

Original Research Article

Different Heat Processing methods on Flour yield, Nutritional composition and Acceptability of Jack Seed flour-based Low-fat functional Breadsticks

ABSTRACT

Jackfruit (*Artocarpus heterophyllus* Lam.) is a popular tropical large fruit of the Moraceae family. The ripe bulbs are sweet delicious to eat besides a variety of preparations. The seeds are discarded as waste. The study was conducted with different heat processing methods like blanching (BL), roasting (RO) and pressure-cooking (PC) to know the flour yield on dry-milling, nutritional composition and its acceptable level. On milling maximum flour recovery of 93.30% (PC), 98.76% (RO) and 96% (BL) were observed. Among the minerals estimated (ICPMS) the potassium content of 9245.90 mg/kg, 7382.24mg/kg, 8232.31mg/kg in BL, RO and PC seed flours were reported. Magnesium content of 942.84 mg/kg, 775.32 mg/kg and 886.14mg/kg observed in BL, RO and PC flours, the highest sodium content of 243.69 mg/kg in PC, followed by 193.23 mg/kg and 46.44 mg/kg in RO and BL samples. Calcium content of 82.01 mg/kg, 60.48 mg/kg, 83.33 mg/kg was observed in BL, RO, PC flour samples were noticed. Iron (43.36 mg/100g BL, 20.10 mg/kg RO, 16.20 mg/kg PC), Aluminium (31.36 mg/kg BL, 16.69 mg/kg RO, 5.50 PC). Zinc (12.46 mg/kg BL, 10.18 mg/kg RO, 16.48 mg/kg PC), Manganese (4.80 mg/kg BL, 2.61 mg/kg RO, 3.81 mg/kg PC), Boron(6.25 mg/kg BL, 2.29 mg/kg RO, 3.46 mg/kg PC), Barium(2.37 mg/kg BL, 1.12 mg/kg RO, 1.88 mg/kg PC), Copper(4.86 mg/kg BL, 2.78mg/kg RO, 3.52mg/kg PC) etc., other elements in traces. The findings suggest that a maximum of 50% PC Jack seed flour was found accepted in the production of functional breadsticks having protein 9.78g/100g, carbohydrates 75.55g/100g and energy 405 K.cal/100g or as a functional food ingredient in different food products.

Keywords: **Jackfruit seed flour, Functional breadsticks, Functional ingredients, Jack seed processing.**

Introduction

Jackfruit (*Artocarpus heterophyllus* Lam.) is a tropical fruit extensively grown in India others neighbouring countries. The ripe fruit bulbs flakes consumed in fresh or processed into several products like juice, natural ice creams and halva and freeze-dried fruit flakes and the matured raw bulbs are utilised in the production of a snack food called chips. The seed is rich in carbohydrates and protein. Seed yield is about 10-15% of total fruit weight and a good source of carbohydrate, protein, dietary fibre, vitamins, minerals and phytonutrients (Abraham and Jayamuthunagai, 2014). Jack fruit seeds are discarded as waste, sometimes boiled or roasted and eaten (Rani *et al.*, 2019). Lectins are known as jacalin, used as a tool to gauge the immune system of an HIV infected person. It has antifungal properties. Jack seeds contain a high amount of resistant undigestible starch, escape digestion in the small intestine, passes into the colon and is reported to act like dietary fibre. This resistant starch is heat stable in most normal cooking operations and permits its use as an ingredient in a wide variety of conventional foods (Hettiaratchi *et al.*, 2011). Seed flour has much potential in the food industry. Seeds are rich in fibre, and carbohydrates could be used as a thickener and foods binding agent (Ocloo *et al.*, 2010). It has a physically protected form of resistant starch that could be incorporated in various baked goods as texture modifiers, imparting a favourable tenderness to the crumb (Sajilata *et al.*, 2006). Jackfruit seed helps maintain bone health, is rich in magnesium, an essential nutrient necessary to absorb calcium and works along with calcium to strengthen the bones and protect the body from various bone-related disorders like Osteoporosis (Anonymous, 2016). Jack seed in the diet makes a genius way of nutritious food (Jessica, 2015), could be used as an alternative source of protein to tackle malnutrition (Chowdhury *et al.*, 2012), due to their rich source of several high-value compounds they serve as vital food for good health (Sreeletha *et al.* 2017). The heat-treated (60-80°C water for 30 to 60 mins) jackfruit seed

