Environment and Ecology 40 (3B) : 1562—1569, July—September 2022
ISSN 0970-0420

Standardization of Jackfruit Chips Based on Traditional Methods Practiced by the People of Garo Hills, Meghalaya

Todik Jimmy T. Sangma, C. Perinba Suresh, Prasenjit Pal

Received 16 March 2022, Accepted 26 July 2022, Published on 11 August 2022

ABSTRACT

This study is an investigation on preparation and storage of jackfruit chips, carried out in the department of Horticulture, North Eastern Hill University, Tura Campus, Meghalaya from 2018 to 2020. Jackfruit, being readily available and nutritionally rich, can be a good source of income and employment to the rural folks. Chips were prepared by making modifications to the traditional methods practised by the common people of Garo hills, Meghalaya with the objective of standardizing the method for preparation of locally available jackfruit. Traditionally jackfruit chips are prepared using matured fruits by directly frying the cut or shredded pieces. In this investigation, we have included sun drying and blanching of jackfruit pieces before frying them at two levels of trying temperature, viz., 150°C and 170°C. The results revealed that chips prepared by blanching and sun drying the pieces and then frying them at 150°C were found be best in terms of overall acceptability. Frying at higher temperature of 150°C resulted in better retention of nutrients in the chips. Thus, it can be concluded that incorporation of blanching and sun drying can be a better alternative in making jackfruit chips as an improvement to the traditional method of directly frying in oil.

Keywords Jackfruit chips, Traditional method, Standardization, Garo hills, Employment generation.

INTRODUCTION

The Garo Hills in Meghalaya is richly blessed with a very conducive climate, which favors the growth of many fruit crops of horticultural importance. Jackfruit (*Artocarpus heterophyllus* Lam.) is one such tree that grows naturally found planted in the backyard or frontyard garden of almost every rural household in Garo hills, Meghalaya. But jackfruit has remained underutilized in the region, despite its multiple usages. It is a common sight to find ripe jackfruits rotting on the trees, due to lack of knowledge and infrastructure that can support scientific and optimum utilization of the available fruits. Understanding the potential of the fruit, the Government of Meghalaya started 'Mission Jackfruit' in August 2018 to promote the value addition of jackfruit among the farmers to encourage processing of jackfruit and to provide opportunities of jackfruit-based entrepreneurship.

Todik Jimmy T. Sangma*
PhD Research Scholar, Department of Horticulture, North Eastern Hill University, Tura, Meghalaya, India

C. Perinba Suresh
Professor, Department of Horticulture, North Eastern Hill University, Tura, Meghalaya

Prasenjit Pal
Assistant Professor, Department of Extension and Social Sciences, College of Fisheries, Central Agricultural University (Imphal), Lembucherra, Tripura

Email: todjim@rediffmail.com
*Corresponding author

Jackfruit, normally consumed as a fruit when ripe and as a vegetable at the unripe stage (Molla *et al*. 2008, Prakash *et al*. 2009) is rich in minerals and vitamins. It was observed that the value addition of jackfruit will help the rural masses, especially women, to generate income and be gainfully employed (Deepa and Murthy 2019). This will also help minimise wastage of the fruit and make it available throughout the year. Jackfruit is a multi-purpose species, as it can provide food, timber, fuel, fodder, medicinal, and industrial products (Thomas 1980, Prakash *et al*. 2009).

Jackfruit has been a part of Garo culture from time immemorial and its uses as food, fodder, timber and medicine are prevalent among the people (Khan *et al*. 2010). But the fruit is eaten as raw or ripe in its original form mostly. Value addition of jackfruit is very negligible, with the exception of a few individuals who engage in pickling and chips preparation out of jackfruit. Being without any formal training they normally follow a traditional method in preparation the products.

It is very important to promote the value addition of jackfruit by the local growers. In this regard, the ethnic value-addition practices followed by the Garos are unique and deserve to be standardized and promoted so that it can be made competitive and market worthy. Therefore, with the objective to develop a standard recipe and process protocol for jackfruit value addition, we have conducted our investigation to prepare and study the acceptability of jackfruit chips in storage at ambient condition.

