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Comparison of Frozen Green Jackfruit Quality following Boiling Water and Microwave Blanching

Taslima Ayesha Aktar Nasrin[1*], Md. Atiqur Rahman[1], Most. Sadia Arfin[1], Mohammad Mainuddin Molla[1], Ashfak Ahmed Sabuz[1], Most Tahera Naznin[2], Md. Abdul Matin[3]

[1]Bangladesh Agricultural Research Institute, Bangladesh

[2]University of Nevada, Reno, USA

[3]International Maize and Wheat Improvement Center (CIMMYT), Zimbabwe

* E-mail: taanasrin@gmail.com; st111058@alumni.ait.asia

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ABSTRACT

Although jackfruit is highly nutritious, it has a high postharvest loss and is only available for a limited time, especially the green type. Therefore, preservation is required to ensure its availability throughout the year. Green Jackfruit can be preserved by freezing; however, blanching is necessary to retain its nutrients and colour before freezing. So, the aim of this study is to examine the effects of boiling water and microwave blanching on the quality of green jackfruit both during freezing and just after blanching. Jackfruits were cleaned, peeled, and cut into one cm thick slices after removing core. Slices were blanched in boiling water (100°C) and microwave (input power 1500 W) and stored for 8 months in a freezer (-20°C) after chilling. Blanching was faster in microwave (2.5 min) than in boiling water (3 min). At eight months, unblanched jackfruit slices received 3.87 scores (considered unacceptable), but slices blanched in boiling water and microwave obtained 6.45 and 6.88 scores respectively in case of overall acceptability, which are considerably higher ($p < 0.05$) than their unblanched counterparts.

Keywords: Green jackfruit, external colour, firmness, organoleptic attributes, boiling water blanching, microwave blanching

INTRODUCTION

The jackfruit (*Artocarpus heterophyllus* L.) is dicotyledonous compound fruit that grows across Southeast Asia's tropical regions but is most prevalent in Bangladesh and India (Goswami, 2011). Bangladesh is the world's second largest jackfruit producer next to India (Alam et al., 2023), with a yearly production of 1.10 million tonnes (BBS, 2021). Jackfruit is considered as the National Fruit of Bangladesh. All stages of the jackfruit are eaten, from tender to ripe. Both the seeds and the flesh of jackfruit are consumed as curries and boiled forms, while the flesh in fully ripen stage can be eaten directly as a fruit (Ranashinghe et al., 2019). This fruit's exceptional nutritional profile, particularly its high protein level, allows undernourished people to consume it instead of shredded meat. Jackfruit is rich in proteins, dietary fibres, vitamins, minerals, and phytochemicals makes it unique from others. Despite of its many advantages, jackfruit is still neglected and not considered as an income-generating crop, even in its main regions of production, (Ranasinghe et al., 2019).

However, jackfruit seeds and ripe fruit have been used for producing a range of ready for consumption and value-added food products like jam, jelly, candy, fruit leather, pitha, Halwa, powder, chips, pickles in the last few years. The majority of them are made of sugar or oil, making them less desirable for everyday consumption, particularly among those who are concerned about their health or who have diabetes or high blood pressure (Pritty et al., 2020). A feasible remedy for this issue is the eating of tender or immature jackfruit (approximately 60–70 days of maturity) as a vegetable (Rana et al., 2018) since, it is low in sugar and high in potassium and ascorbic acid. According to Swami et al. (2016), green jackfruit also contains phyto-chemicals that help reduce the risk of cancer, lung, stroke, and cardiovascular problems. Additionally, the combination of its meat-like texture and high fiber content enhanced its popularity as a vegetable. These unique characteristics of tender jackfruit might have contributed to its high market value, particularly in South Asian nations. Jackfruit is accessible in its green/tender form from late April until early June, although its season spans from April to August. Approximately 2 to 3 weeks remain in the tender/green form after differentiation. Availability of green jackfruit to be utilized as a vegetable is challenged by seasonal availability, highly perishable character, browning and challenges in processing, transportation, and storage (Ranasinghe et al. 2019). The aforementioned issues necessitate more research to find a suitable preservation method that can prolong the shelf life of green jackfruit in a ready to cook state while taking consumer preferences and cost effectiveness into account.

