresh weight of sample (g)}}{\text{Volume of water added + Fresh weight of sample}} \text{ x Volume of aliquot}} \text{ x } 100$$

Statistical analysis

Data were statistically analysed using Microsoft Excel for analysis of variance (ANOVA) and determination of the difference between treatments.

RESULTS AND DISCUSSION

Color of the Flesh of Seriales Fruit

Food acceptance by the consumers is initially affected by color. It is also an indicator to some important beneficial component such as anthocyanin. The colors red, purple, and blue in fruits are relatively associated to high anthocyanin content. F. jangomas (Seriales) is one example of these fruits containing anthocyanin due to its characteristic purplish red coloration (Cimafranca, 2017) or dull brownish red or purple to blackish skin color, with greenish-yellow pulp (Sasi et al 2018).These anthocyanins among other important antioxidants are needed in the body in the prevention and/or treatment of diseases.

As indicated in the results presented in Table 2a, the color analysis revealed that the luminance (L*) ranges from 36.15 (T_1) to 53.98 (T_{12}) regardless whether the fruit is frozen or not. These values are generally higher compared to the values reported by Cimafranca (2017) on ripe seriales fruit. Samples that did not undergo freezing has lowest L value (36.15 for T_1), and the highest (53.10) was observed at 6 minutes exposure to boiling water. However, the latter result was statistically the same with T_3, T_5 and T_6. L* values higher than 50, co-notes that the samples are of lighter hue as compared to values within 0-50 such as T1, T_2 and T_9. ANOVA on the other hand, revealed statistical difference among these data sets for luminance (Table 2a).

Other important parameters are a* and b*, which projects the red versus green color, as well as the yellow to blue hue of the sample tested, respectively. The mean values for a* ranges from 21.28 (T_5) to 29.30 (T_9), while mean b* values ranges from 17.52 (T_9) to 26.30 (T_1). The ANOVA revealed similar results to luminance, that freezing and non-freezing conditions are not affecting the a* value of the samples, but are significantly affected by boiling time (Table 2a). The results of the multiple comparison difference test revealed that T_2, T_3, T_4, T_9 and T_{11} are not significantly different from each other. Other groups that are statistically the same are T_4, T_7, T_{11} and T_{12}, and the lowest a* values are grouped namely T1, T5, T6 and T7 (Table 2a). On the other hand, statistical analysis on the b* discloses that both the storage condition and the time of boiling do not affect the b* values of the treatment samples (Table 2a). Moreover, a significant increase in the luminance value is generally observed in unfrozen boiled Seriales fruit. Table 2a also presents that there are significant differences between treatment values of the samples analysed.

Table 2a

Color characteristics of the flesh of ripe frozen and unfrozen Seriales (F. jangomas) fruit as affected by varying time of exposure to boiling

TREATMENT	SERIALES CONDITION	BOILING TIME (MINUTES)	COLOR VALUES		
			*L**	*a**	*b**
T_1	No freezing	0	36.15 ± 3.25^{d}	16.25 ± 2.21^{d}	26.30 ± 3.93^{a}
T_2	No freezing	2	45.17 ± 1.02^{bc}	27.58 ± 0.55^{ab}	21.22 ± 0.75^{b}
T_3	No freezing	4	50.40 ± 1.04^{ab}	26.28 ± 0.91^{abc}	20.63 ± 1.49^{b}
T_4	No freezing	6	53.10 ± 1.53^{a}	26.12 ± 2.78^{abc}	20.88 ± 0.79^{b}
T_5	No freezing	8	53.05 ± 0.72^{a}	21.28 ± 2.18^{cd}	20.90 ± 0.37^{b}
T_6	No freezing	10	52.70 ± 0.34^{a}	21.43 ± 1.28^{cd}	18.40 ± 0.47^{b}
T_7	Frozen	0	45.72 ± 3.12^{bc}	22.77 ± 1.90^{bc}	20.12 ± 0.46^{b}
T_8	Frozen	2	51.73 ± 2.29^{a}	21.28 ± 1.40^{cd}	21.82 ± 1.21^{b}
T_9	Frozen	4	42.15 ± 0.40^{c}	29.30 ± 1.18^{a}	17.52 ± 0.60^{b}
T_{10}	Frozen	6	53.70 ± 2.08^{a}	21.57 ± 1.71^{c}	20.12 ±1.97^{b}
T_{11}	Frozen	8	52.88 ±1.21^{a}	26.08 ± 1.56^{abc}	19.05 ± 1.19^{b}
T_{12}	Frozen	10	53.98 ±2.49^{a}	23.43 ± 2.65^{bc}	21.28 ± 1.75^{b}

Values are means of triplicate determination ± standard error (SE)
Means of 6 fruit per treatment using a Lovibond LC 100 Spectrocolorimeter. L* = lightness, a* = bluish/green/red-purple hue component, b* = yellow/blue hue component,
Mean values followed by different letter superscripts in the same column are significantly ($p<0.05$) different.