MATERIALS AND METHODS

The present study is the preparation and standardization of jackfruit chips using fully matured but unripe jackfruit bulbs. The research experiments were conducted between 2018 and 2020 in the laboratory of the Department of Horticulture, North Eastern Hill University, Tura Campus (25.5651° N and 90.2355° E), Tura, Meghalaya from May 2018 – May 2020.

Procurement of materials

The fully matured but unripe jackfruits used for the experiments were collected from the homestead garden of a local grower at Upper Rongkhon, Meghalaya. All the required fruits were selected from the same tree. The ingredients used in the experiment for chips preparation were bought from the local market at Tura, Meghalaya.

Preparation of chips

Jackfruit chips were prepared following the process flowchart and the treatment formulations as shown in Fig. 1 and Table 1, respectively. Based on the information gathered from the respondents in the appraisal study, chips were prepared with a little modification to the most commonly practiced traditional methods and recipes used by the people of Garo hills using freshly plucked fully matured but unripe jackfruits. In all the treatments, the flakes (deseeded bulbs) were cut to slices of about 0.6-0.8 cm in breadth, while lengthwise maintaining the length of the bulb and the pieces were fried in refined cooking oil. T_1 was made following the traditional method commonly followed by the people and the rest of the treatments were made with little modifications to the traditional method.

Storage studies

The prepared chips were studied for organoleptic properties and nutritional contents immediately after

Table 1. Treatment formulations for preparation of jackfruit chips.

Sl. No.	Treatment formulation
T_1	Pieces fried in oil till they turn crispy and yellow color is developed, mixed with salt and spices (chilli powder (1%) and coriander powder (1%)) when still hot.
T_2	Sun drying + Frying in oil at high temperature (170°C) + Mixing with salt (2%) and spices (chilli powder (1%) and coriander powder (1%)).
T_3	Sun drying + Frying in oil at low temperature (150°C) + Mixing with salt (2%) and spices (chilli powder (1%) and coriander powder (1%)).
T_4	Blanching + Sun drying + Frying in oil at high temperature (170°C) + Mixing with salt (2%) and spices (chilli powder (1%) and coriander powder (1%)).
T_5	Blanching + Sun drying + Frying in oil at low temperature (150°C) + Mixing with salt (2%) and spices (chilli powder (1%) and coriander powder (1%)).
T_6	Blanching + Sun drying + Frying in oil at high temperature (170°C) + Mixing with ground sugar (2%).
T_7	Blanching + Sun drying + Frying in oil at low temperature (150°C) + Mixing with ground sugar (2%).

TABLES AND FIGURE

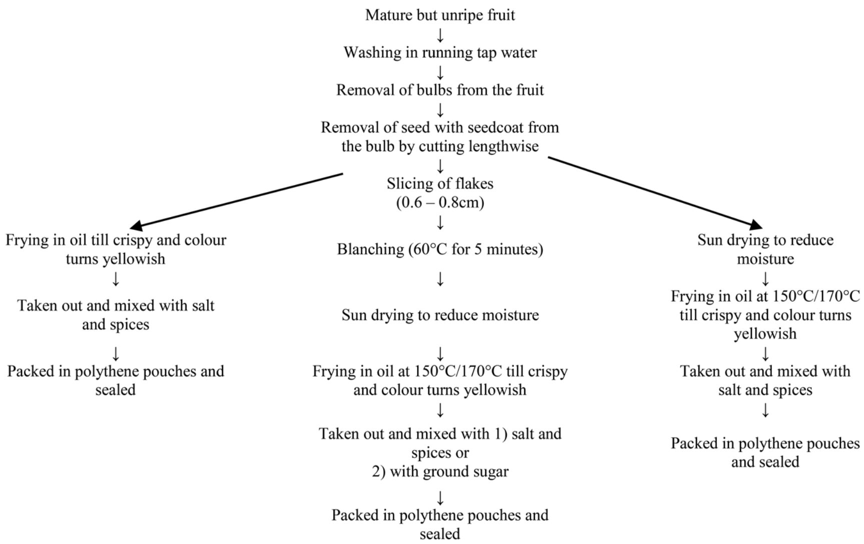

Fig. 1. Process flowchart for preparation of jackfruit chips.

preparation and thereafter at two months interval under storage condition up to six months.

