Evaluation of Physicochemical and Sensory Characteristics of Bottled Star Fruit (*Averrhoa carambola)*

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Abstract

Averrhoa carambola, commonly known as star fruit, is a highly valued tropical fruit due to its unique flavor and numerous health benefits. This study examines the effects of several heat treatments on the physicochemical properties, sensory qualities, and oxalic acid concentration of bottled star fruit (Averrhoa carambola). Pasteurized juice at 60 ± 02 0C for 5 min were poured into pre sterilized jars with star fruit pieces. Sensory aspects were evaluated of the product using a nine-point hedonic scale to rate its general acceptability. The oxalic acid content of raw, mature and ripe were 215.4 mg/L, 196.9 mg/L and 174.7 mg/L respectively while ascorbic acid content was reported as 3.21 mg/L, 3.21 mg/L and 6.42 mg/L. After blanching at 1, 2 and 3 min with 80ºC for ascorbic acid content and oxalic acid content results were recorded as 6.42 mg/L, 3.21 mg/L and 3.21 mg/L and 96.1 mg/L, 84 mg/L and 80.5 mg/L respectively. The fresh and bottled star fruit contained characteristics such as pH of 3.87 and 3.93, titratable acidity of 0.40 % and 0.36 %, brix value of 10 and 09 (TSS), Oxalic acid content 567 ± 26.62 mg/L and 341 ± 5.58 mg/L, ascorbic acid content 6.42 mg/L ± 1.28 mg/L and 3.21 ± 1.28 mg/L were recorded respectively. According to the WHO guidelines that oxalic acid content was got the safer level (50 mg/day) and because of that it can be used for susceptible individuals as well.

Keywords: Own juice, Physicochemical, Sensory, Star fruit, Storage

I. INTRODUCTION

The tropical fruit known as star fruit, or *Averrhoa carambola* in scientific parlance, is grown in Sri Lanka. Because of its star-like appearance when cut crosswise, it is also frequently known as "carambola". It is a member of the Oxalidaceae family (Litz *et al.*, 1989). Numerous star fruit cultivars are grown in Sri Lanka. These come in both tart and sweet versions, with different levels of sourness. In Sri Lanka, some of the most well-liked cultivars include "Fanton," "B10," and "Honey Sweet"(*(Star Fruit)*, n.d.) (Department of Agriculture, Sri Lanka, 2024). In Sri Lanka, star fruit trees are usually grown as ornamental trees or in residential gardens or small orchards and can be considered as organic fruit. When star fruit is completely ripe, it is typically harvested. Harvesting should be timed to suit the desired flavor; some people like their fruit slightly acidic and green, while others prefer it entirely golden and sweet (Pereira *et al.*, 2020). Star fruit is usually eaten raw, but it can also be added to salads, juices, chutneys, and desserts, among other cooked dishes. It is frequently used in fruit platters and salads in Sri Lankan cuisine. Antioxidants, fiber, and vitamin C are all present in star fruit (Pereira *et al.*, 2020). It is regarded as a healthy supplement to a diet because it is low in calories(Lakmal *et al.*, 2021). Like many other tropical nations, Sri Lanka values star fruit not only for its flavour but also for its culinary variety and possible health advantages.

The possible anti-diabetic effects of star fruit have been studied. Star fruit may help people with diabetes, while it is not a replacement for medical care or a diabetes management strategy. Compared to foods with a high glycemic index (GI), star fruit has a comparatively low GI, meaning that it affects blood sugar levels more gradually. Low GI foods can lessen the likelihood of sudden blood sugar spikes and crashes. Dietary fiber (Lakmal *et al.*, 2021) which is present in star fruit, may aid to stabilize blood sugar levels by slowing the body's absorption of sugars and carbohydrates. Antioxidants found in star fruit nclude vitamin C and a variety of polyphenols (Narain *et al.*, 2009). Antioxidants can assist in

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lowering inflammation and oxidative stress, both of which are frequently increased in diabetics (Leivas *et al.,* 2016). According to certain research, polyphenolic chemicals found in star fruit may have anti-diabetic effects. These substances could lessen insulin resistance and increase insulin sensitivity. Potassium, a mineral essential to controlling blood pressure, can be found in star fruit. Potassium encourages blood vessel walls to relax and helps offset the effects of sodium on blood pressure. Dietary fiber, found in star fruit, may support heart health. Lower blood pressure and a lower risk of hypertension are linked to a high-fiber diet. It is an essential component of the nation's culinary heritage and gives a distinctive flavour and aesthetic appeal to a variety of foods (Wang *et al.,* 2021). Star fruit can benefit from thermal treatments that improve its texture, flavour, and safety.