Freezing of fruits and vegetables is frequently used to preserve their fresh-like attributes over a long duration with little loss of nutrients like vitamins and antioxidant content. Frozen fruits and vegetables retain their sensory and nutritional qualities better than those that have been canned or dehydrated (Grover and Negi, 2023). Blanching is a crucial heat treatment that is used prior to a number of preservation techniques, including drying, canning, freezing, frying and it greatly influences the quality of the final product (Xiao et al., 2014). Fruits and vegetables are blanched primarily to inactivate enzymes, decrease microbes, eliminate gases from produce, allow the produce to compress for easier packaging, preserve texture and colour, and clean the surface of produce (Patras et al., 2011).

In industry, hot water and steam are the most often utilized heating media for blanching; however, hot gas and microwave blanching have also been researched. Among these techniques, microwave blanching of vegetables seems to result in a significantly higher nutrient retention than other traditional approaches (Trilokia et al., 2019). Hence, benefits like reduced time to process or better heating efficiency may make microwave blanching a potential substitute (Trilokia et al., 2019). Since peroxidase is known to be the enzyme in vegetables that is most heat stable (Arnok et al., 2010), blanching vegetables to the point where this enzyme is lost causes the inactivation of other several enzymes that would otherwise be in charge of preserving the quality of blanched products (Severini et al., 2016).

Research has been conducted on blanching of tender jackfruit using boiling water with additives for the "Koozha" variety by Praveena and Sudheer (2015) and the "Varikka" variety by Pritty and Sudheer (2012); however, the storage quality of blanched fruit was not examined in their study. Besides, the thermal processing of tender jackfruit in tin-free steel cans has been studied by Pritty et al. (2022). Microwave blanching of green jackfruit and the impact of any blanching method on its frozen storage have not been studied yet. This study compared the blanching techniques of green jackfruit in boiling water and microwave in order to identify an efficient and quick technique that preserves more nutritional and sensory quality during blanching and frozen storage.

MATERIALS AND METHODS

Sample preparation

Green jackfruit (*Artocarpus heterophyllus* L.) which was harvested 60–70 days following fruit formation was purchased from a farmer's jackfruit garden in Shripur, Gazipur, Bangladesh. Jackfruits were cleaned, peeled, and cut into nearly uniform-sized (1 cm thick) slices after removing the spongy stem core. Three sets of jackfruit slices were split into (a) unblanched (control); (b) microwave blanching; and (c) boiling water blanching.

Boiling water blanching (BWB):

After being submerged in boiling water (sample: tap water ratio 1:5 w/w), green jackfruit slices were blanched for 1, 1.5, 2, 2.5, 3, 3.5, and 4 minutes, in that order. Following treatment, they were removed from the water and promptly cooled in running water to prevent overcooking.

Microwave blanching (MWB):

Slices of green jackfruit were placed in a casserole that was safe to use in the microwave. Water (equivalent to half the volume of the jackfruit) was added, and the lid was closed. The switch was kept in "on" position, and the casserole was kept in a microwave oven (model no.: RANGS RMC-IBOK, Korea, input power 1500 W). Jackfruits were blanched for 1, 1.5, 2, 2.5, 3, 3.5, and 4 minutes, respectively, stirring them once during the half-time. Following treatment, they were drained off and quickly chilled in running water to prevent over-cooking.

Following cooling, the peroxidase enzyme inactivation test was determined to assess the effectiveness of the two blanching techniques. Jackfruits that had been blanched were placed in a high-density polyethylene bag, sealed, and stored at -20°C in the freezer for 8 months.

Peroxidase test

In a test tube, twenty grammes of ground sample was mixed with 20 millilitres of distilled water. 0.3% hydrogen peroxide and 1% guaiacol solutions were made. In the test tube, 1.6 millilitres of hydrogen peroxide solution and 1 millilitre of guaiacol solution were added, and everything was properly mixed. Concentrated peroxidase enzyme activity was indicated by a quick and intense brownish red colouring that occurred within 5 minutes. A mild pink hue that gradually developed suggested either minimal peroxidase enzyme activity or partial peroxidase enzyme inactivation. Peroxidase enzyme was deemed inactivated and the reaction regarded as negative if no colour developed after 5 minutes (Praveena and Sudheer, 2015).

External colour measurement

Using a Chroma Metre (Model CR-400, Minolta Corp., Japan) based on CIE (L*a*b*), the outside colour of green jackfruit slices was assessed. L* stands for lightness, while in this chroma meter the a* and b* readings were automatically converted to chroma (c) and hue angle (h°). Calibration was performed using the provided white plate prior to measurement (Nasrin et al., 2018a). From each replication, ten jackfruit slices were examined, and the mean value was taken into account.