flour showed enhanced amino acid levels, besides the highest protein (24.94%) and vitamin-C content (78.78mg/100g) in germinated jack seed flour (Zuwariah *et al.*, 2018). Despite having lots of medicinal, nutritional and physiological benefits, the jackfruit seeds are underutilised. Jack fruit seeds are seasonal and with shorter shelf life and are wasted during the season (Soma and Santa, 2015). Seeds are also a rich source of starch (22%) and dietary fibre (3.9%), lignans, isoflavones, saponins, and phytonutrients with anti-cancer, anti-hypertensive, antioxidant, anti-ulcer and anti-ageing properties. High potassium levels in the seed help lower blood pressure (Ethnichealth, 2013). By keeping the above benefits in view, the present investigation was undertaken to know the local jack seeds nutritional status and find simple ways to utilise the valuable seed as a functional food ingredient using affordable heat processing methods.

Materials and Methods

Jackfruit seeds were procured from the fully ripened fruits of local varieties in and around Gandhi Krishi Vijayan Kendra, University of Agricultural Sciences Bangalore. The fruits were cut into two halves longitudinally, the central core was cut removed using stainless steel knife, and the seeds were separated from the bulbs and seed sacks and graded for damaged, spoiled, sprouted-green colour seeds manually. The good seeds were soaked in cold water for 20-25min, washed 3-4 times in running tap water, and air-dried packed in three HDPE bags and preserved in the refrigerator at 4°C for further study.

Seed treatment method details

The following treatments were given to the cleaned Jack fruit seeds

Method	Treatment
M1	Blanching (Blanched jack seed flour ie., BLJSF or BL)
M2	Roasting (Roasted jack seed flour i.e., ROJSF or RO)
M3	Pressure cooking (Pressure cooked jack seed flour., PCJSF or PC)

After the treatments, the treated seeds were oven-dried and milled, as explained in detail.

Blanching process

The washed seeds were blanched in boiling water for 5 minutes and oven drying at 60°C for 24 hours (Ocloo *et al.*, 2010) for <10 % moisture content. After oven drying, the seeds were cooled to room temperature. The loosened primary seed coat (white arils) and part of the thin secondary seed coat, i.e., thin brown spermoderm covering the cotyledons (Rani *et al.*, 2019), were separated by hand rubbing preserved airtight 200 gauge HDPE bags for further studies.

Roasting process

The fresh washed and air-dried ripened jack fruit seeds without seed sack were halved into two pieces using stainless steel knives. About 250 gm halved seeds per batch were open-plan roasted batch-wise in an aluminium pan for about 16-17 min on a medium flame (Eke- Ejiofor *et al.*, 2014). The roasted seeds were oven-dried at 60°C for 15-16 hours and cooled and dried; the loosened primary seed coat and part of the secondary seed coat were separated by hand rubbing and preserved for further studies.

Pressure cooking process

Washed whole jack seeds were pressure cooked with 300 ml water for 10-12 minutes in a 10-litre capacity stainless steel pressure cooker on a medium flame for two pressure releases ($1\text{kg}/\text{cm}^2$). The cooked seeds were separated from the water and tray dried at 60°C (Vinod *et al.*, 2015) for 15-16 hours ($<10\%$ moisture content), followed by removal of loosened primary seed coat and part of the thin secondary seed coat as explained above. Cleaned seeds are preserved airtight in 200 gauge HDPE bags for further studies.

Production of heat-processed Jackfruit seed flours

The above three heat-treated seed samples weighing one kilogram for each treatment wise was hammer milled separately, milling duration in minutes, per cent flour recovery, and flour loss was computed. The milled flours were sieved separately using 0.1mm or 100 sieve mesh (Vinod *et al.*, 2015; Meethal *et al.*, 2017), and the sieved flours were preserved in airtight sealed 200 gauge HDPE polythene bags and preserved in stainless steel food storage containers in the refrigerator at 4°C (Ocloo *et al.*, 2010) for further studies.

Proximate composition of Jackfruit seed flours

Moisture, ash, crude protein and fats were determined by AOAC (1984) methods. The crude fibre was estimated by treating the jack seed flour sample with dilute sulphuric acid (0.255 N) and dilute alkali (0.313 N) as per the methods of Mayanard (1970). The carbohydrate content was calculated by the difference method (by deducting the values of moisture, crude protein, crude fat and fibre in 100 (Raghuramulu *et al.*, 1983).

