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Jackfruit Waste to Wealth - Confectionery Chews

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Abstract

Jackfruit (*Artocarpus heterophyllus*) belongs to the Moraceae family is an organic fruit grown in many regions of the world without much care. Ripened fruit bulbs are sweet delicious to eat. Matured un-ripened fruit bulbs were used to process deep-fried snacks called chips,and the remaining 59-60 per cent gets wasted. An investigation was undertaken to add value to the peel-rind with a simple osmotic dehydration procedure. The resulted product is named jackpeel rind-chews (JPR-Chews) were accepted with a good score. The output is 1.52 to 1.75 kg chews per kg raw peel rind processed in 60-70 °Brix syrup. Physico-chemical and elemental composition of raw and ready to eat chews were found to be 89.81 per cent (15.55) moisture, 0.62 per cent (0.06) ash, 0.51 per cent (0.22) fat, 3.88 per cent (2.11) fibre, 0.68 per cent (0.32) protein and carbohydrate 4.5 per cent (81.74). Calcium (46.62 mg/l to 25.24 mg/l), Sodium (12.00 mg/l to 2.75 mg/l), Magnesium (62.84 mg/l to 21.84 mg/l), Potassium (603 mg/l to 111.88 mg/l), Zink (17.08 mg/l to 5.13 mg/l), Manganese (0.27 mg/l to 0.13 mg/l), Iron (2.37 mg/l to 1.35 mg/l), Copper (0.53 mg/l to 0.07 mg/l) and other trace elements. The preserved product in glass containers at ambient and refrigerated conditions was safe and best accepted beyond six months.

Keywords : Jackfruit peelwaste, Jack rind chews, Fruit waste to wealth, Osmotic dehydration

Jackfruit (*Artocarpus heterophyllus*) is primarily produced in Asia, India and Bangladesh, with an average of 1.25 million metric tons of fruits annually (Balamaze *et al.,* 2019). The fruits are underutilised due to a lack of awareness about their complete utility (Antony and Thottiam, 2018). The ripened fruit is perishable, produces a strong aroma with sweet bulbs delicious to eat. The raw matured fruits-bulbs utilised to prepare value-added product chips, and the rest gets wasted. About 45-60 percent of the whole fruit is inedible, consisting of outer spiny rind, inner rag, and central core (Beguma *et al.,* 2014**).** The pericarp of the fruit's rind is rich in pectin (Jain NL and Girdhari Lal, 1957), contains 1.57-2.28 percent calcium pectate (Beguma *et al.,* 2014). Jackfruit spiny peel rind goes as waste or animal feed (Feili, 2014). It can be utilised as a potential source of ingredients such as cellulose and pectin and found to be the best substrate for pectinase production (Prasad Rao, 2014). It could be used in functional, beneficial health foods (Antony and Thottiam, 2017a). The rind flours up to five per cent can be incorporated with bread flour as a potential health ingredient (Felli, 2018). The unfertilised perianths are processed to make syrups and jellies due to their pectin and cellulose (Rahman *et al.,* 2014). Jackfruits worth 2000 crores go as waste annually in Karnataka state alone (Anonymous, 2019). Fruit peels (rind) are a better source of minerals and vitamins that can be utilised in dietary supplements, thus reducing environmental solid waste (Gladvin *et al*., 2017). In recent years osmotic dehydration has received more attention for the practical preservation of fruits and vegetables (Chavan and Amarowicz, 2012). Hence, the present study was undertaken to convert Jackfruit peel waste into wealth usinga simple processing technique to convert waste into an acceptable value-added product and its physicochemical properties.

Material and Methods

Raw Material Collection and Preparation

Matured un-ripened jackfruits of local variety were procured from the Jack trees grown in the University of Agricultural Sciences, Bangalore campus. The fruits were washed for surface contamination and air-dried to remove surface moisture. The flakes and the other by-products of the fruit, such as seed, seed sac, outer spiny part and central core portions, were separated and quantified. The rind was separated from the fruit peel and diced into small cubes measuring an average of 5.79 × 3.53 mm using a kitchen dicer. The diced rind chunks were immersed in 1.0 per cent ascorbic acid solution (Javadani *et al*., 2013; Techavuthiporn and Boonyaritthonghai, 2016) for 2 min blanching in hot water maintained at 88±1°C for 1.0 min and packed in high-density polyethene bags before storing at four-degree centigrade for further use.

Preparation of Syrup and Treatment

Sucrose syrup of three different concentrations was prepared as per the method suggestedby Anitha Pedapati *et al*. (2014) with slight modification without using maltodextrin to avoid product surface stickiness. The three syrup concentrations, namely 50, 60, and 70 °Brix,were prepared by dissolving 1.0, 1.2 and 1.4 kg sucrose in 900, 700 and 500-mL potable water maintained at 88±1 °C, respectively. All the syrup solutions were added with 0.3 per cent citric acid.