Firmness measurement

The Fruit Texture Analyzer (GUSS, Model Number: GS-25, SA) was used to assess the firmness of green jackfruit slices. At a speed of 5 mm per second, an 8 mm dia. flat end probe was inserted into the jackfruit slices to reach a thickness of 3 mm. In Newton, the firmness value was determined by using the maximum penetrating force (Nasrin et al., 2018b). From each replication, ten jackfruit slices were examined, and the mean value was taken into account.

Ascorbic acid determination

The titration method (Ranganna, 1986) was used to evaluate the ascorbic acid content of green jackfruit applying a dye solution of 2, 6 dichlorophenol indophenol. Ascorbic acid in an alkaline solution reduces 2, 6-dichlorophenol indophenol dye to an uncoloured phase as part of the estimating process. To calculate the dye factor, the dye solution was first calibrated against standard ascorbic acid. After diluting the sample with 3% metaphosphoric acid, the phosphoric acid extract was titrated against the dye solution until a 15-second-long pink hue was achieved. The dye factor and ascorbic acid were calculated using the following expression.

$$\text{Dye factor} = \frac{0.5}{\text{Titrate volume}}$$

$$\text{Ascorbic acid (mg/100g)} = \frac{\text{Titre x Dye factor x Volume made x 100}}{\text{(Aliquot of extract taken x Weight of sample)}}$$

Reducing sugar determination

The Lane and Eynon procedure were used to determine reducing sugars in green jackfruit (Ranganna, 1986). 1 N NaOH was served to neutralize the material, and phenolphthalein was employed as an indicator. Two milliliters of lead acetate were then incorporated and it was left for ten minutes. Excess lead and potassium oxalate solution were added in the appropriate amounts to provide the requisite volume in order to cause precipitation. Using methylene blue indicator, the solution had been filtrated and titrated against 10 millilitres of Fehling A and B solution on a hot plate. The emergence of brick red colour served as an indication of the final point. The following formula was used to determine the reducing sugars.

$$\text{Reducing sugars (\%)} = \frac{\text{Factor x Dilution}}{\text{Titre value x wt: or vol: of sample}} \text{x100}$$

Total sugar determination

After the conversion of sucrose, a non-reducing sugar, to reducing sugar, the assessment of total sugars was carried out. After adding 2 grammes of citric acid to 20 millilitres of filtered extract, the mixture went through incubation at 60°C to ensure that the sucrose completely inverted to reducing sugars. After cooling the acid hydrolyzed solution to room temperature, NaOH was added for its neutralisation. Five millilitres of the hydrolysed solution were extracted in order to measure the total sugar in the form of invert sugar. The following formulas were used to determine the concentrations of sucrose and total sugar:

$$\text{Sucrose (\%)} = (\text{Total invert sugar} - \text{reducing sugar}) \text{ x } 0.95$$

$$\text{Total sugar (\%)} = \text{Reducing sugars (\%)} + \text{Sucrose(\%)}$$

Titratable acidity determination

The AOAC (2002) technique was used to determine the titratable acidity of green jackfruit. About 10 grammes of specimen were blended with 100 millilitres of distilled water, filtrated and then few drops of phenolphthalein indicator were included to determine the titratable acidity (TA). 0.1N NaOH was used for the titration of solution.

The following formula was used to determine the amount of citric acid:

Titratable Acidity (%) =

$$\frac{(\text{titre vol.} \times \text{normality of NaOH} \times \text{vol.made up} \times \text{eq.wt.of acid}}{(\text{aliquot of sample} \times \text{vol.of sample} \times 1000)} \text{x}100$$

pH determination

A pH meter (HANNA Instrument Inc., model no: pH-211; Microprocessor, pH Meter, Italy) was used to measure the pH of green jackfruit. Using pH 4.0 and pH 7.0 buffer at normal temperature, the pH meter was initially adjusted following the AOAC (2002) technique. In 100 millilitres of distilled water, ten (10) grammes of ground green jackfruit were mixed thoroughly and then filtered. The filtered sample was placed in a 100 ml beaker, swirled, and the pH meter's electrode was inserted. Once the reading stabilized, a direct result was obtained.

Organoleptic quality assessment

After blanching (0 month), 4 months, and 8 months of freezer storage, the organoleptic quality of the green jackfruit slices was assessed. Ten representatives of the scientific community and consumers, comprising both men and women, served as the panel of judges for the organoleptic test (colour, flavour, texture, and overall acceptability). Before the two hours of the organoleptic evaluation procedure, frozen green jackfruit slices were kept out of the freezer. These organoleptic aspects were assessed using a nine-point hedonic scale, which went from 1 (strongly dislike) to 9 (strongly like) (Nasrin and Anal, 2015). The threshold for acceptability was set at an average score of 4.5.