Sensory evaluation for acceptability of the product

The sensory acceptability of the prepared products was evaluated by distributing the samples jackfruit chips to a team of 15 taste panellists. The overall acceptability of the prepared products was judged based on the points scored against sensory parameters like color, flavor, texture and taste of the prepared products on a 5-point hedonic scale (Amerine *et al*. 1965).

Proximate composition of the jackfruit chips in storage condition

The prepared jackfruit chips were studied for changes in bio-chemical properties at an interval of 2 months up to six months.

Acidity

Acidity percentage of the freshly prepared chips as well as in storage was estimated by titrating against standard alkali (N/10 NaOH) solution with phenolphthalein as indicator. Acidity percentage was expressed in terms of citric acid (AOAC 2005).

Ascorbic acid

Ascorbic acid content in jackfruit chips in terms of percentage was determined by using 2, 6-Dichlorophenol indophenol solution as described by Ranganna (1997). Appearance of light pink color which persisted for 15 seconds marked the end point and was expressed as mg of ascorbic acid per 100 ml or 100 g of the sample.

$$\text{Ascorbic acid (mg/100 g)} = \frac{\text{Titre value X Dye factor X Volume made up x 100}}{\text{Volume of sample X Volume of aliquot taken}}$$

$$\text{Dye factor} = \frac{0.5}{\text{Titre value of standard ascorbic acid}}$$

Total soluble proteins

The protein content of jackfruit chips was estimated with the help of spectrophotometer using Folin-Ciocalteau reagent. The readings were taken at 660 nm wavelength and the protein content was calculated by the help of the standard curve and expressed in percentage (%).

Total carbohydrates

The amount of carbohydrates in jackfruit chips was estimated following the method described by Hedge and Hofreiter (1962). The spectrophotometer wavelength was set at 660 nm and glucose was used as the working standard for carbohydrates. Carbohydrate content was calculated from the standard curve and expressed in percentage, using the formula given below:

$$\text{Carbohydrates (\%)} = \frac{\text{Y x Volume x 100}}{\text{Aliquot taken x wt. of sample x 1000}}$$

Y = Amount of carbohydrates from standard curve

β-carotene

The β- Carotene content in the jackfruit chips was estimated by using spectrophotometer set at 452 nm wavelength (Ranganna 1997). The sample was prepared by extraction with acetone and petroleum ether. The amount of β- Carotene was expressed as IU per 100 ml sample.

$$\beta\text{- Carotene (IU)} = \frac{\text{Concentration of } \beta\text{-carotene from standard curve} \left(\frac{\mu g}{ml}\right) \text{ X Final Volume X Dilution X 100}}{\text{Volume of the sample}}$$

1 IU = 0.6μg

Moisture content (%)

The percent moisture content in jackfruit chips was analyzed as per AOAC (2005) protocols. The samples were taken in triplicates for determining the reduction in weight due to loss of moisture. A known weight (5g) of the sample was taken and coarsely ground, and dried in a hot oven dryer at 105°C until a constant weight was obtained. The moisture content was estimated using the formula given below:

$$\text{Moisture content (\%)} = \frac{\text{Initial weight - Final weight}}{\text{Initial weight}} \times 100$$

Statistical analysis

The changes in organoleptic scores and changes in chemical parameters of the jackfruit chips were analyzed using repeated measures ANOVA design (Girden 1992), with treatment as between subject effects and time as within subject factor with the help of SAS 9.3.1 software. Changes in the level of different parameters of jackfruit chips that were freshly prepared and subsequently in storage over the intervals of time periods (0 month, 2 months, 4 months and 6 months) were analyzed. The significance of treatment effect, time effect and the interaction (time*treatment) effect were studied.

The Mauchly's test of sphericity was performed to check the assumption of sphericity at alpha level 0.05. If the test is significant ($p < 0.05$), then the assumption of sphericity has not been met. In such cases, where sphericity cannot be assumed, the Greenhouse-Geisser epsilon is used to make an adjustment to the degrees of freedom of the repeated measures ANOVA and 'Greenhouse-Geisser' row is used to report the results. If the ANOVA is significant ($p<0.05$), this means that there is a difference between at least two time points.