The blanched rind cubes were heat-treated in the syrups (50, 60, and 70 °Brix) maintained at 98±1°C for 10 min and allowed to stand in the same leftover syrup for 12 h at room temperature. After 12 h of soaking, the samples were again heat-treated for 10 min and allowed to stand in the same leftover syrup for 12 h at room temperature. After heat treatment twice and soaking 24 h, the heat treatment was continued for 5 min and followed by soaking in the same leftover syrup for another 12 h. This procedure was continued for seven days to assess the osmotic effectiveness, product quality and sensory attributes. The syrup temperature was raised to near boiling temperature on the eight-day and the soaked rind pieces were taken out from the syrup and dried in a convective dryer at 60±2 °C for 2-3 days. The rind to syrup ratio was 1:3 (Wt./Vol.) for all the treatments.

The yield of the osmotically treated rind named jack peel rind-chews (JPR-Chews) was determined on a weight basis by a difference in initial natural rind weight and the final weight of the chews.

Physico-Chemical Properties

Physico-chemical properties of the ready to eat chews were analysed for moisture, ash, fat, fibre, protein and colour. Moisture (IS, 2012), Ash (IS,1968), Fat (AOAC, 2016), Fibre (AOAC, 2016), Protein (AOAC, 2016), Carbohydrate (IS, 2007). The above physicochemicalproperties of the samples were analysed in the Pesticide Residue and Food Quality Analysis Laboratory. University of Agricultural Sciences, Raichur, Karnataka state, India

Food colour is the basic noble gauge for successful quality evaluation (Ivana Markovic *et al*., 2013). The colour of the ready to eat jackrind-chews was determined using a Spectrophotometer (Konica Minolta CM-5). The values of L*, a*and b* were recorded. The L* value indicates light to dark colour, where a low number L (0-50) indicates dark, and a high number L (51-100) indicates light grey to white colour L (100). The value a* indicates red to green, where positive +a* indicates the red colour and negative -a* indicates green colour. The scale b* indicates yellow to blue, where positive +b* number indicates yellow and negative -b* indicates blue colour (as a* and b* values increase, *i.e.,* values move from the centre to outer periphery and the colour saturation also increases). The instrument was calibrated using the standard black cup and white plate supplied by the manufacturer. The color intensity chroma (C*) and Hue angles (h*) were calculated using the equations $C^* = (a^{*2} + b^{*2})^{1/2}$ *and* $h^* = \tan^{-1}(b^*/a^*)$ (Anonymous, 2007 and Daniel Granato and Maria Lucia Masson, 2010), respectively.

Mineral Elements Analysis

The fresh jackfruit rind and processed ready to eat jackfruit rind-chews were subjected to mineral elements analysis using inductively coupled plasma mass spectrometry (ICP-MS, Make-Perkin Elmer, USA, Model Nex ION 350 X) and with microwave sample digestion (Model-Titan MPS) as per the procedures given by AOAC (2013) in the Pesticide Residue Analysis Laboratory at UAS, Raichur, India (NABL accredited).

Texture Profile Analysis

The texture profile analysis (TPA) of jackfruit rind chewswerecarried out using a texture analyser (Stable Microsystems TA. H.D. Plus) with a cylindrical probe (20 mm) having dimensions more than the sample dimensions (Sara Ansari *et al*., 2014) and 500 kg load cell at room temperature (27±2 °C). The chews were tested with a target distance of 10 mm at the compression rate of 5 mm/s until compressed completely. The cylinder moves up in an upward stroke at 13 mm/s. The data were analysed with three replicates using inbuilt exponent software along with force-time curves.

Sensory Evaluation

The prepared jackfruit rind chews were evaluated for appearance, texture or mouthfeel, colour, flavour, taste and overall acceptability using the 9-point hedonic scale (Jabez *et al.,* 2015) by 21 semi trained judges with a number ranking (1-extremely disliked to 9-liked extremely).

Statistical Analysis

The experimental data were statistically analysed using the IBM SPSS statistic software version 23.

Results and Discussion

Yield Potential of Different Portions of the Jack Fruit on Processing

The weight and size of the individual jack fruit vary within the same tree; accordingly, each fruit showed a different waste yield which is discarded presently without any food value or utilised as animal feed. The average yield and moisture content of different portions of the jack fruit wastes such as seed-sac 2.69 per cent and 77.22 per cent, outer spiny skin 16.55 per cent and 79.60 per cent, rind 13.53 per cent and 86.92 per cent, underdeveloped ovaries called rag 18.00 per cent and 76.01 per cent, central core 6.26 per cent and 85.66 per cent. The average unrecoverable waste such as gummy latex laced with waste parts was 2.45 per cent, respectively, an average of 59.48 per cent of the fruit portion is underutilised or thrown as waste (Table 1).