Oxalate is a naturally occurring substance found in star fruit that may be hazardous to those who have certain medical disorders, especially kidney impairment (Akhtar *et al.,* 2011). Besides the sensory, nutritional, and medicinal benefits of star fruits, their high oxalic acid content has aroused serious concerns (Hönow and Hesse, 2002; Massey, 2007; Sorensen, 2014; Sá *et al.,* 2019). The consumption of oxalic acid increases the formation of insoluble calcium oxalate salts which get deposited in the small blood vessels or to the units in the kidneys that clean blood (Chen *et al.,* 2001; Wijayaratne *et al.,* 2018). Excessive consumption of star fruit has been associated with the development of oxalate nephropathy in patients with both normal and

As a common fruit in many tropical and subtropical countries, including Southeast Asia, star fruit (*Averrhoa carambola*) is grown in household gardens in Sri Lanka. Although it is a well-liked fruit in the area, Sri Lanka typically does not cultivate it extensively for commercial purposes. During the fruiting season, the majority of starfruits are wasted owing to improper usage and fear of the oxalic acid concentration of starfruit. Value addition of Carambola fruits will improve the consumption by different communities and also reduce the postharvest losses of the unexploited fruit, apart from promoting several health benefits. Various strategies have been used for the reduction of oxalates in foods. An attempt to reduce the oxalates content by different methods such as washing, soaking (with $CaCl_2$, NaCl), and blanching has been reported, (Dahal and Swamylingappa, 2006; Hefter *et al.,* 2018; Rofi'ana *et al.,* 2018; Savage and Dubois, 2006; Thapa *et al.,* 2017). This study evaluated how different heat treatments alter the physicochemical qualities and sensory characteristics of bottled star fruit. (*Averrhoa carambola*) in its own juice offers important information about the product's quality and safety. This study adds significant knowledge to the field of fruit juice processing and advances the creation of consumer-friendly, premium, and safe products.

II. MATERIALS AND METHODS

Perhaps the easiest way to comply with the conference paper formatting requirements is to use this document as a template and simply type your text into it. When using this as a template, you do not need to worry about page layout, fonts, etc. The main body of the paper should be organized into sections, as Introduction, Background/ Literature review, Problem specification, Methodology and Experimental design, Results, Discussion and Conclusion, Acknowledgement and References.

A. Ingredients and Equipment

Fresh star fruit (*Averrhoa carambola*), Water, Sterilized glass bottles or jars with tight-fitting lids, cutting board and knife, Saucepan, mixing spoon, Funnel, Boiling water bath, Retort

B. Sample preparation for analysis - Preparation of starfruit juice

Ripe but firm star fruits were selected for the processing. The fruits were washed thoroughly under potable, running water and sliced. The slices were placed in sterilized glass bottles and juice was extracted from additional star fruit slices. Juice was heated in a water bath to 60°C, and poured over the fruit slices to cover them completely. The bottles were exhausted in a water bath at 80°C for 5 minutes. After securely tightening the lids, the samples were sterilized in a retort at 100°C for 25 minutes under 1 bar of pressure. Bottles were allowed to cool to room temperature before storing in a cool, dark place. All equipment utensils used were properly sanitized to prevent contamination.

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C. Testing of physicochemical properties

1) Oxalic acid level measurement:

Diluted samples were titrated for the oxalic acid content determination purpose. A burette was used and titrated the standard oxalic acid solution and sample with Potassium permanganate solution (Narain *et al.*, 2009).

