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Preparation and preservation of value added products from jackfruit and evaluation of their biochemical properties

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ABSTRACT

Value addition through processing and preservation of jackfruit (*Artocarpus heterophilus* Lam.) is currently viewing as an important aspect in fruit industry to reduce post-harvest loss. The present investigation was carried out to prepare value-added products such as jackfruit candy and jackfruit jam from jackfruits (cv. Khaja) and, analyze their biochemical compositions and mineral constituents. The fresh half ripe and fully ripe jackfruit were collected from local market and then washed and peeled followed by removal of seeds. Five jackfruit jams and five jackfruit candies were prepared as value-added products using different ingredients with different combinations. To evaluate the biochemical properties, chemical analysis and organoleptic observations of jackfruit jam and jackfruit candy were performed. The protein, ash, fat, fibre, calcium and magnesium contents of Jam 3 were 1.73%, 0.035%, 0.16%, 0.48%, 44.5 mg/100g and 35.8 mg/100g, respectively. The proximate composition of Candy 4 with protein, ash, fat and fibre contents were 6.75%, 0.10%, 0.81% and 0.72%, respectively. The overall acceptability of Jam3 was the highest and nutritional value was also higher compared to other treatments. In case of candy preparation, Candy 4 showed the highest score for its acceptance. There was a significant difference at probability $p<0.05$ in different jackfruit jams and jackfruit candies.

Keywords: Biochemical properties, Candy, Jackfruit, Jam, Sensory tests

INTRODUCTION

Among the tropical fruits, jackfruit (*Artocarpus heterophyllus* Lam.) is an important underutilized fruit, and often called the poor man's fruit because of its affordability and availability in large quantities during the season. The fruit often assumes the role of a secondary staple food as well as contributes to the livelihoods of the poor. The jackfruit has been named as the national fruit of Bangladesh. It is one of the largest fruits to grow on trees in the world, and a jackfruit tree can live and bear fruits for approximately a hundred year if taken care of correctly (Siddique and Azad 2010,Haq 2006, Haq 2003). Major jackfruit producing countries are Bangladesh, India, Myanmar, Nepal, Thailand, Vietnam, China, the Philippines, Indonesia, Malaysia and Sri Lanka. Jackfruit is also found in East Africa e.g. Uganda, Tanzania and Mauritius as well as throughout Brazil and Caribbean nations such as Jamaica. It has a potential to increase local income when grown in agroforestry and home garden systems (Lakshminarayan 2017). There are variations in

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sweetness, acidity and taste of jackfruit aril. Jackfruits in Bangladesh are usually three types of cultivars namely i) Khaja-hard pericarb, ii) Ghila- the pulp is very juicy and soft and iii) Dorasha an intermediate one, the pulp of which is fairly firm and juicy. The average weight of different types of fruits and percentage of edible portion as well as the eating quality may vary to a great extent (Azad et al. 2007,Haq 2006).

Jackfruit consists of three parts *viz*., bulb (30-32%), seeds (18%) and the rind (5-55%) of the ripe fruit. The economic product of jackfruit is the fruit used at immature and mature stages. The aromatic arils of ripe jackfruit are mainly used as dessert. The fresh de-seeded sweet pulp of the fruits cannot be stored for a long time due to its perishability nature and thus as a consequences huge post-harvest losses occur during the peak season. The fruit pulp is sweet and tasty, and used as dessert or to be preserved in syrup. The ripened pulp of fruitlets is used to flavor products such as ice cream and beverages, and the fresh pulp is used to prepare jams, chutneys, jellies or candies. Dried pulp is utilized for chips preparation. The young and pre-mature fruit is also used as vegetable, which also contain high amount of vitamins and minerals. The jackfruit seeds contained in the ripe fruits are also cooked, boiled or roasted for direct consumption (Sreeletha et al. 2018, Lakshminarayan 2017,Nair et al.2013). The seeds are reported to be more nutritious than the bulb, being richer in protein, fat, potassium and carbohydrate with considerable amount of phosphorus and calcium (Acedo 1992, Rahim and Quddus 2000).