Table 1

Recovery of different waste portions from Raw-Jack-fruit on processing

Raw Fruits	Whole fruit wt.g.	Flakes/ bulbs (Without seed) g.(%)	Seeds wt. g.(%)	Seed sac wt.g (%)	Outer spiny sking.(%)	Rind, wt.g. (%)	Rag wt.g. (%)	Core, wt.g.(%)	Total recovery wt.g.(%)	Unrecoverable waste t.g.(%)	Rind availability/ KgFruit processed.g.	Rind availability/ 100kg fruit processed (Kg.)
F1	8374.5	2271 (27.11)	574.5 (6.86)	252 (3.00)	1818 (21.70)	884.5 (10.56)	1758.5 (20.99)	580 (6.92)	8138.5 (97.18)	236 (2.81)	105.61	10.57
F2	9980.6	3717.5 (37.24)	800.5 (8.02)	243 (2.43)	1262.5 (12.64)	1581 (15.84)	1556.5 (15.59)	572.5 (5.73)	9733.5 (97.52)	247.1 (2.47)	158.40	15.84
F3	9307.4	3218.3 (34.57)	710.7 (7.63)	245.5 (2.63)	1425 (15.31)	1322.5 (14.21)	1621 (17.41)	570.5 (6.12)	9113.5 (97.91)	193.9 (2.08)	142.09	14.20
Average g (%)	9220.83	3068.93	695.23	246.83 (32.98)	1501.83 (7.50)	1262.667 (2.69)	1645.33 (16.55)	574.33 (13.53)	8995.16 (18.00)	225.66 (6.26)	135.37 (97.54)	13.53 (2.45)
Moisture %	-	64.06	42.22	77.22	79.60	86.92	76.01	85.66	-	-	-	-

F1, F2 & F3= number of fruits

The total thickness of the jack fruit peel (spiky skin with rind) was 8.72 mm to 9.20 mm. The recovered average rind thickness was measured to be 4.4 to 6.50 mm, which is in-between the outer spiny skin and the inner immature ovaries (rag). From the findings, eachfruit yields an average of 13.53 per cent organic rind, which is closed to 135.37g/kg or 13.53 kg rind / 100 kg fruit processed having moisture content 86.92 per cent, which was considered for value addition.

Product Yield (RJFR-Chews)

The Osmotic treatment is a blend of dehydration and impregnation processes, minimising undesirable modifications in fresh foods. The yield of ready to eat jack chews varies from 128.66 g per 100 g of rind processed in the treatment (T1), *i.e.,* with 28.66 g weight gain per 100 g raw rind processed, followed by151.83 g chews 100 g rind with 51.83 g weight uptake in the treatment (T2). Maximum weight uptake of 73.79 g with a record of 173.79 g of chews reported in the treatment T3 per 100 g of rind processed. It shows that from one kg of raw rind 1.51 kg to 1.73 kg of ready to eat rind-chews can be recovered (Table 2).

The results (Table 2) reveal that within two days of osmotic treatment, significantly maximum solute absorption had taken place, highest saturation level achieved from day two to six. Hence six days of osmotic treatment is required to archive maximum absorption with a weight gain of 73.79 g/100 g, 51.83 g/100 g and 28.66 g/100 g in 70, 60 and 50 °Brix osmotic solutions. The treatment T3 showed the highest weight gain, may be due to low molecular weight solute mixture makes easier to move into the fruit pieces results in a solid gain. Further alternate boiling and soaking in the syrup increases internal pressure, leading to quick water exclusion from the rind cubes (Azarpazhooh and Ramaswamy, 2009b; Wray and Ramaswamy, 2015a). The reduced syrup viscosity and better contact between the osmotic solution and rind cubes might have helped improve water mobility, permitting maximum solid gain. Similar results reported in the microwave osmotic dehydration of Mango cubes (Bhakti Shinde and Hosahalli Ramaswamy, 2020) the higher temperatures help moisture diffusion out of the sample into the solution. The saturation behaviour of the rind chunks in terms of change in total soluble solids (TSS) during the seven-day treatment duration indicated a significant reduction in TSS to 60, 51 and 36 °Brix in the second day from the initial TSS70, 60 and 50 °Brix, respectively. This might be due to maximum mass transfer (Hasanuzzaman *et al.,* 2014) and confirms that the rind cubes had absorbed maximum sugar within two days of treatment and attained complete saturation within six days after soaking (Fig. 1).

Proximate Composition of JPR-Chew

The effect of osmotic dehydration on the proximate composition of ready-to-eat jack fruit rind chews (RJFR-Chews) and raw untreated rind cubes was presented in Table 1. The initial moisture content of

TABLE 2

Osmotic behaviour of JPR at different sugar concentrations and soak days and yield

Initial rind weight(g)*		Change in TSS during treatment days (°Brix)							Chews yieldg/ 100gpeel rindafter 48 hr drying at 60 !	Weight gain	Yield of chewsper kg rind
		1	2	3	4	5	6	7	(g)	(g)	g (kg)
T1	100	50	36	41	44	44	49	49	128.66	28.66	1286.6 (1.28kg)
T2	100	60	51	54	58.5	60	62	62	151.83	51.83	1518.3 (1.51kg)
T3	100	70	60	62	65.5	67	70	71	173.79	73.79	1737.9 (1.73kg)

