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# Effect of Processing and Drying on Quality Evaluation of Ready-To-Cook Jackfruit

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## ABSTRACT

**The study was conducted with the aim of processing and developing ready to cook jackfruit to evaluate their nutritional and sensory quality attributes. In this study, green tender jack fruits were harvested from 60 to 70 days after synthesis. Then the fruits were washed, peeled and cut into slices. The slices were treated by dipping into different solutions for each treatments viz. control ($T_1$), 0.5% salt solution ($T_2$), 0.2% citric acid solution ($T_3$), 1000 ppm potassium metabisulfite (KMS) ($T_4$), 1000 ppm KMS + 0.5% salt ($T_5$), 1000 ppm KMS + 0.2% citric acid ($T_6$), 0.5% salt + 0.2% citric acid ($T_7$) and 1000 ppm KMS+ 0.2% citric acid+ 0.5% salt ($T_8$). Then the treated sliced was steam blanched at 85°C temperature for 8 min. The roasted beef spices were mixed and then dried at 50°C, 60°C and 70°C temperature owing to preparation of ready to cook. Results revealed that ready to cook dried at 50°C, 60°C and 70°C temperature took 72 hrs, 48 hrs and 36 hrs respectively. Low potassium metabisulfite residue was observed with increasing blanching time and drying temperature. The physicochemical characteristics, phytochemical and antioxidant activities were retained more and the highest sensory score was obtained at 60°C temperature. The marketable life of the RTC jackfruit could be extended to more than 6 months. However, the findings suggest that green tender jackfruit treated with 1000 ppm KMS, blanched for 8 min and dried at 60°C is a quick and healthy option in terms of good marketable life, nutritional and sensory quality attributes.**

**Keywords: Tender jackfruit, ready to cook, nutritional quality, sensory attributes, marketable life.**

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## INTRODUCTION

Jackfruit (*Artocarpus heterophyllus* Lam) originated from the Indian subcontinent and now is widely cultivated in Bangladesh, Burma, India, Indonesia, Malaysia, the Philippines, Srilanka, Thailand and to some extent Brazil and Queensland (Australia) (Oches et. al., 1981). Jackfruit is the most popular, delicious and major fruits in Bangladesh and has gained the position of national fruit due to its popularity and various other features. Bangladesh produces 719920 tons of Jackfruit annually from an area of 10012.55 hectares of land at the rate of 1075525 tons per hectare (Bangladesh Bureau of Statistics, 2019). It ranks second in production among the fruits grown in Bangladesh.

It is grown in almost all districts of the country. The highest volume of production takes place in Dhaka, Gazipur, Tangail, Khagrachari, Rangamati, Mymensingh, Moulvibazar, Narsingdi, Dinajpur and Rangpur district. However, the country is a rich source of variable germplasm of jackfruit; primarily due to the universal practice of seed propagation employed with this fruit. The people of the fruit production concentrated areas consumed this fruit as their breakfast alternative. The reason it is called the poor

**Table 1.** Treatments for ready to cook jackfruit (RTC)

| Treatments | Details |
|---|---|
| $T_1$ | Control |
| $T_2$ | Salt 0.5% |
| $T_3$ | Citric acid 0.2% |
| $T_4$ | KMS 1000 ppm |
| $T_5$ | KMS 1000 ppm+ salt 0.5% |
| $T_6$ | KMS 1000 ppm+ citric acid 0.2% |
| $T_7$ | Salt 0.5%+ citric acid 0.2% |
| $T_8$ | KMS 1000 ppm+ citric acid 0.2%+ salt 0.5% |

man fruit. The fruit contains high nutritive value, therefore, it’s may significantly contribute to the nutrition of the poor and rural people of Bangladesh.

Although, it is a national fruit of the country, however, every year a huge amount of jackfruit is wasted due to its glut production from June to August, natural calamities and highly perishable nature, seasonal, poor transport facilities, lack of marketing facilities and fruit syndicate problems faced by the farmers while they are deprived to get a desirable price of their commodity. However, there is ample scope to process and preserve this fruit but still, little information is available regarding processing and preservation of this fruit. The country has a number of green jackfruit pickles, Jackfruit bulb jam and rind jelly, Jackfruit minimally fresh cut process products, Jackfruit squash (Mondal et al., 2013) but there is a requisite to develop instant ready to eat and ready to cook jackfruit product from green tender jackfruit. If the excess fruits in the season can be preserved as ready to eat and ready to cook and ensuring their quality, consumers’ preferences with mouth feel, the postharvest loss of the fruit could be minimized.

Fried jackfruit product can be made from jackfruit but the fried products are becoming less popular to the masses due to absorbed oil content, health concerns and rancidity, improper packaging and storage techniques. Though a number of jam, jelly, pickles, squash and fresh cut products have been developed from jackfruit, its consumption has decreased over the years. This is mainly due to its lack of awareness and cumbersome handling procedures, which is making it unpopular even in rural areas. In this context, developing a convenient ready to cook (RTC) product with this ethnic fruit maintaining all its sensory qualities would be of tremendous value for urban as well as rural housewives. Therefore, the aim of this is to develop value added ready to cook (RTC) Jackfruit product through proper processing and drying techniques.

## MATERIALS AND METHODS

Green tender jackfruit (*Artocarpus heterophyllus* L.) was collected from the orchard of the Cotton Research Development Center, Sreepur, Gazipur. The fruit trees (50) were tagged for selection of proper maturity. When the fruits' maturity attained 60 to 70 days after synthesis then it was harvested and shifted to Postharvest Technology Division, Bangladesh Agricultural Research Institute (BARI), Gazipur, Bangladesh. The collected fruits were washed thoroughly with tap water and sliced using stainless steel knife. After slicing, it was immediately dipped into the treated solution (Table 1) to avoid browning reaction. After 5 minutes of dipping, the slices were incorporated to steam blanching at 85°C temperature for 8 min. After steam blanching, the slices were again dipped into the previous solution immediately to avoid any kind of browning. After 5 min, the slices were weighed out and mixed with the measured roasted spices. After roasting, then the slices were dried using a hot air mechanical dryer. After drying, the final products were packed into high-density polyethylene (HDPE) packet and sealed. Each HPPE packet contained 100 g of dried RTC jackfruit.