2) Brix value:

Juice was extracted from the star fruits by crushing and filtering the pulp to obtain a clear liquid sample. Refractometric Method was used for the brix level evaluation purpose (AOAC Official Method 932.12).

3) Ascorbic acid level measurement:

Ascorbic acid content was obtained using titration of the samples with iodine solution. Each samples were diluted and starch solution was added for titration (Iodine titration) (Ruvini *et al.*, 2018).

4) pH Measurement:

Star fruit sample was prepared by extracting juice or creating a homogenized mixture. pH was recorded by using pH meter (AOAC Official Method 981.12).

5) Acidity measurement:

One of the most widely used methods is the titration method using sodium hydroxide (NaOH) as the titrant (AOAC Official Method 942.15 - Titratable Acidity).

6) Sensory evaluation:

Sensory evaluation on star fruit pieces in own juice bottle was conducted with nine-point hedonic scale during the time period. Moderate level of preference (07) was obtained from the trained panelists.

7) Microbial evaluation:

Microbial evaluation was performed using the plate count method (AOAC Official Method 966.23). Samples were diluted, plated onto Standard Plate Count Agar, incubated at 35°C for 48 hours, and colonies were counted to determine CFU/g.

8) Statistical analysis:

The results are the mean ± standard deviation (SD) of triplicate evaluations. Analysis of data was carried by one-way analysis of variance (ANOVA) and the mean comparisons were done by the Tukey-HSD test where necessary. analyses were performed by using SPSS-16 for Windows program.

III. RESULTS AND DISCUSSION

A. Physicochemical properties with different maturity stages

1) Oxalic acid content:

According to the maturity stages, immature star fruits were contained low oxalic acid content than the ripe star fruits. Overall, the chart demonstrates that oxalic acid content decreases as the samples move from the immature stage to the ripe stage.

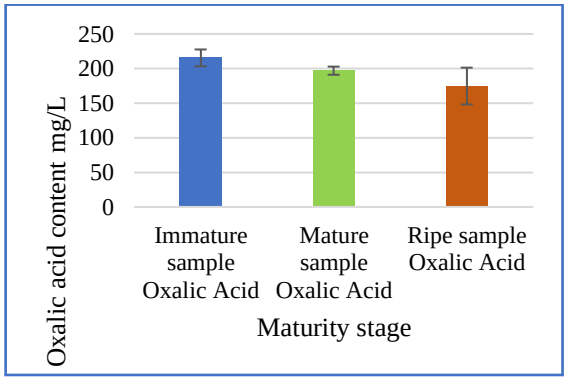

Figure 01. Oxalic acid content on different maturity stages

2) Brix value:

Ripe star fruits were contained high brix value than immature fruits. This bar graph displays the Brix values of samples at different maturity stages: immature, mature, and ripe. Brix is a measure of the sugar content in an aqueous solution, typically used in the context of fruits to gauge their sweetness and ripeness.

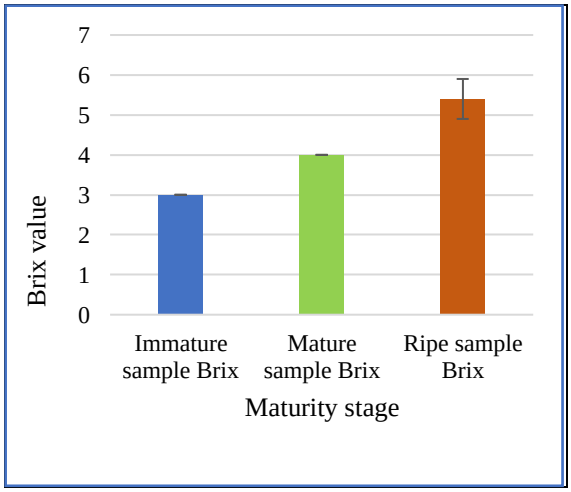

Figure 02. Brix value on different maturity stages

3) Ascorbic acid content:

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This bar chart displays the ascorbic acid (vitamin C) content in mg/L at different maturity stages of a sample. The ascorbic acid content increases from the immature to the ripe sample. Ascorbic acid content was highly contained in ripe star fruits.