The process of changing or transforming a product from its original state to a more valuable state refers to as value addition (Sharma et al. 2014). Different value-adding technologies such as processing and preservation methods, dehydration and drying technology, freezing technology, packing, and labeling etc. can be applied to agricultural products to increase its value. Total value of any agricultural produce /commodities can be increased by performing certain post-harvest processing operations rather than selling it as such after harvest (APO 2009).Therefore, value addition through the using of processing and preservation methods must be considered as an important alternative for reducing the post-harvest losses of these nutritive fruit and for serving in off-season.

Till now, the value-added products of jackfruit have not received much popularity in the market. In Bangladesh, huge amounts of jackfruits are produced in summer season. However, there is no jackfruit processing industry in Bangladesh, which may cause post-harvest loss of fruit due to its storage problems. Furthermore, the importance of the fruit, seed and rind is known very little to the growers and consumers. Hence, value addition is very important to utilize the surplus fruits available during the harvesting season as well as to improve the livelihood of the farmers by producing value added products. The value-added jackfruit products using different chemicals and preservatives with different processing technologies may bring a great achievement in the jackfruit value- added product industry. Moreover, the health benefits of jackfruit can also be obtained throughout the year by providing nutritious products. In addition to these, the information obtained from this research can be used as a baseline for processing and producing of value-added products from jackfruits cultivated in Bangladesh. In this experiment, a better quality jackfruit candy and jam were prepared to extend storage life of jackfruit by utilizing improved processing techniques with a view for utilization in the off-season. The specific objectives of the study were as follows: i) to develop value-added products from jackfruits to utilize the surplus fruits available during the season, ii) to improve the livelihood of the farmers by enabling them to produce value-added products, and iii) to characterize the chemical properties and biochemical component present in value-added products of jackfruits.

MATERIALS AND METHODS

The research work was conducted in the laboratory of the Department of Agricultural Chemistry, Hajee Mohammad Danesh Science and Technology University, Dinajpur. The half-ripe and ripe jackfruits (cv. Khaja) were collected from local market of Dinajpur. Chemicals and reagents used in the study were used from laboratory stock. Sugar, preservatives and other ingredients were collected from local market. Chemicals and solvents used in the study were of analytical reagent grade. Glass bottle and aluminum foil were used as packaging materials for jackfruit jam and candy, respectively.

Jackfruit candy manufacture: For candy preparation, half-ripen jackfruits (medium hard flesh) were selected and washed. These fleshes were then cut into 1.0 cm × 0.5 cm × 0.5 cm pieces (cubes) and then blanched in hot water at 95°C for 4 minutes. Jackfruit fleshes were mixed with powdered milk, cinnamon and cardamom with little amount of salt. After that, the pieces were immersed in 2% calcium lactate and 0.1% potassium metabisulfite (KMS) for 2 hours and were drained. The pieces were then dipped into different sugar solutions until the TSS (total soluble solids) reaches to 64° Brix for 12 hours. The slices were drained and washed with clean water to remove adhering syrup followed by drying at 70°C in a cabinet dryer until the moisture content reaches to 10%. The products were packed in

polypropylene pouch and stored at room temperature (28-32°C) until further analysis (Bhuyan et al. 2013). The formulations of jackfruit candy are shown in Table 1.The developed products were analyzed for assessing their physico-chemical characteristics. The jackfruit candies were stored at normal temperature (25-30°C) covered with aluminum foil.