The Pair-wise comparison tables contain multiple paired t-tests with a Bonferroni correction to keep the Type I error at 5% overall. Tukey's test was also performed to find the best treatment group. Differences were considered significant at 5% level of significance.

RESULTS

The results of the study for changes in organoleptic acceptability and nutrient content of jackfruit chips are hereby presented under different segments.

Sensory attributes of jackfruit chips

The sensory attributes like color, taste, texture and flavor of jackfruit chips have been recorded through a taste testing panel at a bimonthly interval for six months to assess the overall acceptability of the prepared products. The mean and standard deviation of the scores for organoleptic acceptability for 2018 and

Table 2. Mean (M) and standard deviation (SD) for the organoleptic acceptability of jackfruit chips.

	T_1		T_2		T_3		T_4		T_5		T_6		T_7	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
2018	3.79	0.38	3.87	0.09	3.86	0.15	3.90	0.12	3.98	0.06	3.96	0.21	3.88	0.11
2019	4.11	0.18	3.90	0.10	3.97	0.10	3.80	0.12	3.97	0.10	3.89	0.19	3.94	0.17

2019 have been presented in Table 2.

The organoleptic acceptability of jackfruit chips stored at ambient condition over a bimonthly interval of time (2 months, 4 months and 6 months) was analyzed using repeated measures ANOVA. The significance of the treatment effect, time effect and the interaction effect (time x treatment) were studied for the trials of 2018 and 2019. Results of the repeated measures ANOVA with Greenhouse-Geisser correction indicate that there was a significant effect of time on the overall acceptability of jackfruit chips over different assessment points (2 months, 4 months and 6 months), $F (3.68, 240) = 16.037$, $p < 0.001$ and $F (2.520, 240) = 4.485$, $p=0.008$ for 2018 and 2019, respectively, which reveals that there is a difference between at least two time points. The interaction between time and treatment did not have a significant effect on the overall acceptability for 2018 as $F (12.58, 84) = 1.572$, $p = 0.122$ and but it was significant for 2019, $F (18, 84) = 2.153$, $p = 0.010$. Multiple paired t-tests with a Bonferroni correction revealed a significant difference ($p = 0.002$) between each pair of time points for 2019 but it showed no significant difference ($p = 0.477$) among the treatments for 2018. Tukey's test was also performed to find the best treatment group. For 2018, treatment 5 was found to be the best on the basis of mean values but other treatments were at par with treatment 5 as the treatment effect was not found significant, while treatment 1 was the best for 2019.

The changes in bio-chemical parameters of the jackfruit chips

The results of the repeated measures ANOVA for changes in different paraments of jackfruit chips over six months in storage are presented and discussed here. The mean and standard deviation for the effect of time on the changes in bio-chemical parameters have been presented in Tables 3 and 4.

The results of the repeated measures ANOVA with Greenhouse-Geisser correction for the effect of time on different bio-chemical parameters have been presented and discussed here.

β-carotene

Results of the repeated measures ANOVA indicate that there was a significant effect of time on the level of β-carotene in jackfruit chips over different assessment points (0 month, 2 months, 4 months and 6 months), $F (3,42) = 504.57$, $p < 0.001$ and $F(3,42) = 197.19$, $p > 0.001$ in 2018 and 2019, respectively.

Table 3. Mean and standard deviation for the effect of time on the changes in bio-chemical parameters in jackfruit chips.