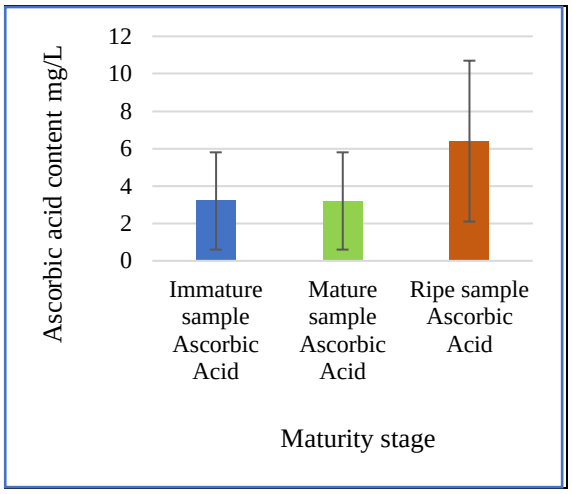

Figure 03. Ascorbic acid content on different maturity stages

4) pH level:

This bar chart depicts the pH levels of samples at different maturity stages: immature, mature, and ripe. The pH level increases as the sample matures from the immature to the mature stage and then stabilizes as it remains constant from the mature to the ripe stage. Acidity level was increased in the ripe star fruits than immature fruits.

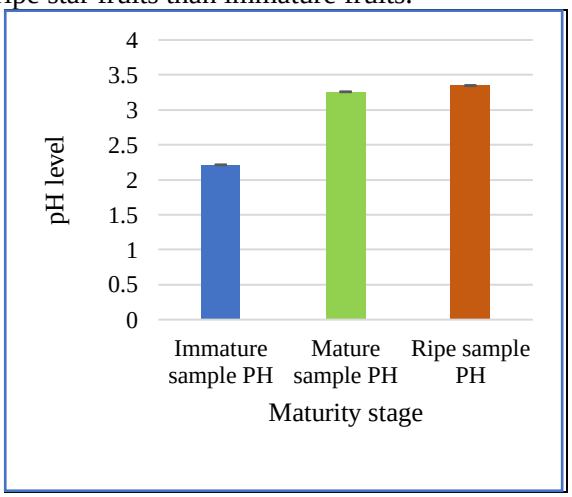

Figure 04. pH level on different maturity stages

A. Physicochemical properties with effect of thermal treatments:

1) Oxalic acid content:

With different blanching times, 03 minutes of blanching time was reduced the oxalic acid content than 01 minutes blanching time.

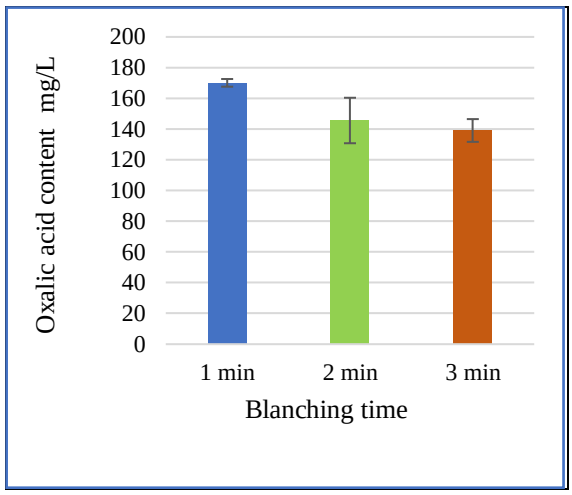

Figure 05. Oxalic acid content on different blanching times

Ascorbic acid content was reduced after the blanching, because that ascorbic acid is water soluble and heat sensitive at the same time. Oxalic acid and ascorbic acid are heating sensitive and available content can be reduced using the heat treatments.

Testing for oxalic acid contents were generated positive results on the evaluation. Final results were obtained after the calculation of final readings. Fresh star fruit juice was resulted 923 mg/l of oxalic acid content according to the process. Water blanched for 01 min sample was obtained 942 mg/l of oxalic acid content. Water blanched for 02 minute and 03minute samples were obtained 749 mg/l, 539 mg/l of oxalic acid contents respectively. Sterilization was done at the final stage of the sample preparation process. Before that, juice pre-heating and exhausting were conducted according to the process. Bottled sample with 03 minutes blanched pieces of star fruits were obtained 317 mg/l of oxalic acid content according to the data.