### Rehydration Ratio of RTC Jackfruit

Although drying is one of the oldest and most widely used methods of food preservation, its success largely depends on the rehydration (reconstitution) capacity of dried products. The dried products will be accepted for food uses only if good color, texture, flavor and nutritive value are restored when these are reconstituted or rehydrated in water (Pervin et al., 2008). In this study, 100 g of dried sample was mixed with 1000 ml of distilled water and stirred properly for 1 hour. Then it was cooked with mild heat for 30 min with the measured spices (Table 2).

### Determination of Physicochemical composition

Physicochemical properties : moisture, ash, total soluble solids (TSS), pH and titrable acidity (TA) were determined using the method of AOAC (2005). Vitamin C (Ascorbic acid) content was determined according to the procedure of Ranganna (1995) and β-Carotene content was determined using the procedure of Holden et al. (1999). The energy content of the treated sample was determined by using Parr 6100 Calorimeter (Parr Instrument Company Moline, IL 61265, USA). The water activity of the sample was determined using Lab

**Table 2.** Ingredients used for RTC Jackfruit cooking.

| | Type of Jackfruit | | | |
|---|---|---|---|---|
| | Fresh Jackfruit | | RTC Jackfruit | |
| Ingredients | (g) | (%) | (g) | (%) |
| Jackfruit | 1000.00 | 21.27 | 1000.00 | 16.22 |
| Roasted | 28.60 (1 pack) | 0.61 | - | - |
| Water | 2500.00 | 53.18 | 4000.00 | 64.91 |
| Soya bean oil | 250.00 | 5.32 | 250.00 | 4.06 |
| Onion | 350.00 | 7.45 | 350.00 | 5.68 |
| Garlic | 350.00 | 7.45 | 350.00 | 5.68 |
| Salt | 40.00 | 0.85 | 30.00 | 0.49 |
| Green chili | 30.00 | 0.64 | 30.00 | 0.49 |
| Coriander leaves | 30.00 | 0.64 | 30.00 | 0.49 |
| Egg | 122.00 (2 Nos.) | 2.59 | 122.00 (2 Nos.) | 1.98 |
| Total | 4700.60 | 100.00 | 6162.00 | 100.00 |

Touch-aw (Novasina, AG, CH-8853, Switzerland).

**Determination of dry matter content**

Dry matter content of the RTC jackfruit was determined using the method of Solaiman et al. (2015) with slight modification. Six jackfruit slices were randomly selected from each treatment and cut into small slices (1-2 mm) and mixed thoroughly. Dry weight of the samples was then determined by drying at 75°C for 72 h in a forced-air oven. The following formula was used for determining DM content of the treated samples.

$$DM\ (\%) = \frac{\text{Dry weight}}{\text{Fresh weight}} \times 100$$

**Determination of Mineral content**

Atomic absorption spectrophotometry (Model-AA-7000S, Shimadzu, Tokyo, Japan) was used to assess the levels of sodium, iron, calcium, copper, magnesium, boron, manganese and zinc. Potassium content was measured by flame photometry. By comparison to the corresponding standard mineral procured from Sigma Chemical Co., USA individual minerals were quantified.

**Texture analysis**

Texture analysis was done using cross-sectional prove by a Texture Analyzer TA.XT plus (Stable Micro System, Godalming, UK). Compression test mode was used to determine the instrument working parameters with test speed at 1mm/s, distance 2.50cm. The analysis of the data was performed by Texture Exponent Lite version 6.1.14.0 software (Stable Micro System, Godalming, UK) to determine the rupture force and is expressed as N.

**Color measurement**

The color of the RTC jackfruit was assessed with a Chroma Meter (Model CR-400, Minolta Corp. Japan). International Commission on Illumination (CIE) lightness (L*), redness (*a), yellowness (*b), chroma (c*) and hue angle (h*) values were measured using D65 illuminates at 10E standard viewer as an orientation method. The equipment was calibrated by standard white tile. Then it was assimilated to measure the values of L*, *a, *b, c* and h* and were replicated three times for each treatment.

**Total flavonoid, ferrous ion chelating activity and DPPH**

Total flavonoid content (TFC) was determined by the aluminum chloride method (Chang et al., 2002) with slight modifications. The 2, 2-diphenyl-1-picrylhydrazyl (DPPH) radical quenching property was assessed by measuring the rate of inhibition following the procedure described by Brand-Williams et al. (1995) with some alteration.

**Sensory evaluation**

The sensory attributes were performed based on the procedure of Joshi (2006). It was performed using a 9-point hedonic scale, i.e. 9= Like extremely, 8= like very much, 7= Like moderately, 6= Like slightly, 5= Neither like or dislike, 4= Dislike slightly, 3= Dislike moderately, 2= Dislike very much and 1=Dislike extremely. Sensory quality attributes like taste, astringent, bitterness, texture, color, flavor, appearance and overall acceptability were evaluated by an expert sensory panelist. The score obtained by the panelist was analyzed statistically.

**Statistical Analysis**

Data obtained for each analysis were expressed in duplicate as means (3 replications) ± standard deviation. Data were analyzed by one-way ANOVA with post-hoc using Turkey Multiple Comparisons Test. The significance was defined at the 95 % confidence level.