*All the observations are mean values of three replications

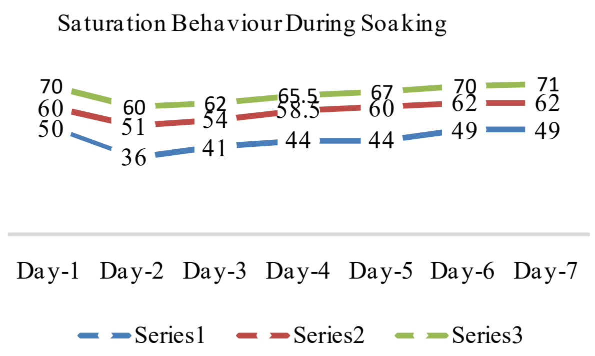

Fig. 1 : Saturation behaviour of Jack peel rind-Chews during treatment days

TABLE 3

Physicochemical constituents of Jack Peel Rind-Chews

Parameter	T0	T1	T2	T3
Moisture (%)	89.81	12.29	13.75	17.55
Carbohydrates(g/100g)	4.50	83.62	83.70	81.74
Protein (%)	0.68	0.51	0.33	0.32
Ash (%)	0.62	0.14	0.11	0.06
Fat (%)	0.51	0.52	0.24	0.22
Fibre (%)	3.88	2.92	1.87	2.11
Colour				
Mean values of L*	64.00	29.64	38.69	35.94
Mean values of a*	1.59	10.91	7.98	6.28
Mean values of b*	21.49	17.71	22.06	19.32
Chroma (C*)	21.54	20.80	23.45	20.31
Hue Angle (h-ab)	85.76	31.61	19.88	18.00

T0- Raw untreated sample, T1-50 °Brix, T2-60 °Brix, T-70 °Brix

89.81 per cent recorded in the raw fresh sample (T0) compared to the treated samples 12.29 per cent (T1), 13.59 per cent (T2) and 17.55 per cent (T3) due to significant water loss and solid uptake. Others also make similar observations (Bchir *et al.*, 2011). It could be associated with the elevated carbohydrate levels in all the treated samples T1 (83.62 g/100 g), T2 (83.70 g/ 100 g) and T3 (81.74 g/ 100 g) reported compared to the lowest carbohydrate level of 4.50 g/100 g in control (T0) which was an untreated fresh raw sample. Protein content was highest in control (0.68 percent), followed by decreasing trend in the treatments T1 (0.51 per cent), T2 (0.33)and T3 (0.32 per cent) due to increased soaking duration and boiling time. A similar decreasing trend was noticed in ash and fat percentage (Table 3). The highest fibre content of 3.88 per cent observed in control (T0) followed by a difference among the treatments, *i.e.,* T1 (2.92 %), T2 (1.87 %) and T3 (2.11%), this may be due to uneven fibre distribution in the rind portion separated from outer spiny skin.

The instrumental L* a* and b* colour values of JPR-chews (Table 3) revealed that the control (T0) sample is lighter in colour L*= 64, a*=1.59, b*=21.49) as compared to other treatments. The calculated Chroma (C*21.54) and hue-angle (85.76) falls in the creamy white band layer significantly; this may be due to natural raw rind colour compared to other treatments. The treatment-T1with readings (L*=29.64, a*=10.91, b*=17.71, C*=20.80, The hue angle=31.61) occupied light pinkish colour compared to the treatments T2 and T3. The treatment T2 (L-38.69, a*=7.98, b*=22.06, C*=23.45 and hue angle= 19.88) occupied light lemon-yellow colour followed by the treatment T3 (L*=35.98, a*= 6.28, b*=19.32, C*=20.31 and a hue angle of 18) occupying lemon yellow band. The treatments T2 and T3 both reported having more attractive colour compared to T1, which is dull light pinkish due to sucrose caramelisation during heat treatments, but overall, without external colour addition product attained its attractive colour.

Effect of Osmotic Dehydration on the Mineral Composition of JackPeel Rind-Chews

Minerals are not a source of energy but are required for the upkeep of normal biochemical processes in the body as reported by Zhao *et al.* (2016). The five essential minerals (inorganic elements) required for the human body are calcium, sodium, magnesium, potassium and phosphorus, as reported by Berdanier *et al.*,(2013) and the remaining are trace elements (Table 4).

The elemental (mineral) composition of fresh jack rind (T0-Control) and osmotically dehydrated jack rind cubes in different osmotic solutions (T1=50 °Brix, T2=60 °Brix and T3=70 °Brix) are furnished in the Table 4. Among the 23 elements estimated, 15 are

TABLE 4

Mineral composition of Jack peel rind-Chews

Element Mg/l	T0	T1	T2	T3
Silver	2.63	Nd	Nd	Nd
Aluminium	2.63	2.25	1.58	2.50
Barium	0.21	0.08	0.06	0.01
Calcium	46.62	34.04	28.13	25.24
Chromium	0.07	0.57	0.05	0.05
Copper	0.53	0.11	0.13	0.07
Iron	2.37	2.18	1.43	1.35
Gallium	0.01	Nd	Nd	Nd
Potassium	603	153.72	126.85	111.88
Magnesium	62.84	28.72	23.18	21.84
Manganese	0.27	0.19	0.14	0.13
Sodium	12.00	2.93	1.29	2.75
Lead	0.01	Nd	Nd	Nd
Strontium	0.15	0.04	Nd	Nd
Zink	17.08	9.75	7.93	5.13

detected in the fresh jack rind (T0), with significantly reduced levels during the soaking and drying process was reported (Table 2).