2) Ascorbic acid content:

Ascorbic acid or vitamin C content is some kind of nutrient included in the fruits or vegetables. In star fruit, it can be available with different values and it depends on the environmental conditions and maturity indices accordingly. In the bottling process, fresh star fruit was obtained 6.42 mg of ascorbic acid value. After processing of star fruit, that ascorbic acid content can be reduce from the materials. Because that ascorbic acid is heat sensitive and water soluble (Narain *et al.*, 2009).

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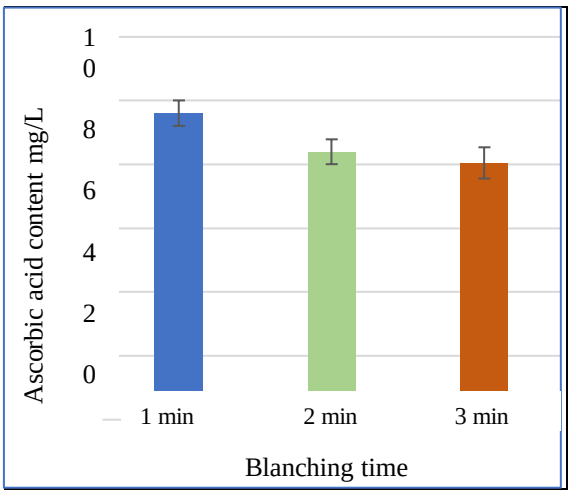

Figure 06. Ascorbic acid content on different blanching times

C. Physicochemical properties result with effect of pre-treatments

1) Oxalic acid content:

Pre-treatments with different acids can significantly alter the physicochemical properties of substances, impacting their stability, solubility, and overall performance in various applications. Comparing the two acids, oxalic acid has a stronger impact on the physicochemical properties of star fruit juice, which could be leveraged in applications requiring significant modification of these properties.

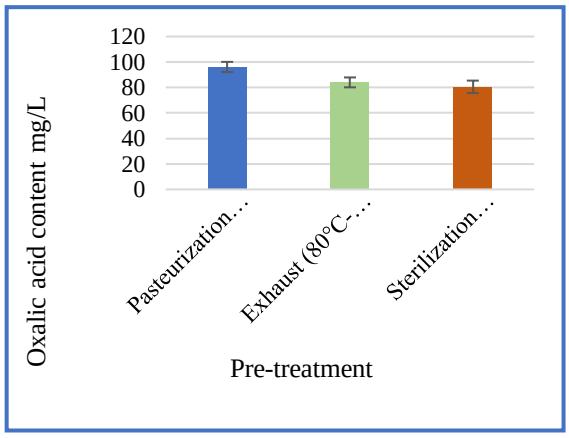

Figure 07. Oxalic acid content on different pre-treatments

2) Ascorbic acid content:

The study demonstrates that oxalic acid and ascorbic acid pre-treatments distinctly influence the physicochemical properties of star fruit. Oxalic acid has a more pronounced effect, which may be beneficial in specific industrial applications.