**Table 3.** Sensory evaluation of RTC jackfruit at on the day of storage.

| Treatment | Sensory quality attributes | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Taste | Astringent | Bitterness | Texture | Color | Flavor | Appearance | Overall acceptability |
| $T_1$ | 5.50± 0.91d | 5.40± 1.07d | 6.50± 0.70 | 5.60± 0.96c | 5.40± 1.07c | 5.90± 1.28 | 5.50± 1.08b | 5.65± 0.49d |
| $T_2$ | 5.80± 1.13cd | 6.00± 0.40cd | 6.50± 0.70 | 6.10± 0.73bc | 6.50± 0.97abc | 6.50± 0.70 | 6.10± 0.73ab | 6.27± 0.27cd |
| $T_3$ | 6.45± 0.89abcd | 6.20± 1.03bcd | 6.70± 0.67 | 6.20± 0.63bc | 6.20± 1.03bc | 6.60± 0.69 | 6.10± 0.73 | 6.35± 0.28c |
| $T_4$ | 7.55± 0.36a | 7.20± 0.63ab | 6.80± 0.78 | 7.50± 0.70a | 7.80± 0.63a | 6.80± 0.78 | 7.00± 0.66a | 7.52± 0.44a |
| $T_5$ | 6.80± 0.94abc | 6.70± 0.82abc | 6.60± 0.69 | 6.70± 1.25abc | 6.90± 0.99 | 5.70± 1.05 | 7.00± 0.81a | 7.01± 0.65ab |
| $T_6$ | 7.20± 0.63ab | 7.40± 0.51a | 6.70± 1.05 | 7.20± 1.39ab | 7.60± 0.80a | 6.60± 0.96 | 7.00± 0.81a | 7.13± 0.41ab |
| $T_7$ | 6.15± 0.74 | 6.00± 0.81cd | 6.60± 0.96 | 6.60± 0.69abc | 5.80± 1.13bc | 6.00± 1.15 | 6.10± 0.99ab | 6.31± 0.43c |
| $T_8$ | 7.30± 0.48a | 7.50± 0.70a | 6.80± 1.03 | 7.30± 0.67ab | 6.90± 1.10ab | 6.00± 1.76 | 7.00± 0.81a | 7.09± 0.57ab |

All values are means of triplicate determinations ± SD. Means within columns with different letters a, b, c, d indicates significant result at $p<0.05$. No letter means no significant difference.

Statistical analysis and data processing were performed using software SPSS 17.0 (IBM INC., New York).

## RESULTS AND DISCUSSIONS

The results of the study on physicochemical changes of jackfruit RTC as affected by different storage periods and treatments are presented and discussed below. All the data were carried out in triplicate.

### Standardization of Treated RTC Jackfruit by Sensory Evaluation

The sensory scores for different treatments of jackfruit RTC are presented in Table 3 based on 9 points hedonic scale. The score for taste, color, flavor, texture, appearance and overall acceptability were maximum in $T_4$ (Jackfruit slices treated with 1000 ppm KMS) and it was 7.52 while the minimum score was recorded in $T_1$ (control), $T_2$ and $T_3$. The minimum score for the treatments $T_1$, $T_2$ and $T_3$ might be due to control, the use of salt and citric acid may not be sufficient to give fine color, texture and taste by the evaluator. On the other hand, treatment $T_4$, $T_5$, $T_6$ and $T_8$ obtained the highest score by the judgment of sensory evaluation might be due to make the more attractive color, appearance and taste as the treatments were treated by the KMS (1000 ppm). So, the treatment $T_4$ was chosen as the best treatment based on the perception of the panelist and used for further processing recipe as well as to prepare standard RTC jackfruit. Then the standardized RTC jackfruit was dried at 50°C, 60°C and 70°C and renamed as treatment $D_1$, $D_2$ and $D_3$ for future Physico-chemical and storage studies. In case of drying, the RTC dried at 60°C was acceptable by the panelist. It’s might be due to its uniform heat transfer over the product during drying (Srinang et al., 2015).

### Physicochemical Composition of Stored RTC Jackfruit

#### Moisture (%), dry matter (%) and TSS (°B)

On the initial day of storage, the moisture, dry matter and TSS content of freshly prepared jackfruit RTC were not significantly different among the treatments. All the treatments showed little decrease in moisture content at entire storage periods (Table 4). The dry matter content of jackfruit RTC was not statistically significant up to 3 months of storage (Table 4). After 6 months of storage, all the treatments significantly differed. Results revealed that the dry matter in all treatments was increased with the advancement of storage periods. The harvesting time and drying temperature may affect the dry matter content of the RTC Jackfruit. The results obtained by Karim et al. (2008) confirmed that late periodic harvest may be associated with the increase in dry matter content of the jackfruit bulb. Inversely low dry matter content is affected by the early harvesting of the jackfruit (Karim et al., 2008). These results are in agreement with the result of Hossain and Haque, (1979). It is notable that there was an inverse relationship between the moisture and dry matter content for all treatments. The TSS content of the RTC jackfruit was not significantly different on the day of

**Table 4.** Moisture (%), Dry matter (%) and TSS (°B) content of RTC Jackfruit at different storage periods.

| Treatment | Storage periods | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 0D | | | 3M | | | 6M | | |
| | MC (%) | DM (%) | TSS (°B) | MC (%) | DM (%) | TSS (°B) | MC (%) | DM (%) | TSS (°B) |
| $D_1$ | 5.70± 0.00 | 94.30± 0.00 | 4.10± 0.00 | 5.02± 0.33 | 94.98± 0.33 | 4.15± 0.02c | 4.27± 0.04b | 95.73± 0.04a | 4.31± 0.04c |
| $D_2$ | 5.70± 0.00 | 94.30± 0.00 | 4.10± 0.00 | 4.76± 0.04 | 95.24± 0.04 | 4.40± 0.04b | 4.69± 0.02a | 95.31± 0.02b | 4.50± 0.02b |
| $D_3$ | 5.70± 0.00 | 94.30± 0.00 | 4.10± 0.00 | 4.73± 0.01 | 95.27± 0.01 | 4.48± 0.02a | 4.71± 0.01a | 95.28± 0.01b | 4.70± 0.01a |

All values are means of triplicate determinations ± SD. Means within columns with different letters a, b, c indicates significant result at p<0.05. No letter means no significant difference.