Statistical analysis

Every study was conducted using a completely randomised design (CRD) with three replications, and the mean ± standard deviation was displayed. The MSTAT-C software's instructions were followed while performing an analysis of variance (ANOVA). The Duncan Multiple Range Test (DMRT) ($p<0.05$) was used to compare the results.

RESULTS AND DISCUSSION

Blanching efficacy measurement

As indicated by Table 1, the peroxidase enzyme took 2.5 minutes to become inactive in MWB and 3 minutes in BWB of green jackfruit slices. Since the BWB of jackfruit takes more time than the MWB, the quality of the green jackfruit could decline as a result of the prolonged heating time. According to Praveena and Sudheer (2015), small slices of green jackfruit were needed to blanch (to inactivate the peroxidase enzyme) in water for three minutes at a temperature of 100°C. According to Severini et al. (2016), microwave blanching took only 80 seconds to completely inactivate the peroxidase in broccoli, whereas steam or hot water blanching required a minimum of 90 and 120 seconds, respectively.

External colour measurement

Figure 1 (a, b, c) depicts the colour values of green jackfruit when it is fresh or unblanched, blanched in a microwave or boiling water, and frozen. L* value was approximately 83 in fresh jackfruit, whereas it was approximately 77 (regardless of kind) after blanching. The blanching processes somewhat reduced the jackfruit's brightness, but this aided in preserving the fruit's colour and lightness throughout frozen storage. Lightness values were found to be 39, 58, and 61 in control (unblanched), boiling water, and microwave blanched frozen green jackfruit, respectively, after eight months of frozen storage. According to Praveena and Sudheer (2015), following blanching procedure of green jackfruit, the values of L* (lightness) and b* (blueness to yellowness) decreased and also exhibited a declining trend as blanching duration increased.

As illustrated in Figure 1(b), the MWB green jackfruit and unblanched jackfruit had the lowest (19.23) and highest (22.73) chroma values, respectively. All frozen jackfruit had more chroma throughout time of storage, while raw or unblanched frozen jackfruit had the highest chroma levels. Chroma values was reduced after blanching of tender jackfruit were reported by Pritty and Sudheer (2012). Chroma is the indicator of colour saturation and intensity. The translucent surfaces of blanched vegetables may invalidate the chroma index (Severini et al., 2016). Blanching can reduce browning by decreasing the reducing sugar content of the product may assist to reduce chroma value (Zhang et al., 2018).

Hue angle value rose after blanching and decreased throughout eight months of frozen storage, in contrast to brightness and chroma. Hue angle values were found to be 93.96, 96.67, and 97 in fresh/unblanched, BWB, MWB green jackfruit. Hue angle value decreased by about 31% in fresh/unblanched, 14.18% in BWB, and 13.4% in MWB green jackfruit for eight months of frozen storage. Nguyen et al., (2019) report that a rise in green colour was noted during microwave blanching (300 W for 4 min) of the green asparagus butt segment. In a similar vein, Suwan (2015) found that blanched vegetable soybean scored higher for green colour than vegetable soybean that were not blanched. Hot water treated (60°C for 1 minute) fresh cut carrot was more orange red colored than control/without heat treated carrot (Nasrin et al., 2021).

The blanched frozen green jackfruit, particularly in MWB, showed the least amount of colour change, whereas the unblanched frozen jackfruit showed the maximum colour change over the course of eight months of frozen storage. Colour is one of the most important sensory factors that influences a consumer's decision while selecting fruits and vegetables. Thus, keeping their colour while being stored is crucial.

Firmness measurement

When vegetables are blanched, frozen, and stored in a frozen state, one of the quality metrics that have the greatest effect is firmness/texture. Figure 2 displays the firmness value of green jackfruit when it is fresh or unblanched, after blanching in a microwave or hot water, and after it is frozen. Fresh green jackfruit slices have a firmness value of 2.65 (N), while after BWB & MWB green jackfruit, it was 1.86 (N) and 1.95 (N), respectively. Firmness and toughness of blanched tender jackfruit were found to be lower than those of fresh samples, according to Praveena and Sudheer (2015). Figure 2 illustrates that during frozen storage, blanched green jackfruit retained more of its firmness than unblanched counterpart. A decrease in pectin extraction is the outcome of this phenomenon, which is caused by a gel that forms when heat and pectic compounds interact (Prestamo et al., 1998).