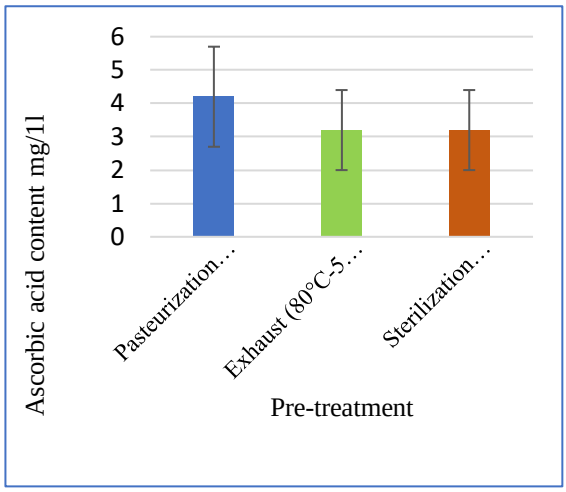

Figure 08. Ascorbic acid content on different pre-treatments

D. Physiochemical properties during storage period

Samples were tested for the ascorbic acid content, pH level, brix value, acidity, microbial count and sensory evaluation with the shelf-life testing. Sample preparation for shelf-life evaluation was conducted using the mature level of star fruits. Fresh star fruit juice was contained 634 mg/l of oxalic acid content at the processing time. Sterilized final product was obtained 341 mg/l of oxalic acid content. During the storage period, samples were resulted reduction of oxalic acid content levels according to the data generated.

Fresh sample was obtained 3.87 pH level and after preparation of the bottles, 3.79 was the pH reading. it can be happening, because that inside bottle was filled with processed and unprocessed materials. Equilibrium level will be process inside bottle during storage period. Level of pH was changed normally after the bottling process.

Brix value of the star fruit was obtained 10 in fresh fruits and after processing, it was gradually decreased with the storage period.

Acidity level was obtained periodically with fresh and bottled samples evaluation.

D. Sensory evaluation results

Sensory evaluation was done during the four-month storage period with 05 trained panelists. Sweet taste increasing idea was concluded finally by the sensory panelists. Additional of value with vitamins, sweeteners like things will commercially valuable in the star fruit-based productions. Moderate level (07) of acceptances were obtained for every month (04) with the positive feedbacks.

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Table 01: Physiochemical properties of Star Fruit juice sample during storage period

Time	Parameter					
	Oxalic Acid content (mg/L)	**Ascorbic Acid content (mg/L)**	**PH**	**Brix (TSS)**	**Acidity (%)**	**Microbial total plate count (TPC)**
Fresh	634	6.42	3.87	10	0.4	Detected
Initial	341	3.21	3.79	9	0.39	Not Detected
Month 01	403	3.21	3.64	8	0.33	Not Detected
Month 02	425	3.21	3.81	7	0.47	Not Detected
Month 03	398	3.21	3.6	7	0.49	Not Detected

E. Sensory evaluation results

Sensory evaluation was done during the four-month storage period with 05 trained panelists. Sweet taste increasing idea was concluded finally by the sensory panelists. Additional of value with vitamins, sweeteners like things will commercially valuable in the star fruit based productions. Moderate level (07) of acceptances were obtained for every month (04) with the positive feedbacks.

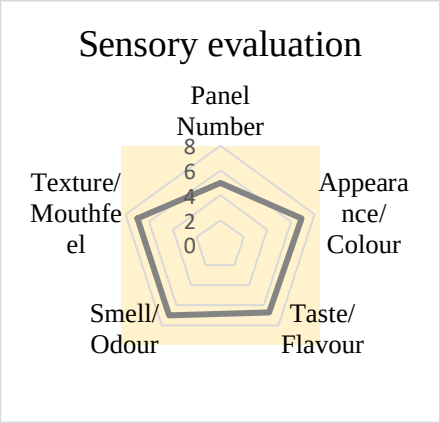

Figure 09. Sensory evaluation data

F. Microbiological results

Microbes were not detected after the bottling process with sterilization.

IV. CONCLUSION

The investigation into how various heat treatments affect the oxalic acid concentration, physicochemical properties, and sensory attributes of bottled star fruit (Averrhoa carambola) offers important information about the product's quality and safety. The star fruit juice was significantly impacted in a number of ways by the heat treatments, such as pasteurization and sterilization. First off, the product's safety and consumption may be enhanced by the reported decrease in oxalic acid content following heat treatments. Excessive concentrations of oxalic acid can be hazardous to human health. Heat treatments have been shown to reduce oxalic acid levels, indicating that these techniques may be useful in reducing the risk. Second, the physicochemical modifications such as variations in pH, colour, and texture are important elements that impact the star fruit juice's overall quality when it is packaged. The study emphasizes how important it is to give these factors considerable thought throughout the heat treatment process in order to preserve desired qualities and create a product that lives up to customer expectations.

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