**Table 5.** TA (%), pH and ash content of RTC Jackfruit at different storage periods.

| | Storage periods | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 0D | | | 3M | | | 6M | | |
| Treatment | TA (%) | pH | Ash (%) | TA (%) | pH | Ash (%) | TA (%) | pH | Ash (%) |
| $D_1$ | 0.32± 0.03a | 5.45± 0.02c | 5.09± 0.02c | 0.29± 0.02a | 5.75± 0.02b | 5.72± 0.02c | 0.35± 0.02a | 5.60± 0.03a | 5.90± 0.02a |
| $D_2$ | 0.21± 0.04c | 5.62± 0.05b | 5.74± 0.02b | 0.19± 0.02b | 5.84± 0.02a | 5.78± 0.03b | 0.23± 0.02c | 5.43± 0.03b | 5.82± 0.02b |
| $D_3$ | 0.27± 0.03ab | 5.70± 0.01a | 5.79± 0.01a | 0.25± 0.01a | 5.85± 0.02a | 5.89± 0.02a | 0.28± 0.01b | 5.47± 0.03b | 5.92± 0.01a |

All values are means of triplicate determinations ± SD. Means within columns with different letters a, b, c indicates significant result at p<0.05. No letter means no significant difference.

storage (0D). After 3 and 6 months (M) of storage, a significant difference was observed among the treatments. The total soluble solids (TSS) content increased gradually with the advancement of the storage periods (Table 4). This increase in TSS content may be attributed to the conversion of starch to sugars (Sharaf and El-Saadany, 1987).

### Titrable acidity (TA), pH and Ash Content

The TA of RTC jackfruit was significantly differed on the day of storage and after 6 M of storage. Up to 3 M of storage, all the treatments remarkably decrease but after 6 M of storage, the treatments slightly increased (Table 5). The initial decrease in acidity during storage is due to the rapid utilization of acids by respiration (Edmundo et al., 1998). The final increase in acidity may be ascribed to a rise in the concentration of weakly ionized acid and its salts during storage. The increase in acidity is also due to the formation of acid by the degradation of polysaccharides and oxidation of reducing sugars or by the breakdown of pectic substances and uronic acid (Hummel and Okay, 1950; Iqbal et al., 2001; Hussain et al., 2008).

The pH of the treated jackfruit RTC was significantly increased up to 3 M of storage. But after 6 M of storage, it was significantly decreased. The initial increase in pH may be due to the breakup of acids with respiration during storage (Pesis et al., 1999) and the final decrease due to the presence of potassium metabisulphite preservative in the RTC jackfruit (Bajwa et al., 2002; Hussain et al., 2008). Here it is interesting that a negative correlation was observed between the acidity and pH of the stored RTC jackfruit during the storage periods.

The ash content of the jackfruit RTC was significantly increased up to 6 M of storage. These increasing trends of the jackfruit may be affected by the delaying of harvesting time. Late harvesting of jackfruit may contribute to an increase in the ash content of the RTC jackfruit whereas the early harvest may decrease the ash content of the RTC jackfruit (Karim et al., 2008). These results are in agreement with the findings of Hossain, (1976).

### Vitamin-C, ß-carotene, water activity ($a_w$) and energy content of Jackfruit RTC

On the day of storage (0D), the vitamin-C content in all treatments of the RTC jackfruit was significantly differed (Table 6). Among the treatments, the lowest vitamin-C content was recorded in $D_3$ than others. The decreasing vitamin-C content of the RTC jackfruit may be affected by the high temperature as well as the RTC dried at 70°C ($D_3$). After 3M and 6M of storage, the vitamin-C content was gradually decreased in all treatments and

**Table 6.** Vit-C (mg/100 g), ß-carotene (µg/100 g), $a_w$ and energy content (Kcal/g) of RTC Jackfruit at different storage periods.

| | Storage periods | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0D | | | | 3M | | | | 6M | | | |
| Treatment | Vit-C | ß-carotene | $a_w$ | Energy | Vit-C | ß-carotene | $a_w$ | Energy | Vit-C | ß-carotene | $a_w$ | Energy |
| $D_1$ | 37.50± 0.06b | 0.98± 0.02a | 0.53± 0.02a | 4.10± 0.06 | 35.80± 0.11b | 0.81± 0.03b | 0.56± 0.02 | 4.13± 0.07 | 34.19± 0.19b | 0.57± 0.03 | 0.59± 0.02 | 4.19± 0.18 |
| $D_2$ | 38.50± 0.10a | 1.02± 0.02a | 0.49± 0.02ab | 4.14± 0.04 | 36.53± 0.07a | 0.91± 0.02a | 0.55± 0.05 | 4.21± 0.05 | 36.10± 0.10a | 0.65± 0.03 | 0.58± 0.02 | 4.23± 0.20 |
| $D_3$ | 36.60± 0.05c | 0.86± 0.02b | 0.45± 0.03b | 4.06± 0.11 | 34.35± 0.16c | 0.78± 0.02b | 0.54± 0.05 | 4.11± 0.03 | 33.21± 0.21c | 0.51± 0.04 | 0.57± 0.03 | 4.17± 0.17 |

All values are means of triplicate determinations ± SD. Means within columns with different letters a, b, c indicates significant result at $p<0.05$. No letter means no significant difference.

the rate of decrease in vitamin-C content in $D_3$ was always found lowest than others. The highest vitamin-C content was found in $D_2$ (60°C), which might be due to uniform heating with reasonable drying time (36 hrs). Treatment $D_3$ took the lowest time (24 hrs) for drying but the temperature was higher (70°C) than other treatments. Treatment $D_1$ dried at a low temperature (50°C) than others but it took more drying time (72 hrs). Moreover, all the treatments lost their vitamin-C content during the study periods. The loss in vitamin-C content might be due to thermal destructions during heat processing, leaching into water during heating and subsequent oxidation during storage (Brock et al., 1998). This reduction in vitamin C contents of the RTC jackfruit may also be attributed to the susceptibility of ascorbic acid to oxidative destruction by some enzyme which has not been ascertained in this study.