Table 1. Formulations of jackfruit candy

Sl no.	Ingredients	Candy 1	Candy 2	Candy 3	Candy 4	Candy 5
1.	Jackfruit flesh (g)	250	250	250	250	250
2.	Sugar (g)	50	100	150	200	250
3.	Powdered milk (g)	50	100	150	200	250
4.	Salt (g)	0.5	0.5	0.5	0.5	0.5
5.	Cinnamon (g)	3	3	3	3	3
6.	Cardamom (g)	3	3	3	3	3
7.	Calcium lactate (g)	2	2	2	2	2
8.	KMS (g)	0.10	0.10	0.10	0.10	0.10

Jackfruit jam manufacture: The bulbs (edible portion) from the fruits were removed manually after cutting the fruit in several pieces. As the fruit contains sticky latex, small quantity of mustard oil was applied on hands and then seeds were removed from bulbs. It was prepared from the pulp of ripe fruits with additives. Bulbs from a fully ripe jackfruit were blended and boiled for 5-7 minutes to extract juice. Then 50, 100, 150, 200 and 250 g sugar were added to 500g jackfruit pulp and 5g pectin was added to each treatment. All combinations were cooked until the TSS (total soluble solids) reaches to 64° Brix, then citric acid (0.25%) was added. The flake test was used for the determination of end point and the hot jam was poured in sterilized bottle and stored at room temperature (Bhuyan et al. 2013). The treatment combinations of different ingredients for manufacturing jackfruit jam are shown in Table 2. The developed products were analyzed for assessing their physico-chemical characteristics. The processed jackfruit products were stored at normal temperature (25-30°C) in glass bottle.

Table 2. Formulations for jackfruit jam

Sl no.	Ingredients	Jam 1	Jam 2	Jam 3	Jam 4	Jam 5
1	Jackfruit pulp (g)	500	500	500	500	500
2	Sugar (g)	50	100	150	200	250
3	Citric acid (g)	2.5	2.5	2.5	2.5	2.5
4	Vinegar (ml)	2	2	2	2	2
5	Cinnamon (g)	3	3	3	3	3
6	Cardamom (g)	3	3	3	3	3
8	Pectin (g)	5	5	5	5	5
9	Sodium benzoate (g)	1	1	1	1	1

Biochemical analysis: The crude protein, fat, moisture content and ash were determined by AOAC method (AOAC 2000). Total soluble solids (Brix %) was determined using a sugar refractometer. pH was determined using a digital pH meter (Model PHS-2F). Total titratable acidity was determined by the (AOAC 2000) method. Carotene content was determined by column chromatographic method as described in AOAC method (AOAC 2000). Vitamin C content was measured according to the 2, 6-dichlorophenol indophenol visual titration method as described in AOAC (2000). Total sugar content was determined colorimetrically by the anthrone method (Jayaraman 1981) as explained in AOAC (2000). Reducing sugar content was determined by dinitrosalicylic acid method (Miller 1972) described in AOAC (2000). Non-reducing sugar was estimated in accordance with the method given in AOAC (2000). Ca^{2+} and Mg^{2+} were analyzed by complexometric titration whereas K^{+} and Na^{+} were estimated by flame emission spectrophotometer (APHA 2005).The total phosphorus (TP) was analyzed from the unfiltered sample as the dissolved inorganic phosphorus (DIP) after persulfate digestion and determined after the Mo-blue method according to APHA (2005). SO_4^{2-} was determined turbidimetrically. Statistical analysis was done using analysis of variance (ANOVA) and means

were separated by the Least Significant Difference (LSD) procedure.

Sensory evaluation of value-added products of jackfruit: The sensory properties of the value-added products were evaluated for color, flavor, taste, texture and overall acceptability parameters by 20 tasters. The panelists were selected from the teachers, students and employees of the Faculty of Agriculture, Hajee Mohammad Danesh Science and Technology University, Dinajpur. They were asked to rate the given sample a 9-point hedonic scale with ratings of: 9 =Like extremely, 8 = Like very much, 7 = Like moderately, 6 = Like slightly, 5 = Neither like or unlike, 4 =Dislike slightly, 3 =Dislike moderately, 2 = Dislike very much, 1 = Dislike extremely. The results were evaluated by Analysis of Variance and Duncan's Multiple Range Test (DMRT) procedures using SPSS 22.