Mineral or Elemental Analysis

The study of the elemental or mineral composition in foods is of significant scientific interest. Since some of these elements are toxic at low concentrations (e.g., Cd and Pb), some are nutritionally essential and required for everyday functions. Hence different heat-treated Jack seed flours were subjected to 23 mineral or elemental analyses using Inductively Coupled Plasma Mass Spectrometry (ICP-MS) Make- PerkinElmer, USA. (Model NexION 350 X) and with microwave sample digestion (Model-Titan M.P.S.) with standard protocols (AOAC 2013.)

Colour Measurement

Food colour is the noble gauge for successful quality evaluation (Markovic *et al.*). The colour of the Different heat-treated and milled Jack seed flours was measured using Konica Minolta Spectrophotometer CM-5. The instrument was calibrated using the standard black cup and white plate supplied by the manufacturer. The values of *L, a*, b* were recorded, the *L scale indicates light to dark colour, low number *L(0-50) indicates dark, and a high number L (51-100) indicates light grey to white colour *L(100). The scale a* indicates red to green, where positive +a* indicates red and negative -a* indicates green. The scale b* indicates yellow to blue, positive +b* number indicates yellow and negative -b* indicates the blue colour

Sensory Evaluation

Sensory evaluation of the different heat-treated jack seed flour incorporated breadsticks were assessed by serving for 21 semi-trained judges for appearance, mouthfeel/texture, colour, flavour, taste, and overall acceptability using a nine-point hedonic scale 1=dislike extremely to 9=like extremely. The judges were provided with glasses of water to rinse their mouths in between the sample.

Statistical analysis

The data obtained from different sensory attributes were pooled and subjected to analysis of variance (ANOVA) using the IBM statistical package (IBM-SPSS) version 23. Means are computed using Duncan's Multiple Range Tests (Duncan, 1955) at a 95% confidence level ($p \leq 0.05$).

Ingredients and Product formulation

The heat processed, dried, milled, and sieved jack seed flours such as Blanched Jack Fruit Seed Raw Flour (BLJSF), Roasted Jack Fruit Seed Flour (ROJSF) and pressure-cooked jack seed flours (PCJSF) were used at different levels (10 to 100%) to standardise the low-fat Breadsticks by incorporating different levels of prepared jack seed flours to all-purpose flours (bread flour). All-purpose flour, bakery fat, powdered salt and sugar was procured from the local supermarket.

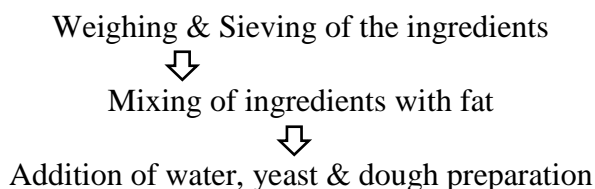
The following levels of all-purpose flour and heat-treated jack seed flours were tried separately in ten different combinations to prepare low-fat Breadsticks (Table 1).