β-carotene is the main safe dietary source of vitamin A. It is essential for normal growth and development, immune system functioning and vision (Liji and Dibakar, 2015). After 6 M of storage, the β-carotene content of the RTC jackfruit ranged from 0.51 to 0.65 µg/100 g whereas it was from 0.86 to 1.02 µg/100 g at on the day of storage (0D) (Table 6). It can be seen that the β-carotene decreased with the advancement of storage periods. The loss in β-carotene content which was high in treatment $D_1$ and $D_3$ might be due to their more drying time and temperature during drying and storage. The loss of β-carotene can be attributed to the non-oxidative changes (cis-trans isomerization, epoxide formation or heat degradation of tissues) (Aruna et al., 1999).

The growth and multiplication of microorganisms depend on water activity ($a_w$). The cell of the microorganism becomes dormant in the presence of low $a_w$ and osmotic stress conditions. It is also mentioned that the microorganisms could not be eliminated but it could stop the activities of the microorganism by limiting $a_w$. The highest $a_w$ enhances the faster microorganisms like bacteria, yeast and mold to grow in food. On the day of storage, the $a_w$ of the RTC jackfruit ranged from 0.45 to 0.53 and after 6M of storage, it ranged from 0.57 to 0.59 (Table 5). The lowest $a_w$ was calculated as 0.45 in treatment $D_3$ and the highest was 0.53 in treatment $D_1$. It indicates that high temperature influenced the low $a_w$ and the high $a_w$ was affected by the low temperature. The $a_w$ for the RTC jackfruit ranged from 0.57 to 0.59 means that microorganisms generally inhibited to grow within this range (Beuchat, 1981), indicates that all the treated RTC jackfruit comprised safe for its microbial stability, quality and shelf life up to 6M.

Energy is essential for rest, activity, growth and maintenance of sound health. Its content is of concern to health-conscious consumers (Liji and Dibakar, 2015). At the initial day of storage, the energy of the RTC jackfruit ranged from 4.06 to 4.14 Kcal/g but after 6M of storage the range was from 4.17 to 4.23 Kcal/g (Table 6). It can be seen that the energy was increased with the increase of storage periods. The highest energy content was found in $D_2$ whereas the lowest was recorded in $D_1$ and $D_3$. The RTC dried by the uniform temperature at 60°C might be contributed to achieving the highest energy content in treated sample $D_2$.

## Mineral content of RTC Jackfruit

Minerals are the inorganic components present in foodstuff which play an important metabolic role in the functioning of the body and contribute to daily diet. In this study, eleven (11) minerals of the RTC jackfruits were measured (Table 7). It can be seen that P and Mn were not significantly different but the other minerals were significantly different. RTC jackfruit dried at 50°C retained more minerals than the RTC dried at 60°C ($D_2$)

**Table 7.** Mineral content of RTC jackfruit after 6 months of storage.

| | Treatments | | |
|---|---|---|---|
| **Minerals** | **$D_1$** | **$D_2$** | **$D_3$** |
| Ca | 1.90±0.01a | 1.60±0.10b | 1.18±0.10c |
| Mg | 1.33±0.02a | 1.22±0.03b | 1.01±0.01c |
| K | 1.42±0.04a | 1.31±0.02b | 1.19±0.04c |
| P | 0.50±0.59 | 0.42±0.02 | 0.13±0.03 |
| S | 0.59±0.02a | 0.41±0.02b | 0.41±0.02b |
| Na | 1.97±0.03a | 1.24±0.03b | 1.19±0.03c |
| Cu | 8.80±0.10a | 8.40±0.10b | 7.30±0.05c |
| Fe | 99.30±0.70a | 94.20±0.10b | 80.80±0.10c |
| Mn | 17.01±2.00 | 16.60±0.40 | 15.50±0.50 |
| Zn | 30.60±0.40a | 28.80±0.10b | 21.48±0.10c |
| B | 60.00±2.00a | 44.00±01.00b | 33.00±2.0c |

All values are means of triplicate determinations ± SD. Ca, Mg, K, Na, P and S expressed as mg %; B, Cu, Fe, Mn and Zn expressed as ppm. Means within columns with different letters a, b, c indicates significant result at $p<0.05$.