After eight months of frozen storage, unblanched green jackfruit had a firmness value of 0.24N, however, MWB green jackfruit had the highest firmness value (0.92N), followed by 0.85 N in BWB one. The predominant damage caused by freezing, instead of blanching, is confirmed by these findings, which take place in the middle lamella of the cells. Frozen raw samples revealed physical alterations in histology, such as amorphous cell walls and layer separation between cell layers, which were elucidated through the ice crystal phenomenon. In contrast, there was no evidence of tissue damage in the cells of the blanched samples. Blanched carrots lost only 21% of their initial firmness, compared to approximately 50% in raw samples during frozen storage, according to Prestamo et al. (1998).

Ascorbic acid determination

The ascorbic acid concentration of green jackfruit is displayed in Figure 3 while it is fresh or unblanched, after blanching in hot water or microwave, and when it is frozen. 8.04 mg/100g of ascorbic acid has been detected in fresh green jackfruit, compared to 6.96 and 6.33 mg/100g in MWB and BWB counterparts respectively. Ascorbic acid levels in unblanched jackfruit after 8 months of freezer storage were 2.27 mg/100g, but BWB and MWB jackfruit showed 2.62 and 3.61 mg/100g, respectively. According to Ranashinghe et al. (2019), young jackfruit could hold 12–14 mg of ascorbic acid per 100g. According to Kidmose and Marten (1999), microwave-blanched carrot slices held more ascorbic acid, carotene, and sucrose than conventional blanching techniques both immediately after blanching and three months later when frozen. Microwave blanching led to higher preservation of ascorbic acid in mango than water blanching (Xanthakis, et al., 2018).

Total sugar, reducing sugar, pH and titratable acidity determination

Fresh, green jackfruit had a total sugar content of 3.61% and a reducing sugar content of 1.27% as shown in table 2. Both sugar contents were slightly lower after blanching due to leaching of soluble sugars during blanching in water, but there were no significant differences ($p < 0.05$) among the treatments. Blanching treatments could significantly reduce reducing sugar, asparagine, and acrylamide in potato chips (Zhang et al., 2018). Sugar content was decrease in sweet corn kernels after blanching, and this reduction rate was risen during increasing blanching time (Szymanek, et al., 2020). Total and reducing sugar decreased marginally in all samples throughout eight months of frozen storage but there were no significant differences ($p < 0.05$) among the treatments.

Table 3 displays the pH and titratable acidity values for fresh, green jackfruit, which were 6.11 and 0.64%, respectively. Both were somewhat reduced following blanching. The pH rose during the eight months of frozen storage, while the acidity marginally decreased, but there was no significant differences ($p < 0.05$) among the treatments. The crucial point is that unblanched, green jackfruit underwent greater chemical parameter changes during frozen storage than blanched jackfruit, and within the blanching technique, MWB jackfruit preserved more nutrients than BWB jackfruit. No research information has been found on these chemical values for green jackfruit.

In comparison to previous blanching techniques, Kidmose and Marten (1999) discovered that microwave-blanched carrot slices maintained a higher level of carotene, ascorbic acid, and sucrose both immediately after blanching and three months later when frozen. The fresh cauliflower exhibited 6.8° Brix TSS, 6.5 pH, 2.1% reducing sugar, 4.7% total sugar, and 0.25% titratable acidity (Nasrin et al., 2022). Titratable acidity, total sugar, and reducing sugar content all marginally decreased throughout the course of 20 days of refrigeration storage, whereas TSS and pH increased slightly (Nasrin et al., 2022). In fresh-cut carrots, TSS, pH, total sugar, and reducing sugar content were 9.5° Brix, 6.3, 6.75%, and 2.78%, respectively. All values were somewhat decreased following hot water treatment (60°C for 1 minute) and over the 12 days refrigerator storage period, but there was no significant difference among the treatment (Nasrin et al., 2021).

Organoleplic quality assessment

Regarding colour, flavour, texture, and overall acceptability, the organoleptic attributes of blanched and unblanched green jackfruit were measured immediately upon blanching (0 months), four, and eight months after frozen storage. Every sample displayed a reduction in organoleptic quality throughout storage as shown in Table 4 & 5. Unblanched jackfruit scored highest before freezing but lowest after freezing in all organoleptic traits. After 8 months of frozen storage, MWB jackfruit achieved the highest 6.84 (like slightly to like moderately) score in terms of overall acceptability, which was statistically similar ($p < 0.05$) to the result of BWB jackfruit. Control/unblanched jackfruit obtained 3.15 (dislike slightly to dislike moderately), which is significantly lower ($p < 0.05$) than the scores for both type of blanched jackfruit. Therefore, blanching, especially MWB, helped to effectively retain the green jackfruit's organoteplic attributes (typically colour and texture) throughout frozen storage. This statement is also proved by the pictorial views of 8 months frozen stored unblanched, BWB and MWB green jackfruit before and after cooking during study period as shown in Figure 4.