RESULTS AND DISCUSSION

This research was conducted to measure the biochemical and mineral components of different value-added products of jackfruit variety Khaja grown in Dinajpur district. Some photographs of jackfruit jam and jackfruit candy are shown in Figure 1. The results obtained from the research were presented and discussed in this chapter under the following headings:

Chemical composition of jackfruit: The biochemical and mineral compositions of ripe and half-ripe jackfruits are shown in Table 3. In general, the main biochemical constituents of jackfruit are vitamin A, vitamin C, thiamin, riboflavin, calcium, potassium, iron, sodium, zinc, and niacin among many other nutrients. The caloric content is 94 calories from 100 g of jackfruit (Mukprasirt and Sajjaanantakul 2004). It contains very good amounts of vitamin B-6 (pyridoxine), niacin, riboflavin, and folic acid. Another benefit of eating jackfruit is that it is a good source of vitamin C. Vitamin C is an antioxidant that protects the body against free radicals, strengthens the immune system, and keeps our gums healthy (Umesh et al. 2010).In this study, the vitamin C content of the half-ripe and ripe fruits was14 mg/100g and 12.25 mg/100g, respectively. Amadi et al. (2018) mentioned vitamin C content at 2.11 mg/100 g in jackfruit pulp. Balamaze et al .(2019) reported ascorbic acid contents ranging from 1.6 mg/100 g to 4.3 mg/100 g depending on the variety and fruit selection of jackfruit. The jackfruit is rich in carotene and carbohydrates, moderately rich in ascorbic acid (Rahim and Quddus 2000, Samaddar 1985). It also contains some minerals like calcium and potassium and vitamin B complexes like thiamin, riboflavin, and niacin (Acedo 1992). Niacin is known as vitamin B_3 and necessary for energy metabolism, nerve function, and the synthesis of certain hormones. A portion of 100 g of jackfruit pulp provides 4 mg niacin (Soobrattee et al. 2005). The recommended daily amount for niacin is 16 mg for males and 14 mg for females (Institute of Medicine 2000). Jackfruit contains phytonutrients: lignans, isoflavones, and saponins that have health benefits that are wide ranging. These phytonutrients have anticancer, antihypertensive, antiulcer and anti-aging properties.

Total titrable acidity of half-ripe and ripe fresh jackfruit was found to be 0.06% and 0.07 % respectively (Table 3). Goswami et al. (2011) found the value of total acidy of five different varieties for fresh jackfruit to be high ranging from (0.46 – 0.91%). Fresh half-ripe jackfruit was found to contain TSS of 22.35 ^{o}Brix and the ripe jackfruit contained 19.09 ^{o}Brix. Eke-Ejiofor and Owuno (2013) reported the value of 23% for fresh jackfruit.

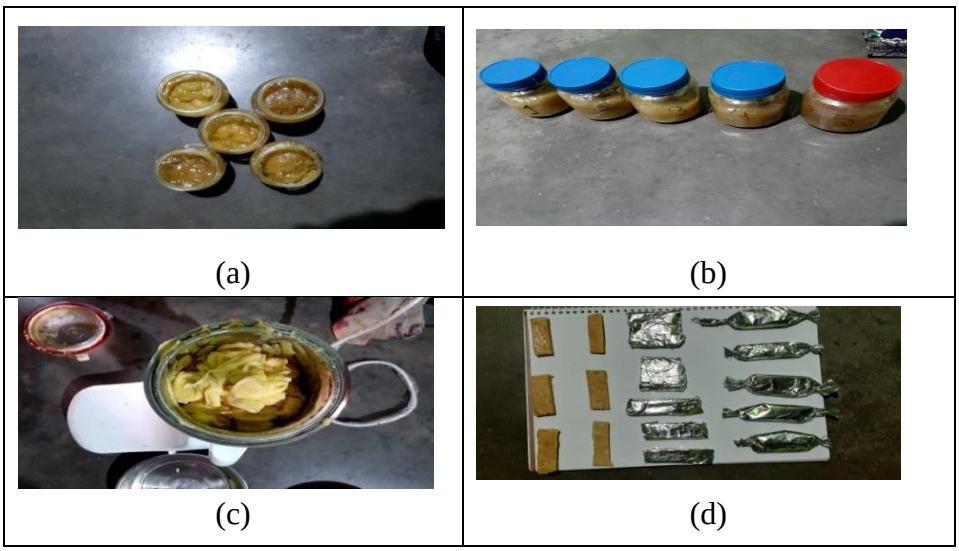

Figure 1. Photographs showing a) preparation of jackfruit jam, b) packing of jam in glass bottle, c) half-ripe jackfruit flesh ready for candy preparation and d) packing of jackfruit candy with aluminum foil