Bio-chemical parameters	2018													
	T_1		T_2		T_3		T_4		T_5		T_6		T_7	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
β-Carotene	116.45	15.09	126.56	11.23	129.94	9.90	144.65	10.76	140.46	6.51	147.33	9.50	140.01	7.02
Carbohydrates	21.44	0.96	22.21	0.36	22.70	0.50	22.87	0.30	23.28	0.58	22.89	0.39	23.46	0.34
Proteins	1.16	0.19	1.43	0.11	1.53	0.11	1.49	0.08	1.55	0.13	1.51	0.08	1.56	0.09
Ascorbic acid	4.87	0.00	6.09	0.00	6.89	0.00	6.09	0.00	6.89	0.00	6.09	0.00	6.94	0.00
Acidity	0.13	0	0.13	0	0.13	0	0.13	0	0.13	0	0.13	0	0.13	0
Moisture content	4.56	0.36	4.41	0.37	4.39	0.34	4.37	0.35	4.37	0.33	4.30	0.31	4.29	0.30

Table 4. Mean and standard deviation for the effect of time on the changes in bio-chemical parameters in jackfruit chips.

Bio-chemical parameters	2019													
	T_1		T_2		T_3		T_4		T_5		T_6		T_7	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
β-Carotene	116.71	14.60	127.53	12.53	127.97	10.22	145.89	11.31	138.60	7.19	147.10	10.85	138.83	8.13
Carbohy-drates	22.25	1.50	21.98	1.14	22.44	1.10	22.57	0.87	23.69	1.24	23.42	1.19	23.46	0.87
Proteins	1.18	0.19	1.49	0.13	1.53	0.10	1.48	0.09	1.60	0.13	1.51	0.08	1.57	0.16
Ascorbic acid	4.452	0.74	5.72	0.73	6.68	0.72	5.72	0.73	6.572	0.88	5.72	0.739	6.57	0.42
Acidity	0.27	0	0.29	0.06	0.288	0.06	0.32	0.0739	0.33	0.064	0.352	0.04	0.35	0.04
Moisture content	4.90	0.29	4.70	0.32	4.66	0.34	4.65	0.35	4.63	0.34	4.60	0.39	4.57	0.40

This indicates that there is a difference in the levels of β-carotene between at least two time points of assessment of the products. The interaction between time and treatment had a significant effect on the level of β-carotene in jackfruit chips for 2018, $F(18,42) = 7.217$, $p < 0.001$ and 2019, $F(18,42) = 3.463$, $p < 0.001$. Multiple paired t-tests with a Bonferroni correction revealed a significant difference ($p < 0.001$) in the level of β-carotene in chips between each pair of time points for 2018 and 2019. Tukey's test confirmed treatment 6 to be best for both 2018 and 2019. β-carotene content showed a decreasing trend with increase in storage time. A similar trend was reported by Patil *et al.* (2014) in jackfruit chips.

Carbohydrates

Result of the repeated measures ANOVA for 2018 indicates that there was a significant effect of time on the level of carbohydrates in jackfruit chips over different assessment points (0 month, 2 months, 4 months and 6 months), $F(3,42) = 3.199$, $p = 0.033$ but it had no significant effect, $F(3,42) = 2.499$, $p = 0.073$), for 2019. This indicates that there is a difference in the levels of carbohydrates in chips prepared in 2018 between at least two time points of assessment of the products. The interaction between time and treatment had no significant effect on the level of carbohydrates in jackfruit chips for 2018, $F(18,42) = 0.447$, $p = 0.996$ and but it had a significant effect in 2019, $F(18,42) = 3.509$, $p < 0.001$. Multiple paired t-tests with a Bonferroni correction revealed a significant difference ($p < 0.001$) in the level of carbohydrates in chips between each pair of time points for 2018 and 2019. Tukey's test confirmed treatment 7 and treatment 5 to be best in 2018 and 2019, respectively. Carbohydrate content showed a decreasing trend with increase in storage time.

Proteins

Results of the repeated measures ANOVA for 2018 and 2019 indicate that there was a significant effect of time on the level of proteins in jackfruit chips over different assessment points (0 month, 2 months, 4 months and 6 months), $F(3,42) = 99.286$, $p < 0.001$ and $F(3,42) = 64.047$, $p < 0.001$, respectively. This indicates that there is a difference in the levels of proteins in chips between at least two time points of assessment of the products. The interaction between time and treatment had no significant effect in 2018 on the level of proteins in chips, $F(18,42) = 1.849$, $p = 0.051$ but it had a significant effect in 2019, $F(18,42) = 3.024$, $p = 0.002$. Multiple paired t-tests with a Bonferroni correction revealed a significant difference ($p < 0.001$) in the level of proteins in chips between each pair of time points for 2018 and 2019. Tukey's test confirmed treatment 7 and treatment 5 to be best in 2018 and 2019, respectively. Protein content showed a decreasing trend with increase in storage time.