CONCLUSION

Less time and water were needed to blanch green jackfruit in microwave than in boiling water. Thus, the BWB method resulted in a greater loss of nutrients such as ascorbic acid, total sugar, reducing sugar, and acidity. The firmness of green jackfruit slices declined upon blanching; however blanched green jackfruit was firmer than unblanched counterparts during freezing. Furthermore, blanched green jackfruit changed less in colour than unblanched jackfruit. As enzymes (peroxidase, catalase) were not destroyed by blanching in unblanched green jackfruit, it substantially lost all physico-chemical and sensory attributes especially colour during frozen storage, and at 8 months it was no longer acceptable; in contrast, blanched one remained good with desirable appearance even after that period. This study might have some limitations considering not all jackfruits may have reached the exact same maturity stages. More research can be conducted in future, on changes of phytochemicals, and other important parameters in green jackfruit during freezing and just after both type of blanching techniques.

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Table 1. Comparison of microwave and boiling water on blanching time of green jackfruit

Treatment	Presence of peroxidize enzyme						
	1 min	1.5 min	2 min	2.5 min	3 min	3.5 min	4 min
Microwave blanching (MWB)	+	+	+	-	-	-	-
Boiling water blanching (BWB)	+	+	+	+	-	-	-

Table 2. Effect of microwave and boiling water blanching on total sugar, reducing sugar of green jackfruit during frozen storage (-20°C)

Treatment	Total sugar (%)			Reducing sugar (%)		
	0 month	4 months	8 months	0 month	4 months	8 months
Fresh jackfruit	3.61±0.47	3.36±0.18	3.28±0.45	1.27±0.08	1.15±0.27	1.07±0.51
BWB jackfruit	2.83±0.26	2.56±0.54	2. 19±0.53	1.07±0.57	0.91±0.18	0.94±0.85
MWB jackfruit	2.63±0.20	2.42±0.15	2.23±0.12	0.95±0.26	0.70±0.73	0.70±0.09

BWB=Boiling water blanching, MWB=Microwave blanching. Means with different letters within each column are significantly different ($p < 0.05$)

Table 3. Effect of microwave and boiling water blanching on pH and titrable acidity of green jackfruit during frozen storage (-20°C)

Treatment	pH			Titratable acidity (%)		
	0 month	4 months	8 months	0 month	4 months	8 months
Fresh jackfruit	6.11±0.90	6.18±1.79	6.22±0.51	0.640±0.50	0.384±0.62	0.256±0.10
BWB jackfruit	5.90±0.58	5.96±0.55	6.09±1.10	0.512±0.39	0.256±0.39	0.192±0.10
MWB jackfruit	5.78±0.61	5.82±0.67	5.95±0.55	0.512±0.35	0.256±0.51	0.128±0.76

BWB=Boiling water blanching, MWB=Microwave blanching. Means with different letters within each column are significantly different ($p < 0.05$)

Table 4. Effect of microwave and boiling water blanching on organoleptic quality (appearance and flavour) of green jackfruit during frozen storage (-20°C)

Treatment	Appearance			Flavour		
	0 month	4 months	8 months	0 month	4 months	8 months
Fresh jackfruit	8.75±0.23^{a}	5.73±0.10^{b}	3.85±0.76^{b}	8.11±1.04^{a}	5.84±0.58^{b}	3.15±0.65^{b}
BWB jackfruit	8.30±1.45^{a}	7.18±0.81^{a}	6.61±1.0^{a}	8.09±0.61^{a}	7.86±0.17^{a}	6.67±1.10^{a}
MWB jackfruit	8.34±0.10^{a}	7.32±0.65^{a}	6.84±1.02^{a}	8.18±1.19^{a}	7.97±1.10^{a}	6.84±0.43^{a}

BWB=Boiling water blanching, MWB=Microwave blanching. Means with different letters within each column are significantly different ($p < 0.05$)

Table 5. Effect of microwave and boiling water blanching on organoleptic quality (texture and overall acceptability) of green jackfruit during frozen storage (-20°C)