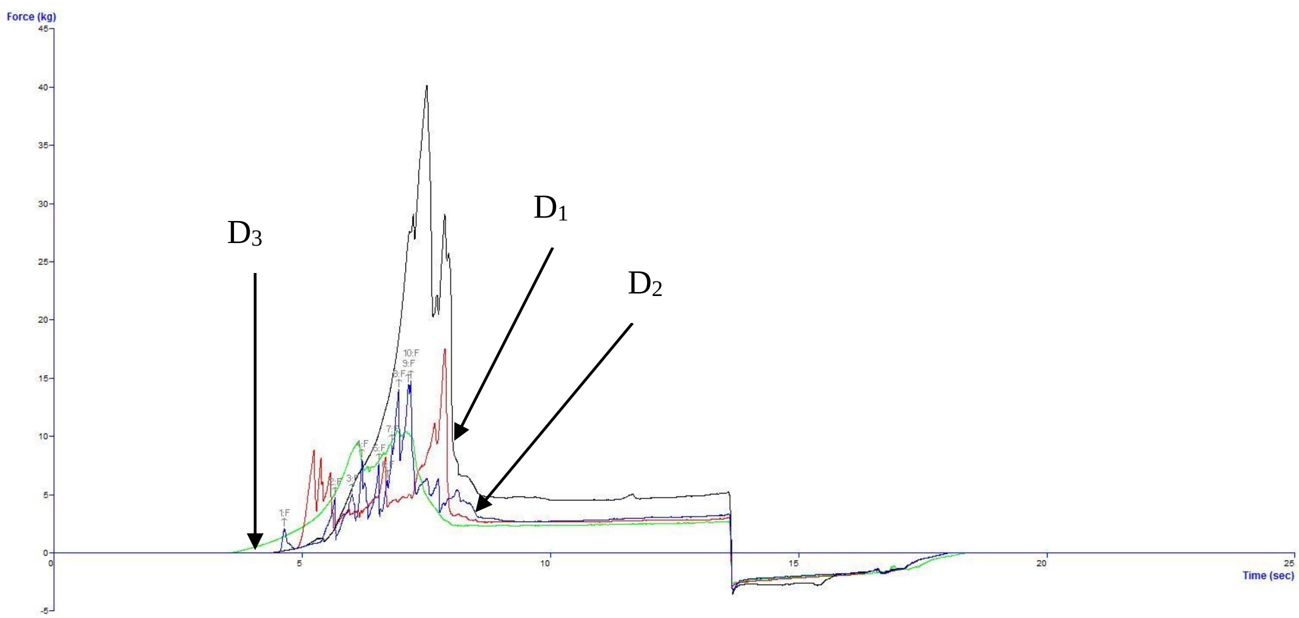


**Figure 1.** Texture of the RTC jackfruit after 6 months storage.

and 70°C ($D_3$), this indicates that high temperature influenced the minerals of the product (Table 7).

**Texture analysis of the Jackfruit RTC**

The rupture forces (FR) of the RTC jackfruit are illustrated in Figure 1. The FR of the RTC jackfruit dried at 50°C ($D_1$), 60°C ($D_2$) and 70°C ($D_3$) were observed at the end of the storage periods (6 months). The results revealed that RTC dried at 70°C gained the highest peak which indicates that its hardness was maximum than others. As a reason, it can be said that the higher temperature might be contributed to achieving more hardness. The second peak was recorded for RTC dried at 60°C and was suitable for the rehydration process. The lowest peak was observed for RTC dried at 50°C.

**Effect of blanching and drying on the residue of KMS**

Figure 2 represents the blanching and drying time and their effects on the residue of KMS. The concentration of the KMS residue decreased gradually with the advancement of storage periods. Results indicate that RTC jackfruit treated with KMS, blanching and drying at

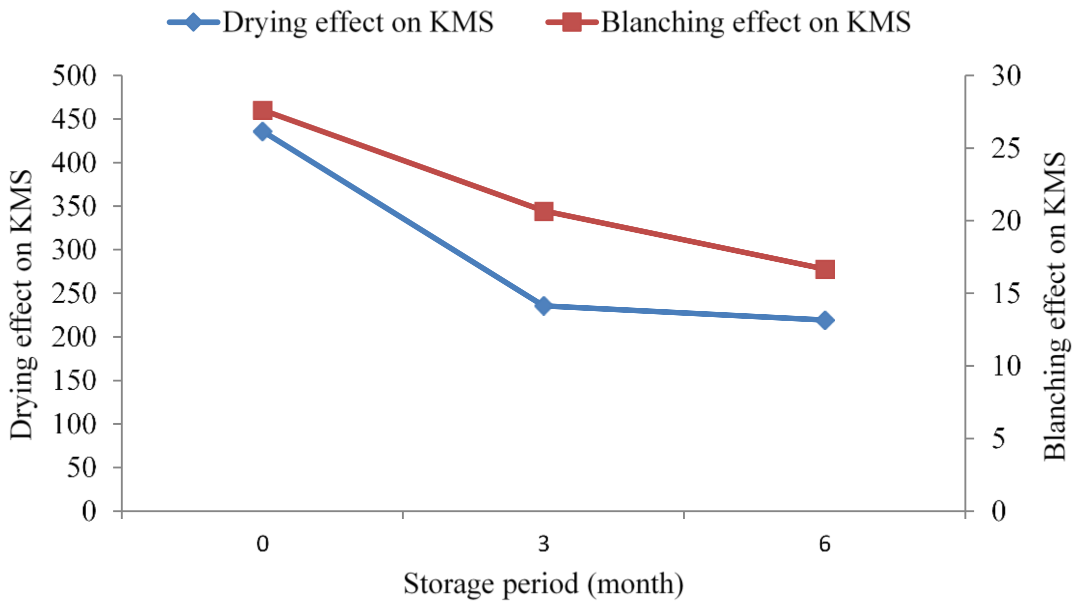


**Figure 2.** Blanching and drying effect on the KMS residue of RTC jackfruit

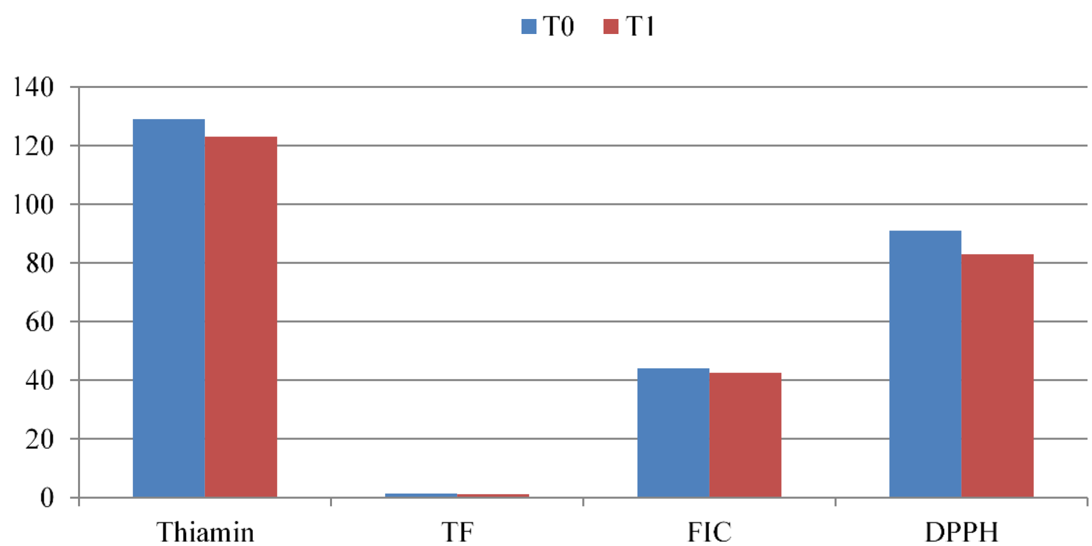


**Figure 3.** Thiamin, total flavonoid, FIC and DPPH of the fresh and developed RTC jackfruit.

high temperature could contribute to lower the residual level of KMS.