Calcium content in the fresh jack peel rind was 46.62 mg/l (T0), compared to reduced calcium levels in the treatments T1 (34.04 mg/l), T3 (28.13 mg/l) and T3 (25.24 mg/l). The highest Sodium content of 12.00 (mg/l) was reported in the sample (T0), followed by significantly reduced levels in T1 (2.93 mg/l), T2 (1.29 mg/l) and T3 (2.75 mg/l), respectively.

The highest magnesium content of 62.84 mg/l was reported in the fresh rind (T0) compared to T1 (28.72 mg/l), T2 (23.18 mg/l) and T3 (21.84 mg/l). The highest Potassium content of 603 mg/l was reported in the fresh rind (T0) followed by a significant reduction in the treatment procedure, *i.e.,* T1 (153.72 mg/l), T2 (126.85 mg/l) and T3 (111.88 mg/l). The reduced levels of mineral elements among the treatments are mainly due to leaching into the osmotic solution due to alternate heating and soaking procedure. These findings confirm the findings of other workers (Antony and Thottiam, 2017b) using Atomic Absorption Spectroscopy. The trace elements vital for specific biochemical functions in the body are zinc, manganese, molybdenum, iodine, selenium, sulphur, iron, chlorine, cobalt and copper (Berdanier *et al.,* 2016)

The Zink content in the fresh jack rind was 17.08 mg/l (T0) compared to 9.75 mg/l (T1), 7.93 mg/l (T2) and 5.13 mg/l (T3). The highest manganese content of 0.27 mg/lwas detected in the treatment T0 compared to T1 (0.19 mg/l), T2 (0.14 mg/l) and T3 (0.13 mg/l). The Iron content was 2.37 mg/l in fresh rind (T0) compared to T1 (2.18 mg/l), T2 (1 .43 mg/l) and T3 (1.35 Mg/l). The highest copper content of 0.53 g/l was reported in fresh rind (T0) compared T1 (0.11 mg/l), T2 (0.13 mg/l) and T3 (0.07 mg/l). Similar results were reported in the watermelon rind where iron (1.25 mg/100 g), manganese (1.42 mg/100 g), phosphorus (135.24 mg/100 g), calcium (29.15 mg/100 g), sodium (12.65 mg/100 g), copper (0.45 mg/100 g), zinc (1.29 mg/100 g), magnesium (1.48 mg/100 g) and potassium (1.37 mg/100 g) were documented (Gladvin *et al.,* 2017).

The other trace elements, such as silver, were detected only in fresh peel rind (T0, 2 .63 mg/l), with complete loss in other treatments (T1, T2 and T3). The element Barium found to be 0.21 mg/l in fresh rind (T0) compared to the treatments T1 (0.08 mg/l), T2 (0.06 mg/l) and T3 (0.01 mg/l). In the fresh rind, the element chromium was 0.57 mg/l (T0), reduced to 0.07 mg/l (T1) and 0.05 mg/l in T2 and T3 due to leaching. The element strontium was reported to be 0.15 mg/l (T0) followed by T1 (0.04) and complete loss in the treatments T2 and T3, respectively.

The Aluminium content was found to be 2.63 mg/l in the fresh untreated peel rind (T0) followed by slight variations among the treatment T1 (2.25 mg/l), T2 (1.58mg/l) and T3 (2.50 mg/l) it maybe due to non-uniform distribution within the rind. Similar variations were reported in most fruit juices (5 mg/l), herbal tea (14 and 67 mg/kg), 1 and 4 mg/kg in ready-to-consume soups; 5 and 15 mg/kg (dry soups) as reported by Stahl *et al.*(2011) respectively. The accepted aluminium levels in fruit juices are lesser than 8 mg/l in Germany (Anonymous, 2007). Naturally, available aluminium is considered safe and not harmful (Anonymous, 2018).