Treatment	Texture			Overall Acceptability		
	0 month	4 months	8 months	0 month	4 months	8 months
Fresh jackfruit	8.71±1.06[a]	5.88±1.6[a]	3.23±1.17[b]	8.51±0.52[a]	5.11±1.20[b]	3.87±0.83[b]
BWB jackfruit	7.15 ±0.98[b]	6.64±0.41 [a]	6.18±0.71 [a]	8.31±0.09[a]	7.13±0.24[a]	6.45±1.0[a]
MWB jackfruit	7.44±0.70 [b]	6.82±0.62[a]	6.32±0.28[a]	8.35±0.98[a]	7.25±0.19[a]	6.88±1.80[a]

BWB=Boiling water blanching, MWB=Microwave blanching. For each sample, means with different letters within each column are significantly different ($p < 0.05$)

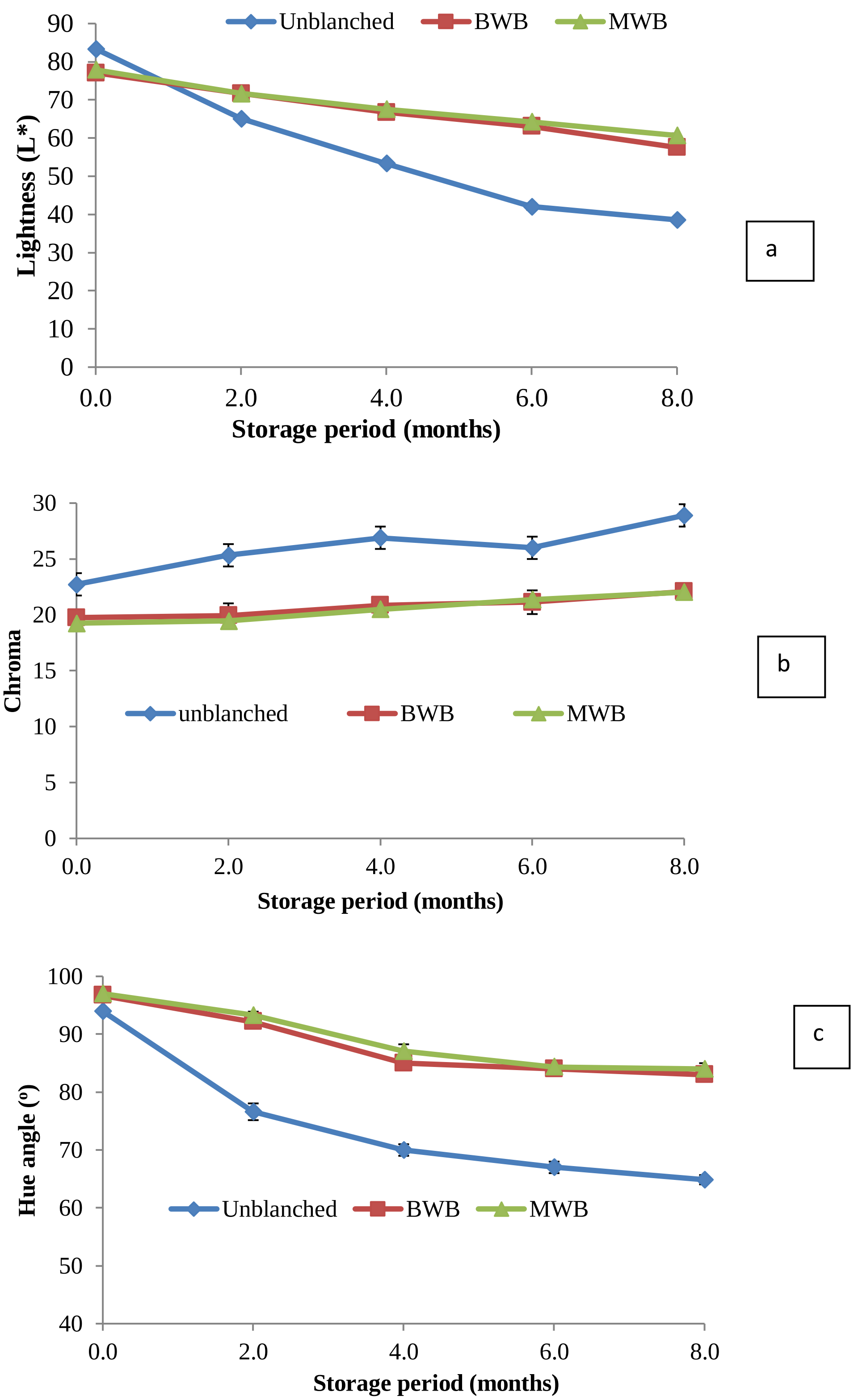

Figure 1. Effect of microwave and boiling water blanching on (a) lightness, (b) chroma and (c) hue angle of green jackfruit during frozen storage **(**-20°C**).** BWB=Boiling water blanching, MWB=Microwave blanching. Vertical bars indicate standard deviation.