Color of the Skin of Seriales Fruit

The seriales fruit had different colors of its peel (skin) and pulp (flesh). Specifically, the fruit skin was darker red than the pulp (low L* and b* values; and positive a* values). Moreover, means of a* and b* values reflected in Table 2b were all positive, indicating that the color plays around red (positive a*) and yellow (positive b*).
The higher value denotes lighter hue than the other. Generally speaking, all values indicate darker hue since L* ranges within 0-50 (Table 2b). The lowest L value is that of T_9 (24.10), while T_{10} got the highest luminance of 36.82. The ANOVA revealed that the treatment samples are significantly affected by boiling time and not on the storage condition of the fruit. Further, the test of difference between treatments show that T_2 is significantly different from the rest of the treatment samples. Specifically, T_1, T_3 and T_9 possesses the lowest L values, while T_2 had the highest.

Similar with the results of the ANOVA for luminance, the ANOVA for the a* values revealed that storage condition did not affect the forenamed parameter, but boiling time was. The test to determine the difference between treatments as displayed in Table 2b denotes that the highest a* values are observed on treatment samples T_4, T^{10}, T_{11}, and T_{12}. On the contrary, low a* values are denoted in T_5 and T_7, but these two treatment samples are statistically of no significant difference with T_1 and T_8.

Meanwhile, the b* as another important parameter to color characteristics were noted to range from 11.18 (T_1) to 24.65 (T_6). The former is not statistically different from T_9 and T_{11}, while T_6 was statistically the same with T_4, T_5, T_8 and T_{12}. Storage condition and boiling time were found to cause significant effect on the aforesaid parameter as shown in Table 2b.

Total Soluble Solids (TSS)

Total soluble solids is the measure of sugar content of the fruit, which includes the carbohydrates, organic acids, proteins, fats and minerals. The Seriales fruits in Leyte had higher TSS values as compared to other countries (Cimafranca, 2017). The forenamed author reported a mean TSS value of 14.93^{0}B, which is within the range of TSS values noted in this experiment (11.67 to 18.00^{0}B). However, processing sometimes reduces the TSS content due to dilution effect, and often results to nutrient degradation (Hwang et al. 2012). That is why a decreasing trend in the TSS values was reflected in Table 3. Similar result was reported on vegetables namely broccoli, cabbage, cauliflower, spinach and watercress, where significant reduction was evident due to leaching of soluble sugars and organic acids into the water (Vinha et al., 2015). The statistical results in this experiment indicates that the total soluble solids of the seriales were affected by boiling at different time variation, similar with the results on boiled Khilek young flowers (Teangpook et al., 2012). PassoTsamo et al. (2015) on contrary, suggested that boiling may not affect the soluble sugar contents of the pulp and the peel in bananas.

pH

Table 3 presents the pH values of the different treatment samples. The range of values was 3.12 (T10) to 3.32 (T4). These values are in agreement to the pH values

Table 2b

Color characteristics of the skin of ripe frozen and unfrozen seriales (F. jangomas) fruit as affected by varying time of exposure to boiling

TREATMENT	SERIALES CONDITION	BOILING TIME (MINUTES)	COLOR VALUES		
			*L**	*a**	*b**
T_1	No freezing	0	25.68 ± 0.74^{ef}	19.25 ± 3.38^{def}	11.18 ± 1.38^{fg}
T_2	No freezing	2	43.02 ± 4.72^{a}	21.83 ± 0.81^{cde}	21.05 ± 0.89^{abcde}
T_3	No freezing	4	28.13 ± 1.34^{def}	24.22 ± 2.38^{bcd}	17.42 ± 2.67^{de}
T_4	No freezing	6	32.82 ± 1.06^{bcd}	28.18 ± 0.87^{ab}	24.12 ± 4.84^{ab}
T_5	No freezing	8	32.47 ± 1.04^{bcd}	16.17 ± 0.40^{f}	23.27 ± 1.75^{abcd}
T_6	No freezing	10	35.32 ± 1.30^{bc}	23.28 ± 2.25^{bcd}	24.65 ± 0.86^{a}
T_7	Frozen	0	30.07 ± 1.21^{cde}	15.80 ± 0.63^{f}	18.05 ± 0.56^{cde}
T_8	Frozen	2	33.70 ± 2.40^{bc}	17.72 ± 0.44^{ef}	23.52 ± 2.90^{abc}
T_9	Frozen	4	24.10 ± 1.08^{f}	15.72 ± 1.55^{f}	08.25 ± 1.91^{g}
T_{10}	Frozen	6	36.82 ± 0.93^{b}	28.03 ± 0.46^{ab}	18.55 ± 0.60^{bcde}
T_{11}	Frozen	8	32.03 ±1.90^{bcd}	29.48 ± 2.80^{a}	16.57 ± 0.34^{ef}
T_{12}	Frozen	10	34.23 ±1.10^{bc}	25.13 ± 1.99^{abc}	20.97 ± 1.44^{abcde}