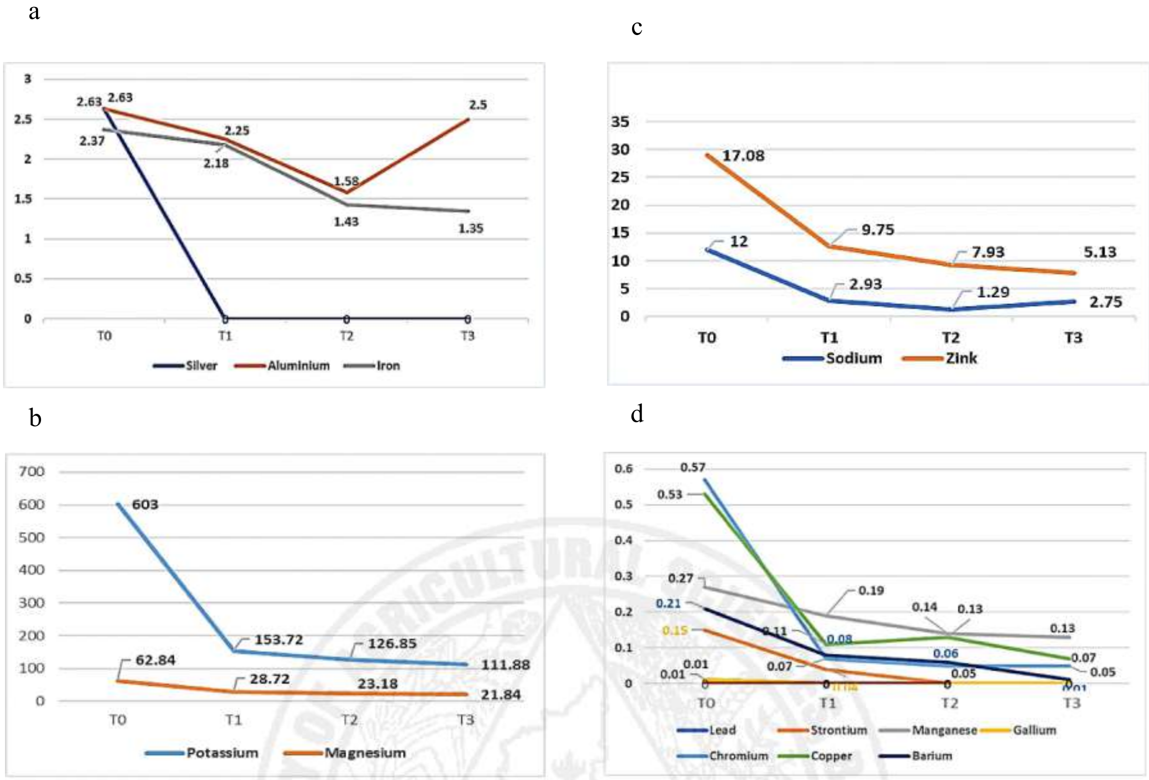

Fig.2: Elemental concentration in ready-to-eat Jack peel rind-Chews

The silver content of 2.63 mg/l detected in the fresh peel rind against complete loss among the treatments. The element lead was detected in the fresh peel rind T0 (0.01 mg/l) in traces and complete loss during the treatment.

Texture Profile Analysis (TPA) of JPR-Chews

The average texture profile analysis results are presented the Table 3. The TPA plot of JPR- Chews consists of two force peaks during the two repeated compressions. A negative area is seen in the TPA plot (Fig. 3) upon upward movement of the probe after the first compression indicates sample adhesiveness. It depends on the degree of stickiness of the JPR-Chew sample to the probe (Sara Ansari *et al.,* 2014).

Cohesiveness describes how well a food retains its form between the first and second biting cum mastication in the mouth, the rate at which the material deforms under mechanical force is related to the strength of internal food structure and difficulty in breaking down the internal bonds is measured as cohesiveness (Hamedi *et al.,* 2018), it depends on the strength of internal bonds in the food sample. All three samples exhibited equal and low cohesiveness values (0.135, 0.151 and 0.122) and continue to decrease even with higher hardness levels, maybe due to surface dryness and soft-gummy fibres. Food is easy to chew,

TABLE 5

Texture profile of JPR-Chews for different treatments

Parameters	T1	T2	T3
Hardness(g)	6309.59	9627.49	7050.54
Fracturability(g)	7949.00	10482.31	6327.04
Adhesiveness	-154.71	-147.62	-125.93
Springiness	0.386	0.378	0.394
Cohesiveness	0.135	0.151	0.112
Gumminess(g)	846.85	1424.42	821.01
Chewiness (g/mm)	319.84	519.76	284.50
Resilience	0.037	0.048	0.035

The above observations are the average of three readings.

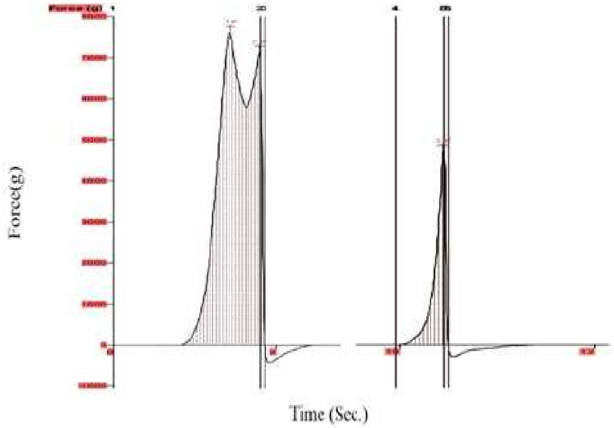

Fig. 3 : Force-time curves for a two-bite test on Jack peel rind-Chews

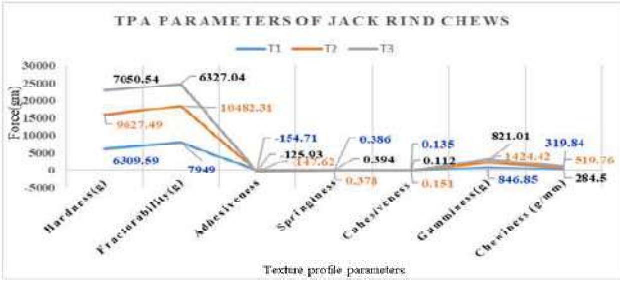

Fig. 4 : Texture profile behaviour of osmotically dehydrated Jack peel rind-Chews

bite and swallow at low cohesiveness value and is the vital parameter for acceptance by all age groups (Kawano *et al.,* 2017); similar observations were reported in the jelly dessert with an increased level of gelatine **(**Garrido *et al.,* 2014**)** and jelly candies with cohesiveness values 0.54 and 0.82 (Mutlu *et al.,* 2018).