Table 3. Composition of fresh jackfruit cv. Khaja used in processed product

Parameters	Stages of the fruit	
	Half ripe	Ripe
Moisture (%)	71.12	77.61
pH	6.31	5.98
Acidity (%)	0.06	0.07
Total soluble solids (^{o}Brix)	22.35	19.09
Total sugar	6.33	10.76
Fibre (%)	2.95	2.13
Ash (%)	0.73	0.82
Protein (%)	2.11	1.78
Fat (%)	0.25	0.18
Vit -C (mg/100g)	14.00	12.25
β-carotene (mg/100 g)	0.11	0.06
Ca (mg/100 g)	26.53	20.04
Mg(mg/100 g)	29.67	24.30
P (mg/100 g)	10.12	15.13
K (mg/100 g)	200.55	233.30

The moisture, total sugar and K content increased in ripe fruits while the Ca and Mg contents decreased (Table 3).However, it is a rich source of potassium with 303 mg found in 100 g of jackfruit. Studies have reported that food rich in potassium helps to lower blood pressure (Fernando et al. 1991). Potassium is also important in modulating various body processes, including but not limited to acid-base balance, nerve conduction, and muscle contraction. Sampath et al. (2019) determined the mineral composition of different jackfruit genotypes. The authors established that the potassium content ranged from 231.43 mg/100 g to 332.33 mg/100g. Calcium content in this study was 26.53 mg/100 g at half-ripe stage and 20.04 mg/100 g at ripe stage. Calcium is required for mineralization and essential for bone growth (Sampath et al. 2019).The magnesium concentration of jackfruit pulp ranged from 24.30mg/100 g to 29.67 mg/100g. Magnesium facilitates calcium absorption and acts along with it to help strengthen bones and prevent bone disorders such as osteoporosis (Swaminathan 2003). These findings were in agreement with Amadi et al. (2018) where calcium and potassium contents in jackfruit pulp were at30mg/100g and 330 mg/100g, respectively. The results of fresh jackfruit were close to that found on other literatures for different fresh jackfruit varieties: calcium (20-37mg/100g), sodium (2-41mg/100g) and potassium (191-407 g/100g) as reported by many researchers (Soepadmo 1992, Gunasena et al. 1996, Azad 2000). The differences in mineral contents found in this study maybe due to location and variety.

Shafiq et al. (2017) established the nutritional profile of dried jackfruit, showing that it contains a considerable amount of protein (1.48%). The amount of protein in the edible pulp of various jackfruit varieties reported by Goswami et al. (2011) ranged from 0.57% to 0.97%. In this study, the percent proteins of the half-ripe and ripe jackfruit were 2.11 % and 1.78%, respectively. The post-harvest losses in jackfruit are around 30-35% during the peak season (Lakshminarayan 2017). Jackfruit has great potential for value addition and more than 100 items can be prepared from jackfruit immature stage to well ripened stage. Food preservation has an important role for better utilization of fruits in order to avoid the glut and utilize the surplus during the off-season. Different value-added products are being produced at both household and commercial levels with different popular fruits cultivated world over. Examples of processed products are jam, ready to serve fruit drinks, chutneys, candies, pickles, squashes, concentrate etc. (Roy 2000, Singh et al.2008). Different value added products like canned jackfruit bulbs in syrup, squash, raw jack pickle, roasted jack seeds and jack seed flour have been prepared from jackfruit (Berry and Kalra 1987,Chadha and Pareek 1988, Das and Prakash 2009).

Nutritional qualities of jackfruit jams: Jam was prepared by boiling fruit pulp with sugar, pectin and acid. Jam is an intermediate moisture food and high sugar content increases its caloric value. It is very popular among the children due to its sweet and fruity taste as well as the texture which can be enjoyed with any bakery stuff. The developed product was found to be highly acceptable with distinct jackfruit color and flavor.