**Thiamin, Total Flavonoid, Ferrous ion chelating activity and DPPH of the fresh and Developed RTC Jackfruit**

Figure 3 shows the thiamin, total flavonoid, ferrous ion chelating activity and DPPH of fresh and RTC jackfruit. Thiamin (vitamin B1) helps the body's cells to change carbohydrates into energy. The main role of carbohydrates is to provide energy for the body, especially the brain and nervous system. It plays a significant role in muscle contraction and conduction of nerve signals. It is an essential cofactor for several key enzymes required for brain oxidative metabolism while it is naturally found in high concentrations in the human substantia nigra (Baker et al., 1984). In thiamine deficiency, there are reduced levels of striatal dopamine and intrastriatal administration of thiamine has been shown to enhance the release of dopamine (Yamashita et al., 1993). This study showed that fresh tender jackfruit contained 129.00 ppm (0.129 mg/100 g) of thiamin whereas the RTC jackfruit contains 123.00 ppm

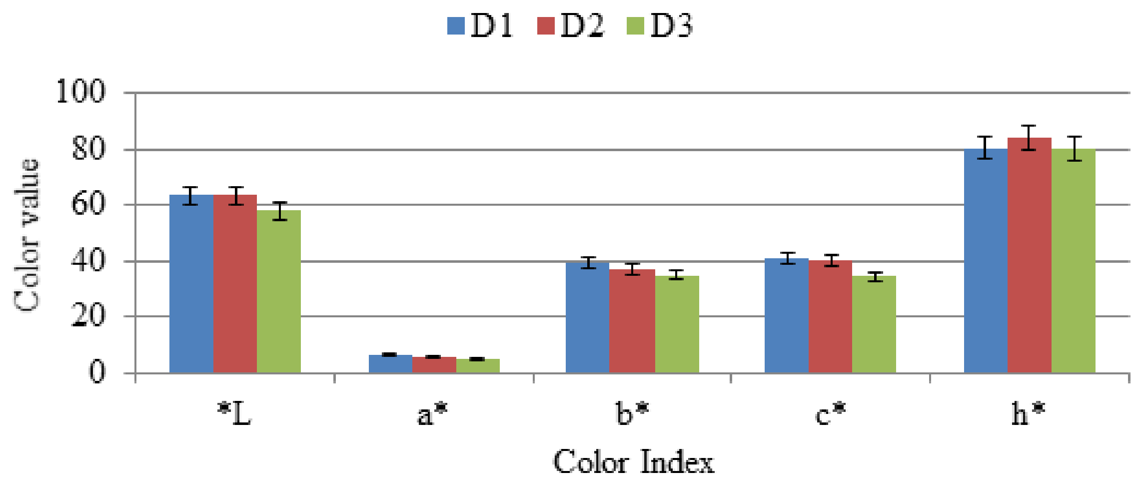


**Figure 4.** Color changes of the RTC jackfruit after 6 months storage.

(0.123 mg/100 g) of thiamin. Several studies showed that the young and ripe jackfruit contained 0.05-0.15 mg/100 g and 0.03-0.09 mg/100 g of thiamin respectively (Arkroyd et al., 1966; Narasimham, 1990; Soepadmo, 1992; Gunasena et al., 1996; Azad, 2000; Haq, 2006;). Fresh and RTC jackfruit is a rich source of thiamin which may be capable of reducing the thiamin deficiency in the human body.

The ferrous ion chelating (FIC) activity is frequently used to measure the antioxidant potentiality in foodstuffs and determine the capacity to lessen ferric ($Fe^{3+}$**)** to ferrous iron ($Fe^{2+}$). As regards the capacity of the jackfruit to reduce $Fe^{3+}$ to $Fe^{2+}$, the value was found in fresh and RTC jackfruit to be 44.04 % and 42.50 % respectively which indicates that fresh jackfruit contributed a higher amount of FIC as compared to RTC jackfruit. It means that the high FIC value was found in fresh jackfruit that could donate an electron to reduce the yellow ferric complex to a blue ferrous complex and advocate the phenolic composites which are the leading contributors to the high antioxidant ability of this fruit.

Flavonoids are a group of polyphenolic compounds naturally present in most edible fruit and vegetable plants. They constitute most of the yellow, red and blue colors in the fruit (Erlund, 2004). Flavonoids from fruit and vegetables are currently widely studied as components that have the potential to provide multiple health benefits. Epidemiological and clinical studies have provided evidence of a potential role for flavonoids in lowering the risk of coronary heart disease prevention, cardiovascular diseases, free radical scavenging capacity, neurodegenerative diseases, osteoporosis, and lung cancer (Yao et. al., 2004; Lampila et. al., 2009). In this study, the total flavonoid content of fresh and RTC jackfruit was found to be 1.34 and 1.13 mg QE/g. These results indicate that the flavonoid content of the RTC jackfruit is affected by the drying temperature compared to the fresh one. The differences in the flavonoid structures and their substitutions influence the phenoxy radical stability, thereby affect the antioxidant properties of the flavonoids (Wojdylo et al., 2007).