Hardness is recognised as firmness, a significant sensory parameter (Nurlina Yusof *et al.,* 2019) used to evaluate the mouthfeel and demarcated as the force required to attain a given deformation (Garrido *et al.,* 2014; Kek *et al.*, 2013). The hardness of the 50, 60 and 70 °Brix osmotically dehydrated jack rind chews were 6309.59 g, 9627.49 g and 7050.54 g, respectively. The variations in hardness may be due to varied sugar impregnation, fibre distribution within the rind-chews and moisture content of the sample (Fig. 4).

Fracturability (g) tends to fracture, crumble, crack, shatter or fail upon applying force or impact is noticed when dry product is bitten or subjected to stress.The testvalues significantly differed among the treatments. The maximum force absorbed for fracturability is 10482.31g in the treatment T2, followed by T3 (7050.54 g) and the minimum force of 6309.59 g noticed in the treatment T2. It maybe due to surface hardness, variations in the cube size, moisture content, accumulated sugar in the voids, fibre distribution and its strength in the cubes results in varied hardness 6309 g (T1), 7050g (T3) and 9627g (T2) and brittleness values.

Adhesive or stickiness indicates the work required to overcome the adhesive forces between the surface of the food and the material with which the food comes into contact (teeth) (Mutlu *et al.*, 2018). All three samples showed negative results (-154.712, -147.625 and -125.934); this indicates adhesiveness (Sara Ansari *et al.,* 2014) and the work required to separate the cylinder probe from the test sample after the first compression. The higher adhesiveness value suggests a soft, sticky texture inside and the product could be used in specific dessert preparations (Mutlu *et al.,* 2018).

The springiness of the food is inversely related to hardness (firmness increases, elasticity decreases); and is connected with elasticity (Kreungngern and Chaikham, 2016; Chandra and Shamasundar, 2015) shows how well a product physically springs back after compression with teeth. The chews showed shallow springiness values (0.386, 0.378 and 0.394) in all the treatments, Higher springiness (close to one) seems the sample is elastic compared to low springiness (near zero), it returns to its original shape after compression, resulting in tissue damage after compression. Similar results reported in dry figs (Sara Ansari *et al.*, 2014). The lesser springy sample will not stick to the teeth; higher springiness requires more energy for mastication in the mouth (Rahman and Mahrouqi, 2009); hence the prepared peel rind chews can be used in bakery and confectionery products due to their low springiness.

The higher gumminess (hardness x cohesiveness) values (846.85 g, 1424.42 g and 821.01g) were reported against their respective increased hardness values 6309.59 g, 9627.49 g and 7050.54 g. This might be due to maximum syrup impregnation in the rind cubes during soaking and heating process. A similar trend of increased product gumminess was reportedin honey-based jelly candy (Mutlu *et al.,* 2018) atincreased hardness.

Chewiness signifies the energy required to masticate the food to a state ready for swallowing (Calvarro *et al.,* 2016). Parallel to gumminess values, chewiness values also increased from 319.84, 519.76 and 284.50 in all three treatments as the degree of hardness increases (Mutlu *et al.,* 2018).

Resilience is similar to elasticity or springiness; it measures how well a product fights back to regain its original shape during the biting process. All the samples showed poor resilience values of 0.037, 0.048 and 0.035; this might be due to maximum solid gain in the rind tissue-fibre structure and weakening of fibrous strength during the frequent rise in syrup temperature before drying. Hence much energy is not required for mastication in the mouth, besides the lower fracturability and adhesiveness values T3 (6327.04g, -125.93) compared to slight variations in the fracturability values in the treatmentsT2 (10482.31g, -147.62) and T1 (7949.00 g, -154.71).

Storage Studies

The prepared jack peel rind-chews were packed in air-tight glass containers and stored in ambient conditions, and found to be best accepted even after seven months of storage. Similar results were reported in osmotically dehydrated sliced jack fruit bulbs in 54° and 50° Brix solution when stored for eight months at room temperature and recommended for commercial Production (Md. Mizanur Rahman *et al.,* 2012). Total sugars and microbial load measured in the fresh and seventh month stored jack peel rind-chews (Table 6).

An increasing trend of total sugars in the stored rind chews was noticed in all the treatments even after seven months of storage. The total sugars in the fresh chews were 79.55 g/100 g, 80.26 g/100 g and 81.07 g/ 100, which increased to 86.13 g/100 g, 83.10 g/100 g and 84.60 g/100 g in 50, 60 and 50 °Brix sucrose treatments. A similar increasing trend in total sugars during storage was reported in mixed fruit toffee after six months of storage due to moisture loss and solid concentration during storage (Ntuli Victor *et al*., 2017).