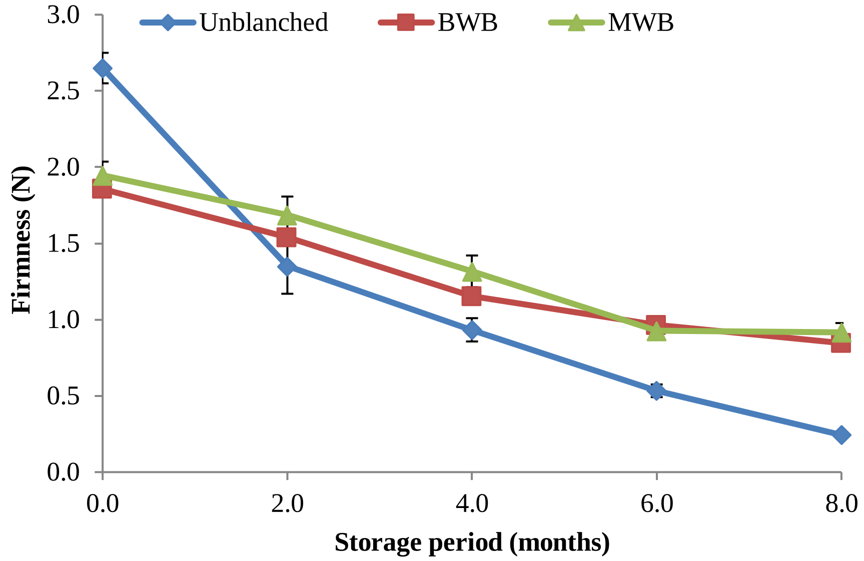

Figure 2. Effect of microwave and boiling water blanching on firmness of green jackfruit during frozen storage **(**-20°C)**.** BWB=Boiling water blanching, MWB=Microwave blanching. Vertical bars indicate standard deviation.

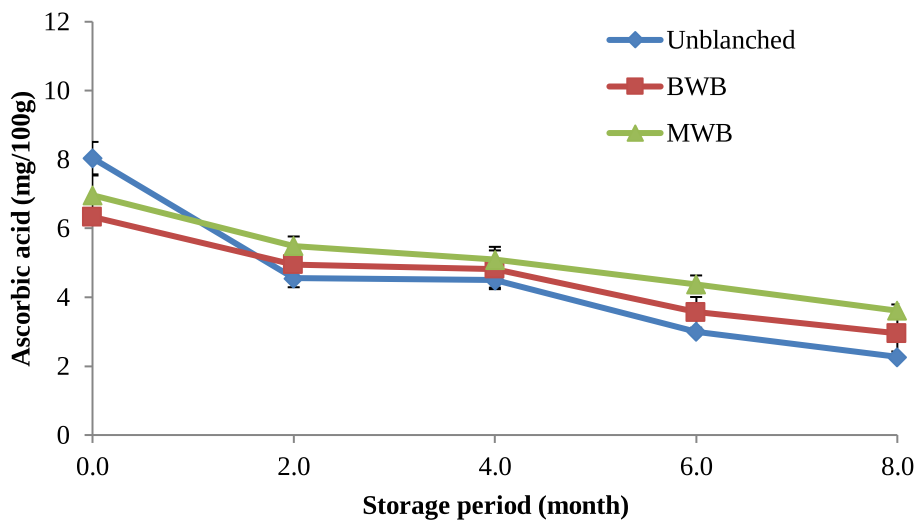

Figure 3. Effect of microwave and boiling water blanching on ascorbic acid content of green jackfruit during frozen storage **(**-20°C)**.** BWB=Boiling water blanching, MWB=Microwave blanching. Vertical bars indicate standard deviation.

Unblanched green jackfruit, 8 months frozen storage

BWB green jackfruit, 8 months frozen storage

MWB green jackfruit, 8 months frozen storage

8 months frozen stored unblanched green jackfruit after cooking

8 months frozen stored BWB green jackfruit after cooking

8 months frozen stored MWB green jackfruit after cooking

Figure 4. Pictorial view of 8 months frozen stored unblanched, BWB and MWB green jackfruit before and after cooking