Ascorbic acid

Result of the repeated measures ANOVA for 2018 and result of the repeated measures ANOVA with Greenhouse-Geisser correction in 2019 indicate that there was a significant effect of time on the level of ascorbic acid in jackfruit chips over different assessment points (0 month, 2 months, 4 months and 6 months), F (3,42)

= 36.112, $p < 0.001$ and F (1.744,24.419) = 96.20, $p < 0.001$, respectively. This indicates that there is a difference in the levels of proteins in chips between at least two time points of assessment of the products. The interaction between time and treatment had no significant effect in 2018 on the level of proteins in chips, F (18,42) = 1.785, p = 0.061 but it had a significant effect in 2019, F (10.465,24.419) = 2.867, p = 0.016. Multiple paired t-tests with a Bonferroni correction revealed a significant difference ($p < 0.001$) in the level of proteins in chips between each pair of time points for 2018 and 2019. Tukey's test confirmed treatments 3, 5 and 7 to be best in 2018 and 2019 as they were on par with each other. Ascorbic acid content showed a decreasing trend with increase in storage time.

Acidity

Results of the repeated measures ANOVA with Greenhouse-Geisser correction for 2019 indicate that there was a significant effect of time on the level of acidity in jackfruit chips over different assessment points (0 month, 2 months, 4 months and 6 months), F (3,42) = 46.385, $p < 0.001$. This indicates that there is a difference in the levels of proteins in chips between at least two time points of assessment of the products. The interaction between time and treatment had a significant effect in 2019 on the levels of acidity in chips, F (18,42) = 4.744, $p < 0.001$. Multiple paired t-tests with a Bonferroni correction revealed a significant difference ($p < 0.001$) in the level of acidity in chips between each pair of time points for 2019. Tukey's test confirmed treatment 7 to be the best in 2019. Results could not be obtained for 2018 as the readings were same for all the time points of assessment. Acidity showed a decreasing trend with increase in storage time. This is in line with the findings of Patil (2003) and Patil *et al.* (2004), who reported a gradual increase in titratable acidity with increase in the storage time.

Moisture content

Results of the repeated measures ANOVA for 2018 (with Greenhouse-Geisser correction) and 2019 indicate that there was a significant effect of time on the levels of moisture content in jackfruit chips over different assessment points (0 month, 2 months, 4 months and 6 months), F (1.897,26.555) = 611.13, $p < 0.001$ and F (3,42) = 1683.51, $p < 0.001$, respectively. This indicates that there is a difference in the levels of moisture content in chips between at least two time points of assessment of the products. The interaction between time and treatment had no significant effect on the levels of acidity in chips both in 2018, F (11.381,26.555) = 0.525, p = 0.873, but it was significant in 2019, F (18,42) = 5.186, $p < 0.001$. Multiple paired t-tests with a Bonferroni correction revealed a significant difference ($p < 0.001$) in the level of moisture content in chips between each pair of time points for 2019. Tukey's test confirmed treatment 1 to be the best in 2018 and 2019. Moisture content increased with increase in storage time. This is due to the absorption of moisture present in air inside the packet as the products are hygroscopic in nature. Molla *et al.* (2008) gave absorbed moisture and sealing gaps as reasons for moisture gain.

This is in agreement with the findings of Patil *et al.* (2014) who reported that the moisture content in jackfruit chips increased significantly with increase in storage time.

Molla *et al.* (2008) carried out a storage study of jackfruit chips at ambient temperature by using different packaging materials, viz., polypropylene pouch, high density polyethylene pouch and metalex foil pouch, and observed an increase in moisture content in the chips irrespective of the packaging material used. Molla *et al.* (2008) also pointed out that the moisture content of the freshly prepared chips should be 4% and that the removal of water depends on frying time and temperature. Their study confirmed that frying at 170°C requires 10 minutes to reach moisture level of 4% from initial 75%. They further noted that the moisture content of jackfruit chips during storage is dependent on relative humidity of the storage structure. Similar results were observed by Patil (2003) in jackfruit chips.