The microbial load of fresh and stored chews was within the acceptable levels; fresh chews showed a total microbial count of $2.27x10^2$, $3.0x10^2$, $1.81x10^2$ cfu/g in 50, 60 and 70 ° Brix sucrose treated samples compared to seven month stored chews $1.68x10^2$, $2.09x10^2$ and $3.81x10^2$ cfu/g respectively, the above results are in line with the findings. Due to higher concentration of sugar in the syrup coupled with low moisture content ranging from 12.29 (T1), 13.75 (T2) and 17.55 (T3) might have prevented microbial growth. Similar findings reported in the osmotically dehydrated jack fruit bulb slices stored for eight months found to be safe and scored highest overall acceptability (Md. Mizanur Rahman *et al.*, 2012). The variations in microbial load of initial and seven moth stored chews may be due to variation in storage temperatures (Victor *et al.,* 2017) and frequent handling for sensory evaluation. A similar study with nil microbial growth reported in fresh and six-month stored kinnow peel candy treated with 40 per cent, 50 per cent and 60 per cent sucrose under ambient and refrigerated conditions (Kohinkar *et al.,* 2012). The product stored under refrigerated conditions did not show any microbial load even after seven months of storage.

TABLE 6

Total sugar andmicrobial load in the fresh and preserved Jack peel rind (JPR)-Chews

Parameters	Fresh Chews			Seven months stored chews		
	50 °Brix	60 °Brix	70 °Brix	50 °Brix	60 °Brix	70 °Brix
Total sugars(g/100g)	79.55	80.26	81.07	86.13	83.10	84.60
Total microbial load (cfu/g)	$2.27x10^2$	$3.0x10^2$	$1.81x10^2$	$1.68x10^2$	$2.09x10^2$	$3.81x10^2$

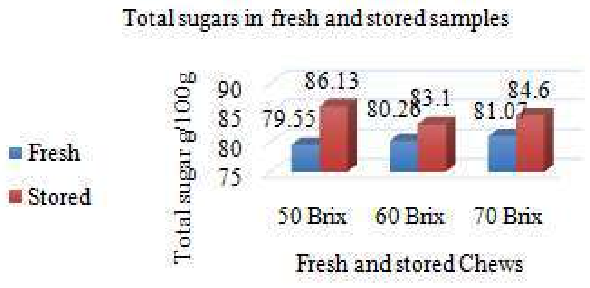

Fig. 5 : Total sugars in fresh and stored JPR-Chews

Sensory Evaluation of Fresh JPR-Chews

The results of the acceptability of jack peel rind chews (Table 7) revealed significant variation in the overall acceptability among the treatments. The treatment T2 was liked extremely with a mean score of 8.77 in overall acceptability due to its taste, texture and natural colour, followed by the treatment T3 (7.60) and T1 (7.21) liked moderately. The highest acceptability in the treatment T2 may be due to soaking the prepared rind pieces in 60 °Brix solution before drying at 65°C leading to enhanced mass transfer (Hasanuzzaman *et al.,* 2014) and best accepted this is in confirmation with the results of pineapple candies (Sultana *et al*., 2015) and osmotically dehydrated pumpkin slices (Lee and Lim, 2011). Soaking duration and frequent mixing, longer heating time showed significant water loss and solid gain reported in papaya (Sultana Anjuman Arakhanom *et al.,* 2015**)**.

The syrup temperature and concentration were the most distinct factors affecting weight gain and water loss, followed by immersion time. A similar trend was reported (Jesulin Aronika and Manimehalai 2014**)** in the osmotic dehydration of pumpkin slicesbefore hot-air drying with sucrose concentration of 30-60 °Brix with an immersion temperature of 35 - 65 °C.

Jackfruit peel is rich in phytochemicals and hasample health benefits. Presently, 60 per cent of the whole fruit, such as peel rind with rag, goes to waste without any food value. This waste could be used to produce ready-to-eat or ready-to-use products. The inductively coupled mass spectroscopy of the jack rind value-added product showed significant mineral elements. The present investigation demonstrated a simple technique to convert waste into wealth. The product showed better acceptability and storage stability of more than six months under ambient and refrigerated conditions and found safe for consumption. This could be an alternative organic raw material to replace papaya based Tutti-fruity in preparing several usual food preparations, especially the bakery and confectionery industry. This may be a boon for women self-help groups and processors to convert fibre-rich organic peel waste into an income-generating activity in the production catchment. Hence the findings conclude that Jack peel rind is a potential source of functional food.

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TABLE 7

Mean sensory scores of Jack peel rind-Chews

Variation	Appearance	Texture	Colour	Flavor	Taste	OA
T1	7.88 ± 0.63	7.66 ± 0.55	7.95 ±0.66	7.47 ± 0.60	7.33 ± 0.91	7.21 ± 0.66
T2	8.21 ± 0.64	8.14 ± 0.77	7.95 ±0.66	8.23 ± 0.70	8.28 ± 0.71	8.77 ± 0.40
T3	8.21 ± 0.64	7.54 ± 0.49	8.23 ±0.62	7.90 ± 0.62	7.76 ± 0.51	7.60 ± 0.59
Mean±SD	8.10 ± 0.64	7.78 ± 0.66	8.04 ±0.65	7.87 ± 0.70	7.79 ± 0.82	7.86 ± 0.86
F value	*	NS	*	NS	NS	NS
SE(m)	0.14	0.13	0.14	0.14	0.16	0.12
CD	1.04	-	1.05	-	-	-

Note: T1-50°Brix, T2- 60°Brix and T3-70°Brix, OA-Overall acceptability, NS-Non significant, *Significant

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