Moisture content of jackfruit jam 3 was found to be 29.79% (Table 4) while that of fresh jackfruit was 77.61%. This difference in moisture between processed and unprocessed jackfruit is expected because of the sugar added and heating process involved during jam making that caused moisture evaporation. This result was high compared to the findings of Eke-Ejiofor and Owuno (2013) where the moisture content of jackfruit jam was 24.60%. The moisture content of the food is normally used as indicator of its shelf life (Fellows, 2000). Higher moisture content suggests that the jams have a short shelf life.

Protein content of jackfruit jam 3 was found to be 1.73 % while fresh jackfruit contained 1.78%. According to jam nutritional labeling, the most common ingredients are fruits, sugar, pectin and citric acid. None of these ingredients used are rich source of protein, hence low protein content of jam (Mohd Naeem et al. 2015). Most processed products such as jams tend to have lower nutritional values when compared to fresh fruits due to exposure to the heat generated during processing (Jawaheer et al. 2003).

Table 4. Biochemical constituents of jackfruit jam

Sl no.	Moisture (%)	Ash (%)	Fat(%)	Fibre (%)	Vit-Cmg/ 100g	Protein (%)	Reducing sugar (%)	Total sugar (%)	Non-reducing sugar (%)
Jam 1	28.34c	0.038a	0.167a	0.52ab	11.17a	1.38c	7.64b	72.00d	77.43bc
Jam 2	27.94c	0.043a	0.170a	0.54ab	10.14b	1.30c	7.75b	77.23c	77.82bc
Jam 3	29.79b	0.035a	0.160a	0.48b	8.91c	1.73a	8.14a	84.98b	76.08c
Jam 4	31.97a	0.041a	0.177a	0.56a	9.56b	1.72a	8.14a	89.30a	80.50a
Jam 5	27.71c	0.024a	0.070b	0.52ab	9.62b	1.55b	8.10a	87.00ab	78.90ab
LSD	0.755	0.0057	0.058	0.058	0.56	0.16	0.28	2.50	2.48
CV %	1.42	8.18	4.91	5.29	3.11	5.77	1.92	1.68	1.74

In a column, values having different letter (s) differed significantly at P ≤5 % level of probability by DMRT

Fat is also a major source of energy and provide essential lipid nutrients. In many foods the fat component plays a major role in determining the overall physical characteristics, such as flavor, texture, mouth feel and appearance (Muhammad et al. 2009). Haque et al. (2009) observed that the fat content of different fruits ranged between 0.0084% and 1.27%. Jackfruit contains no saturated fatty oil and cholesterol making it a healthy fruit to savour (Priya et al. 2014). The research results showed that both the jam and fresh jackfruit contained small amount of fat which is for human health especially those under weight control programs.

The ash content of the jackfruit jam 3 was found to be 0.035% and that of fresh jackfruit 0.82%. Haque et al. (2009) reported that ash contents of fresh fruits ranged from 0.053% to 0.902%. The percent crude fibre of the fresh ripe jackfruit was 2.13 % (Table 3). This value is slightly low compared to the value 3.06 % reported by Singh et al.(1991). The difference may be due to varietal distinctions and the geographical location while crude fibre in jackfruit jam was 0.48%. The fiber content of jackfruit helps protect the colon mucous membrane by binding to and eliminating cancer-causing chemicals from the colon. Vitamin C was recorded as 12.25 mg/100gin ripe jackfruit and 8.91 mg/100g for developed jackfruit jam 3. The acid present in the jam was expected to be high due to the addition of citric acid during jam making.