DPPH is a free radical generating compound and has been widely used to evaluate the free radical scavenging ability of various antioxidants (Gupta et al., 2011). In the present study, maximum antioxidant activity was found in fresh jackfruit (90.96 %) whereas the RTC jackfruit possessed 82.90 % antioxidant activity which shows that RTC jackfruit is also a rich source of scavenging activity as compared to the fresh one. High antioxidant activity of the jackfruit may be related to elevated vitamin C values that work as antioxidants, protects the body against free radicals, aid in improving skin health, strengthen the immune system and mitigate periodontal diseases (Umesh et. al. 2010).

**Color changes of the RTC jackfruit after storage**

Total color change of the RTC jackfruit was analyzed in terms of L*, a*, b*, c* and h* values. The L* values of the samples treated at 50°C ($D_1$) and 60°C ($D_2$) were statistically insignificant but at 70°C ($D_3$) the value was tremendously decreased (Figure 4). During the study, the * value for all treatments showed a decreasing trend (Figure 4) and the minimum values obtained 70°C ($D_3$) treated sample than others. The b* values of the samples showed a decreasing trend with storage and it was gradually decreased with increasing drying time. The c* value of the sample treated with 70°C ($D_3$) decreased tremendously than the sample treated at 50°C ($D_1$) and 60°C ($D_2$) whereas the treated sample 50°C ($D_1$) and 60°C ($D_2$) insignificantly differed. The deviation of color ($\Delta E$) of RTC jackfruit calculated from L*, a*, b* and c* values showed the highest deviation in samples treate d at 70°C ($D_3$) (Figure 4). The high

**Table 8.** Sensory evaluation of RTC jackfruit after 3 and 6 months storage periods.

| Temperature (°C) | Storage periods | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **3M** | | | | **6M** | | | |
| | **Color** | **Flavor** | **Texture** | **Overall acceptability** | **Color** | **Flavor** | **Texture** | **Overall acceptability** |
| $D_1$ | 7.10± 0.56b | 7.10± 0.73ab | 7.00± 0.66 | 7.07± 0.46ab | 7.00± 0.47 | 6.90± 0.56ab | 6.90± 0.56 | 6.93± 0.33b |
| $D_2$ | 8.00± 0.94a | 7.70± 0.823a | 7.50± 0.84 | 7.74± 0.77a | 7.50± 0.70 | 7.60± 0.69a | 7.40± 0.69 | 7.52± 0.55a |
| $D_3$ | 6.90± 0.56b | 6.60± 0.84b | 7.20± 0.63 | 6.91± 0.55b | 6.90± 0.56 | 6.50± 0.70b | 7.10± 0.56 | 6.84± 0.50b |
| | **Storage periods** | | | | | | | |
| | **3M** | | | | **6M** | | | |
| | Taste | **Astrin gency** | **Bitter ness** | **Overall acceptability** | **Taste** | **Astrin gency** | **Bitter ness** | **Overall acceptability** |
| $D_1$ | 7.01± 0.69ab | 6.90± 0.99 | 6.70± 0.94 | 7.08± 0.58b | 7.30± 0.67b | 6.50± 0.52b | 6.70± 0.67ab | 6.84± 0.27b |
| $D_2$ | 8.20± 0.78a | 7.70± 0.67 | 7.50± 1.26 | 7.79± 0.61a | 8.20± 0.78a | 7.70± 0.67a | 7.50± 1.26a | 7.79± 0.61a |
| $D_3$ | 6.60± 0.84b | 6.90± 0.56 | 6.60± 0.69 | 6.70± 0.51b | 6.60± 0.84b | 6.40± 0.51b | 6.20± 0.63b | 6.39± 0.55b |

All values are means of triplicate determinations ± SD. Means within columns with different letters a, b indicates significant result at $p<0.05$. No letter means no significant difference.

temperature may have affected the color of the RTC jackfruit which is also responsible for the hardeness of the product (Figure 1). The highest color retained by the treatment $D_1$ and $D_2$ (temperature 50°C and 60°C) might be due to the inhibition of oxidation during drying which might have contributed to achieving the highest color and nutrient content.

**Sensory evaluation of jackfruit at different storage periods**

Table 8 shows the sensory evaluation of the RTC jackfruit after 3 and 6 M of storage. The RTC jackfruit dried at 50°C ($D_1$), 60°C ($D_2$) and 70°C ($D_3$) and stored up to 6 M of storage significantly differed. Results exposed that maximum scores were gained by the temperature of 60°C based on the sensory attributes of color, flavor, texture, taste, astringency, bitterness and overall acceptability. The RTC jackfruit dried at 50°C performed near to temperature 60°C. During the sensory evaluation, most of the panel of judges opined that they felt an odd flavor although its color was acceptable. The color of the RTC jackfruit dried at 70°C was not satisfactory to the panelist. However, the RTC jackfruit dried at 60°C ($D_2$) was found satisfactory and acceptable by the judgment of the sensory panels.

## CONCLUSION

Bangladesh occupies a superior position in the world in jackfruit production. In glut season, all the farmers come to the market together; hence they do not get reasonable price for their jackfruit. On the other hand, the farmers cannot process it (tender jackfruit) due to lack of proper processing technology. Results revealed that tender jackfruit treated with 1000 ppm is the best treatment to preserve its color by reducing browning. Blanching and boiling highly affect the reconstitution characteristics of the dried product. This study shows that blanching time affects the KMS concentration and its residue was decreased with the increase of blanching time. Drying is one of the most important primary operations for increasing the storage life of the fruits by reducing their moisture. RTC jackfruit dried at 60°C temperature retained more nutritional value and was acceptable by the judgment of the sensory panels. Results indicate that RTC jackfruit treated with KMS and dried at high temperature could contribute to lower the residual level of KMS. Therefore, it is recommended that green tender jackfruit (angular size) can be treated with 1000 ppm, blanched at 8 min at 85°C temperature and dried at 60°C in terms of retaining color, texture, nutritional and organoleptic test. The storage life of the RTC jackfruit could be extended to more than 6 months. This RTC jackfruit does not only reduces the cooking time but also reduces the hassle of peeling, grinding, processing of large jackfruit before cooking.

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