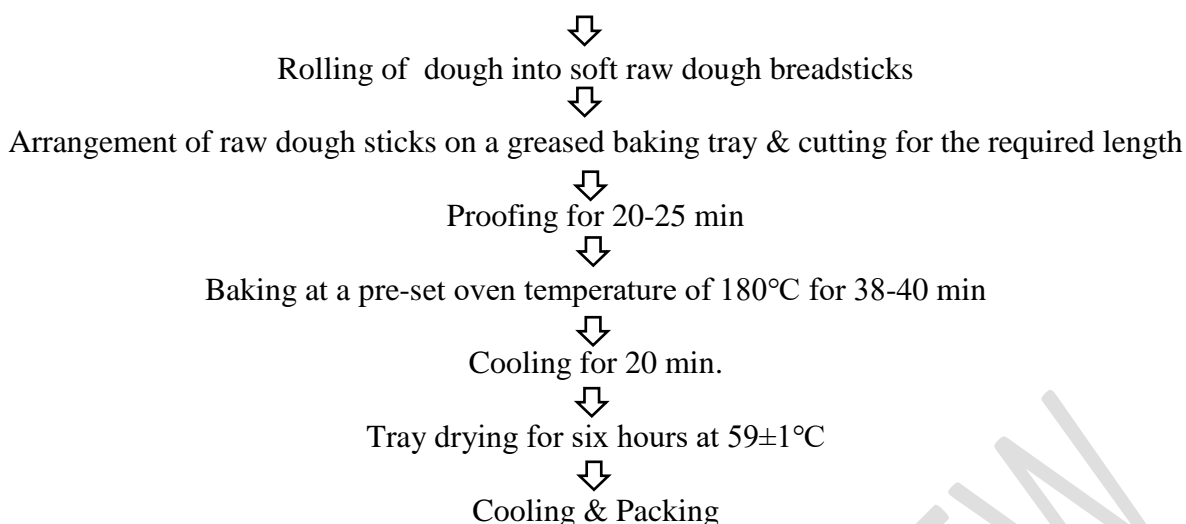
The treatments formulations were, All-purpose flour : Blanched jackfruit seed flours (APF : BLJSF) ie., 90g:10g(T1), 80:20g(T2), 70:30g(T3), 60:40g(T4), 50:50g(T5), 40:60g(T6), 30:70g(T7), 20:80g(T8) , 10:90g(T9), 0:100g(T10). The control(C) had 100 per cent all-purpose flour. For all the treatment formulations, 10% fat, 10% skim milk powder (SMP), 2% salt, 2% ajwain seeds and 2% powdered yeast dissolved in little lukewarm water was used to prepare the dough. The dough was rolled to a thickness of 10-12 mm, arranged on a greased baking tray, and cut into 10 ± 1 cm length using a rolling knife followed by proofing for about 20-25 min at room temperature. The prepared-raw soft breadsticks were baked in a preheated table-top kitchen baking oven at 180°C for 38 ± 1 min, and oven-drying for 5 ± 1 hours at 60°C . The procedure was repeated for all the heat-processed seed flours. The cooled breadsticks were packed in HDPE bags airtight and preserved for further studies.

Table 1. Different heat-processed jack seed flour blended Breadstick formulation.

Ingredients (%)	C	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
All-purpose flour (APF)	100	90	80	70	60	50	40	30	20	10	0
Fat	10	10	10	10	10	10	10	10	10	10	10
Yeast	2	2	2	2	2	2	2	2	2	2	2
Salt	2	2	2	2	2	2	2	2	2	2	2
SMP	10	10	10	10	10	10	10	10	10	10	10
Ajwan seeds	2	2	2	2	2	2	2	2	2	2	2
M1-BLJSF	0	10	20	30	40	50	60	70	80	90	100
M2-ROJSF	0	10	20	30	40	50	60	70	80	90	100
M3-PCJCF	0	10	20	30	40	50	60	70	80	90	100

Chart 1 : BLJF-Blanched, ROJSF-Roasted and PCJSF Pressure-Cooked Jack Fruit Seed Flour, C-Control.





Results and Discussion

The milling duration, flour recovery, milling loss, flour colour, nutritional and proximate or nutrient composition of heat-treated jackfruit seed flours, best-accepted product, and acceptability studies were discussed and summarised below.

It was evident from the results (Table 1) that the highest flour recovery of 98.76% (987.65mg/1000g) was noticed in the treatment of roasted seeds (M2) with a flour loss of 1.23%, followed by blanched seed flour recovery (M1) 96% (960mg/1000 g) with 4% flour loss on milling. The lowest flour recovery of 93.30% (933.00mg/1000g) was recorded in the treatment (M3) pressure-cooked with 6.70% flour loss (Table 2).

Table 2 Jackfruit seed flour recovery and colour on different heat processing and milling

Treatments	Initial Seed wt. (g)	Milling time (Min.)	Flour Recovery (g)	Flour recovery (%)	Flour loss (%)	Flour colour			
						L*	a*	b*	Comparative colour
M1	1000	3.02	960.00	96.00	4.00	79.50	5.97	33.14	Light biscuit
M2	1000	1.33	987.65	98.76	1.23	84.33	2.25	15.09	Light ivory
M3	1000	1.00	933.00	93.30	6.70	82.81	2.94	16.95	Light ivory

M1: Blanched (BL), M2: Roasted (RO), M3: Pressure cooked (PC.)