Among the five combinations, Jam 3 was identified as the best one according to the sensory analysis(Table 8)although the percent of moisture, ash, lipid and fibres were highest in Jam 4 compared to the other jams prepared in this study (Table4).Only the percent protein and calcium content were high in the Jam 3. There were some significant differences in different parameters analyzed in different jams (Table 4 and Table 5).It is now widely accepted that the beneficial effects of fruits for the prevention of certain diseases are due to the bioactive compounds they contain (Galaverna et al. 2008). The food products that can help maintain health; and the role that diet plays in the prevention and treatment of many illnesses are being the interest of consumers, researchers, and the food industries (Vinuda-Martos et al. 2010).

Table 5. Mineral constituents of jackfruit jam

Sample	Ca mg/100g	Mg mg/100g	K mg/100g	Na mg/100g	S mg/100g	P mg/100g
Jam 1	36.58d	32.43d	314.5b	31.03b	25.26d	45.73b
Jam 2	41.96c	37.17b	320.4b	31.17ab	28.02cd	46.33b
Jam 3	44.50b	35.80c	315.4b	30.61b	32.31c	35.16c
Jam 4	42.77c	38.70a	332.4a	31.38ab	41.35b	47.85b
Jam 5	52.99a	36.63bc	331.1a	32.12a	49.77a	52.92a
LSD	1.15	0.95	7.78	0.97	4.54	4.54
CV %	1.44	1.44	1.32	1.69	7.06	5.47

Mean values in a column having the same letter (s) do not differ significantly at 5% level of DMRT

Nutritional qualities of jackfruit candies: The five candies manufactured in this study were analyzed for various nutritional quality parameters and are presented in Table 6 and Table 7.Among the five candies, Candy 4 selected as the best one based on sensory evaluation. For Candy4, the moisture, protein, fat and fibres were 4.38 %, 6.75%, 0.81% and 0.72%, respectively. The moisture, protein, fat and fibres of half-ripe jackfruit flesh were 71.12%, 2.11%, 0.25% and 2.95%(Table 3).

Table 6. Biochemical constituents of jackfruit candy

Sample	Fibre	Ash	Fat	Moisture	Vit-C	Protein	Reducing sugar	Total sugar	Non-reducing sugar
	(%)	(%)	(%)	(%)	mg/100g	(%)	(%)	(%)	(%)
Candy 1	0.78a	0.108a	0.54d	9.87a	12.77b	4.63 c	17.07a	72.37a	46.35ab
Candy 2	0.83a	0.094a	0.62c	9.65b	13.41a	4.39d	16.77a	61.17a	45.35b
Candy 3	0.62c	0.089a	0.70b	9.35c	12.25c	5.64 b	16.91a	63.67a	47.90a
Candy 4	0.72b	0.100a	0.81a	9.38c	11.75d	6.75a	17.24a	62.34a	45.07b
Candy 5	0.53d	0.061a	0.25e	9.11d	11.96cd	4.70c	17.19a	65.14a	47.73a
LSD	0.057	0.058	0.058	0.20	0.411	0.20	0.69	18.74	1.95
CV %	3.02	4.55	6.20	0.19	1.81	2.12	2.22	15.86	1.15

Mean values in a column having the same letter (s) do not differ significantly at 5% level of DMRT

Vitamin C is an antioxidant that protects the body against free radicals, strengthens the immune system, and keeps the gums healthy (Umesh et al. 2010). Frequent consumption of jackfruit and jackfruit jam will help the body develop resistance against infectious agents and scavenge harmful free radicals (SCUC, 2006).Vitamin C content of half-ripe flesh used for candy preparation was 14 mg/100g while the best candy (Candy 4) selected by panelists had 11.75 mg/100g of vitamin C (Table 6).

Table 7. Mineral constituents of jackfruit candy

Sample	Ca mg/100g	Mg mg/100g	K mg/100g	Na mg/100g	S mg/100g	P mg/100g
Candy 1	181d	136d	353a	136e	222c	128a
Candy 2	181d	138d	378a	154d	214d	108a
Candy 3	263a	159c	386a	181b	221c	136a
Candy 4	224c	164b	274a	175c	230b	146a
Candy 5	238b	171a	394a	187a	243a	155a
LSD	5.31	3.03	165	3.92	3.94	48.47
CV %	1.34	1.08	25.48	1.29	0.96	19.76

Within column values followed by different letter(s) are significantly different at 5% level of probability by DMRT

Ash content is a measure of the total amount of minerals present within a food, although most minerals have fairly low volatility at high temperatures of 500°C; some are volatile and may be partially lost. Ash is important in terms of nutrition because it tells how dense the minerals are in a particular food sample. Generally, low ash content indicates that the food product analyzed is not a rich source of minerals. Ash content of the half-ripe jackfruit flesh was 0.73 % while it was 0.10 % in Candy 4.Table 7 shows the mineral composition of the developed jackfruit candies.