Values are means of triplicate determination ± standard error (SE)
Means of 6 fruits per treatment using a Lovibond LC 100 Spectrocolorimeter. L* = lightness, a* = bluish/green/red-purple hue component, b* = yellow/blue hue component,
Mean values followed by different letter superscripts in the same column are significantly ($p<0.05$) different.

gathered by Cimafranca (2017) on the same commodity. In comparison with F. jangomas from other countries, the pH of the seriales fruit in Leyte are comparably lower than 3.64±0.01 pH obtained on similar fruit from Bangladesh (Ara et al. 2014). With respect to boiling time, Table 3 revealed that an increase in pH was noted up to 6 minutes of exposure to boiling water, then dropped down in the subsequent heating period. Significant decrease of the pulp pH of bananas was observed after boiling. PassoTsamo et al. (2015) cited Vaclavik and Christian (2014), stating that the release of organic acids from the cell walls to the cytoplasm caused pH to lower upon cooking. Relative to storage condition, a generally downward trend was observed. However, it should be noted that statistically, all these values do not differ from each other, a result dissimilar to the trend exhibited on boiled Khilek.

Total titratable acidity (TTA)

Titratable acidity of fruit juices is an important parameter in determining fruit maturity and sour taste in citrus fruits. It is a measure of the amount of acid present in a solution, which is expressed as grams/liter (g/L). The total titratable acidity of F. jangomas deliberates on the fruit's total acidity but not the measurement of the strength of acids.

In the experiment, the % TTA ranges from 0.01 to 0.02% (Table 3), which is in disagreement to the %TTA values gathered by Cimafranca (2017) and Ara et al. (2014). This could probably be due to variability of the fruit. According to Robertson et al. (1990), titratable acidity decreased with increased maturity, and this could be one reason of the variability between the results of the previous studies from various authors.

Results of statistical analysis on the other hand revealed that both storage condition and boiling time did not affect the % TTA of the treatment sample.

CONCLUSION

It was concluded that boiling time significantly affected the TSS values of the fruits, the L* and a* values of the flesh, and all color parameters of the skin. TSS was significantly affected by boiling time, while pH and % TTA were unaffected by both storage condition and boiling time.

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Table 3

TSS, pH and % TTA of the ripe frozen and unfrozen seriales (F. jangomas) fruit as affected by varying time of exposure to boiling

TREATMENT	SERIALES CONDITION	BOILING TIME (MINUTES)	PHYSICO-CHEMICAL PROPERTIES		
			TSS*	pHns	%TTA
T_1	No freezing	0	18.00 ± 0.73[a]	3.20 ± 0.16	0.02 ± 0.003[ab]
T_2	No freezing	2	17.33 ± 0.49[ab]	3.23 ± 0.04	0.01 ± 0.001[c]
T_3	No freezing	4	15.00 ± 0.52[cd]	3.27 ± 0.06	0.01 ± 0.001[c]
T_4	No freezing	6	14.00 ± 0.89[cde]	3.32 ± 0.03	0.01 ± 0.001[bc]
T_5	No freezing	8	14.67 ± 0.42[cde]	3.27 ± 0.05	0.01 ± 0.001[bc]
T_6	No freezing	10	13.17 ± 0.60[def]	3.18 ±0.06	0.02 ± 0.012[a]
T_7	Frozen	0	17.50 ± 0.67[ab]	3.30 ± 0.13	0.02 ± 0.001[abc]
T_8	Frozen	2	15.67 ± 1.38[bc]	3.27 ± 0.04	0.01 ± 0.001[abc]
T_9	Frozen	4	17.83 ± 0.48[a]	3.17 ± 0.03	0.01 ± 0.001[bc]
T_{10}	Frozen	6	12.67 ± 0.80[ef]	3.12 ± 0.12	0.01 ± 0.001[c]
T_{11}	Frozen	8	12.67 ± 0.76[ef]	3.13 ± 0.02	0.01 ± 0.001[bc]
T_{12}	Frozen	10	11.67 ± 0.67[f]	3.13 ± 0.03	0.01 ± 0.001[c]

Values are means of triplicate determination ± standard error (SE)
Means of 6 fruits per treatment using a Lovibond LC 100 Spectrocolorimeter. L* = lightness, a* = bluish/green/red-purple hue component, b* = yellow/blue hue component,
Mean values followed by different letter superscripts in the same column are significantly (p<0.05) different.

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