The highest flour loss in (6.7%) in the treatment M3 (PC) might be due to substantial leaching loss in the pressure cooking process took lesser milling duration (1.00 min) in M3 due to the soft brittle nature of the treatment compared to 1.23 per cent flour loss in the treatment M2 (1.23%) roasted seeds, which took a slightly higher milling duration of 1.33 minutes might be due to insufficient feed in the mill chamber and temporary sticking of the broken feed to the inner-corrugated periphery-wall of the mill chamber due to centrifugal force and hence higher flour recovery (98.76%). Blanched and dried seeds reported higher flour loss (4%) during milling with violent milling noise due to the rugged or rocky nature of treatment took 3.02 min milling time besides higher flour loss in the form of fine dust yielding 96% flour. The result confirms the

findings of other workers where lye-peeled dried seeds reported to be 75% flour recovery on milling (Islam et al., 2015).



Fig.1 Different heat-treated seed flours

Flour colour

With respect to flour colour, blanched seed flour reported slightly lesser *L value (79.50) with lower a*(5.97) and b*(33.14) might be due to insufficient blanching time caused enzymatic browning on drying and strong odour on milling (biscuit or light straw colour) as compared to increased *L (lightness) and decreased a*, b* values contributed light (ivory) colour in roasted seed flour (*L=84.33, a*=2.25, b*=15.09) and pressure cooked seed flour(*L=82.81, a*=2.94, b*=16.95) seed flours (Table 2).

Proximate or Nutrient composition of heat-treated jackfruit seed flours

The proximate composition of three different heat-treated, jack seed flours are furnished in the table-2 and fig-2 below

Table 3 Proximate composition of different Heat-processed Jackfruit Seed Flours

Sl. No.	Parameter	Seed flours		
		BLJSF(BL)	ROJSF(RO)	PCJSF(PC)
1	Moisture (%)	7.58	6.70	8.92
2	Ash (%)	3.13	2.78	3.01
3	Fat (%)	1.13	0.98	0.62
4	Fibre (%)	3.46	3.08	3.33
5	Protein (%)	12.79	11.28	11.46
6	Carbohydrate (%)	71.91	72.78	75.06

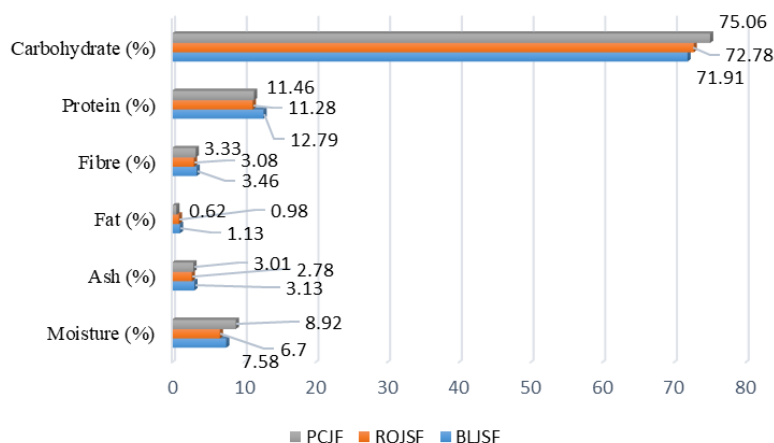


Fig. 2 Proximate composition of Different heat-treated Jack Seed Flours

The moisture content of jack seed flour varied from 7.58% (BLJSF), 6.70% (ROJSF) and 8.92% (PCJSF). The ash content ranged from 2.78% in ROJSF to 3.13 % in BL-seed flour in between 3.01% in PCJSF. Many workers reported similar results (Ocloo *et al.*,2010; Samata Airani, 2007). The variation in ash content might be due to the variety and locality. The fat content significantly reduced from 1.13% (BLJSF) to 0.98% (ROJSF) and 0.62%(PCJSF) might be due to losses during processing. The higher crude fibre content of 3.46%(BL) was observed due to 5 minutes blanching against lower fibre content of 3.08% (RO) due to degradation by higher conductive dry-heat transfer for16-17min open-pan roasting and 3.33% (PCJSF) in pressure cooking. Crude protein content decreased from 12.79% (BL) to 11.46% (PCJSF), and 11.28%(ROJSF) may be due to the leaching of nutrients during heating and pressure cooking; similar findings were reported in 60 minutes boiling of jack seeds (Akinmutini, 2006). The carbohydrate content was reported to be low in BL seed flour (71.91%); a similar result was documented in lye peeled jack seed flour (Islam *et al.*, 2015; Samata Irani, 2007) compared to ROJSF (72.78) and PCJSF (75.06%) seed flours (Table 3)