Table 8. Rating scores of jackfruit jam

Sample	Colour	Flavor	Texture	Taste	Overall acceptability
Jam 1	5.15c	5.30c	5.55d	6.10bc	5.35c
Jam 2	5.35c	5.90bc	6.10c	5.25d	5.55c
Jam 3	6.90a	6.90a	7.25a	6.85a	7.35a
Jam 4	6.30ab	6.60a	6.65b	6.65ab	6.90ab
Jam 5	6.10b	6.50ab	6.45bc	5.95c	6.70b
LSD	0.61	0.60	0.46	0.58	0.53
CV %	16.23	15.39	11.34	15.05	13.29

Mean values in a column having the same letter (s) do not differ significantly at 5% level of DMRT

The Candy 4 contained calcium (224 mg/100g), magnesium (164 mg/100g), sodium (175 mg/100g) and potassium (274 mg/100g) with sulphur (230 mg/100g) and phosphorus (146 mg/100g). Jackfruit candies are worldwide consumed because they are recognized as a significant source of molecules with essential health benefits. The fruit is also a good source of phenolics and flavonoids, compounds that have been found to possess good antioxidant properties (Jagtap et al. 2010b). The current consumers' concern about their wellness leads them to change the purchasing behavior and looking for new beneficial health-related products.

Sensory properties of jackfruit jam and jackfruit candy: Sensory evaluation is the scientific method used to determine the perception and acceptability of the consumers to the characteristics of foods. Sensory evaluations of jackfruit jam and jackfruit candy were performed with the help of sensory panelist. All samples were presented before the panelists at room temperature under normal lighting conditions in white disposable

plastic cups and coded with three-digit numbers. Spoons were provided to the panelists and drinking water was provided for oral rinsing. The samples attributes assessed were taste, color, flavor, texture and overall acceptability. Among the five jackfruit jams, the overall acceptability of Jam 3 produced highest score(Table 8) while in case of five jackfruit candies, Candy 4 represented the highest score(Table 9).

Table 9. Rating scores of jackfruit candy

Sample	Colour	Flavor	Texture	Taste	Overall acceptability
Candy 1	5.30c	5.90c	5.55d	5.45c	6.10c
Candy 2	6.10b	6.50b	6.55c	6.15b	6.55b
Candy 3	7.10a	6.75b	6.80bc	6.55b	6.75b
Candy 4	7.35a	7.40a	7.35a	7.45a	7.55a
Candy 5	7.25a	7.30a	7.20ab	7.30a	7.50a
LSD	0.48	0.51	0.45	0.41	0.43
CV %	11.61	11.89	10.72	9.81	9.93

Mean values in a column having the same letter (s) do not differ significantly at 5% level of DMRT

COCLUSION

Possibilities and opportunities exist for small food producers to process jackfruit for local income generation and employment. In rural areas in jackfruit producing countries, food processing is a major source of employment. It is not only important to the national micro-economy but also is one of the fastest growingsectors and is particularly relevant to marginalized and vulnerablewomen. Enhanced income allows this group of women theflexibility to spend on education, nutrition, and health. The overall acceptability of the Candy 4 and Jam 3 were the best possible combinations for producing jackfruit candy and jackfruit jam in this study. Jackfruit offers exciting possibilities for adding novel products to the food processing industry and contributes towards enhancing the farm income of rural people. Further research is needed in order to understand more about jackfruit processing because it has many local types and varieties so that we can identify the types that are good for developing specific products which have health benefit potential.

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