DISCUSSION

As the objective was to standardise the preparation of chips, seven different treatment formulations were used to prepare the chips and storage studies were conducted over a period of six months by recording the changes in bio-chemical properties, organoleptic acceptability levels and presence of spoilage microbial colonies. The results obtained in these studies have been discussed here to elaborate their implications in the processing of jackfruit into chips.

Sensory evaluation showed treatment 5 to be the best in 2018 and treatment 1 to be the best in 2019. The difference in the results for the two years could be attributed to the subjective nature of liking of the individuals for the various treatments and the subjective nature of scoring of the products during the time of tasting. Other reason could be variability in the composition of the raw material used which could very well be different in two different years even though fruits from the same tree were used for the trials. Same thing can be said about the different results for bio-chemical parameters.

The study of bio-chemical properties revealed treatment 6 to be the best in relation to β-carotene, treatment 7 in terms of carbohydrates and proteins, treatments 3, 5 and 7 in terms of ascorbic acid, treatment 1 in terms of moisture content for 2018 experiments. Experiments of 2019 showed treatment 6 to be best in terms of β-carotene content, treatment 5 in terms of carbohydrates and proteins, treatment 3, 5 and 7 in terms of ascorbic acid, treatment 1 in terms of moisture content and treatment 7 in terms of acidity.

CONCLUSION

From the findings it can be concluded that treatment 1 can be considered as the best product as it had the least moisture content in 2019 trial and was judged the most acceptable treatment from organoleptic point of view in 2018. This is because moisture content plays an important role in storage quality of packaged chips, as the presence of moisture lowers the crispiness of the chips which is an important factor related to the product texture.

ACKNOWLEDGEMENT

We are grateful to the department of Horticulture, North Eastern Hill University, Tura Campus, Meghalaya for providing us all the necessary help and facilities to conduct the investigations.

REFERENCES

AOAC (1990) Official methods of analysis, 15th edn., Virginia, Association of Official Analytical Chemists.

Deepa MPM, Murthy PS (2019) Economic Analysis of Women Empowerment Through Value Addition of Jackfruit in Bengaluru Rural District. *Econ Affairs* 64(2): 401-406.

Girden ER (1992) ANOVA: Repeated Measrues. Sage University Paper Series on Quantitative Applications in the Social Sciences, 07-084. Newbury Park, CA: Sage.

Khan R, Zerega N, Hossain S, Zuberi MI (2010) Jackfruit (*Artocarpus heterophyllus* Lam.) diversity in Bangladesh: Land use and artificial selection 1. *Econ Bot* 64(2): 124-136.

Molla MM, Nasrin TAA, Islam MN, Bhuyan MAJ (2008) Preparation and packaging of jackfruit chips. *Int J Sustain Crop Prod* 3(6): 41-47.

Patil RR, Mokat MKD, Relekar P, Puj K (2014) Effect of pre-treatments on physico-chemical composition of dehydrated jackfruit chips during storage at ambient temperature. *Life Sci Leaflets* 54, 27-to.

Patil RS (2003) Studies on physico-chemical composition, storage, processing and waste utilization of jackfruit (*Artocarpus Heterophyllus* Lam.). Doctoral dissertation, Dr Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli.

Prakash O, Kumar R, Mishra A, Gupta R (2009) *Artocarpus heterophyllus* (Jackfruit): An overview. *Pharmaccog Rev* 3: 353−358.

Ranganna S (1997) Hand book of Analysis and Quality control for fruit and vegetable Products. 2nd ed. Tata McGraw-Hill Publishing Company Ltd., New Delhi.

Rowe-Dutton P (1985) *Artocarpus heterophyllus*-Jackfruit, Garner JR, Chaudhury SA eds., The propagation of Tropical Fruit Trees, FAO, CAB, London, pp 269-290.

Thomas CA (1980) Jackfruit, *Artocarpus heterophyllus* (Moraceae), as source of food and income. *Econ Bot* 34(2): 154-159.