Mineral composition of different heat-treated jack seed flours

Results of the mineral or elemental composition of different heat-processed jackfruit seed flours (table 3.) revealed that the highest potassium content of 9245.90 mg/kg, 7382.24mg/kg, 8232.31mg/kg documented in blanched (BLJSF), roasted (ROJSF) and pressure cooked (PCJSF) seed flours. Highest magnesium content of 942.84 mg/kg, 775.32 mg/kg and 886.14mg/kg observed in blanched (BLJSF), roasted (ROJSF) and pressure cooked (PCJSF) samples. The highest sodium content of 243.69 mg/kg reported in pressure cooked against 193.23 mg/kg and 46.44 mg/kg in roasted and blanched seed flour samples. Calcium content of 82.01 mg/kg, 60.48 mg/kg, 83.33 mg/kg was observed in BLJSF, ROJSF and in PCJSF flour samples. Other elements reported were Iron (43.36 mg/100g in BLJSF, 20.10 mg/kg in ROJSF, 16.20 mg/kg in PCJSF), Aluminium (31.36 mg/kg in BLJSF, 16.69 mg/kg in ROJSF, 5.50 in PCJSF). Zinc (12.46 mg/kg in BLJSF, 10.18 mg/kg in ROJSF, 16.48 mg/kg PCJSF), Manganese (4.80 mg/kg BLJSF, 2.61 mg/kg ROJSF, 3.81 mg/kg PCJSF), Boron (6.25 mg/kg in BLJSF, 2.29 mg/kg in ROJSF, 3.46 mg/kg in PCJSF), Barium (2.37 mg/kg in BLJSF, 1.12 mg/kg in ROJSF, 1.88 mg/kg in PCJSF), Chromium (0.84 mg/kg in BLJSF, 0.51 mg/kg in ROJSF, and 0.42 mg/kg in PCJSF samples), Nickle (0.81 mg/kg in BLJSF, 0.42 mg/kg in ROJSF, 0.82 mg/kg in PCJSF seed flours). Copper (4.86 mg/kg in BLJSF, 2.78mg/kg in ROJSF and 3.52mg/kg in PCJSF samples). The other trace elements observed significantly in lowered level were Strontium (1.08 mg/kg, 0.71 mg/kg, 1.38 mg/kg), Lead (0.28 mg/kg ,0.13 mg/kg, 0.11 mg/kg) Gallium (0.32 mg/kg, 0.15 mg/kg, 0.24 mg/kg) and Cobalt (0.18 mg/kg, 0.02 mg/kg ,0.06 mg/kg). This might be due to heat and leaching loss during roasting, water blanching and in pressure-cooking process (Table 4). Different workers reported the above facts (Swamy *et al.* 2012) hence the seeds could be consumed as a right source of naturally available nutrients and a potential source for value addition and nutraceutical developments (Sreeletha *et al.*, 2017).

Table 4 Mineral composition (mg/kg) of different Heat-Treated Jack Seed Flours

Elements	BLJSF	ROJSF	PCJSF	Elements	BLJSF	ROJSF	PCJSF
Aluminium	31.36	16.69	5.50	Potassium	9245.90	7382.24	8232.31
Boron	6.25	2.29	3.46	Magnesium	942.84	775.32	886.14
Barium	2.37	1.12	1.88	Manganese	4.80	2.61	3.81
Calcium	82.01	60.48	83.33	Sodium	46.44	193.23	243.69
Cobalt	0.18	0.02	0.06	Nickle	0.81	0.42	0.82
Chromium	0.84	0.51	0.42	Lead	0.28	0.13	0.11
Copper	4.86	2.78	3.52	Strontium	1.08	0.71	1.38
Iron	43.36	20.10	16.20	Zink	12.46	10.18	16.48

Gallium	0.32	0.15	0.24				
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AOAC 2013.06, 20th Edition 2016, ICM-MS

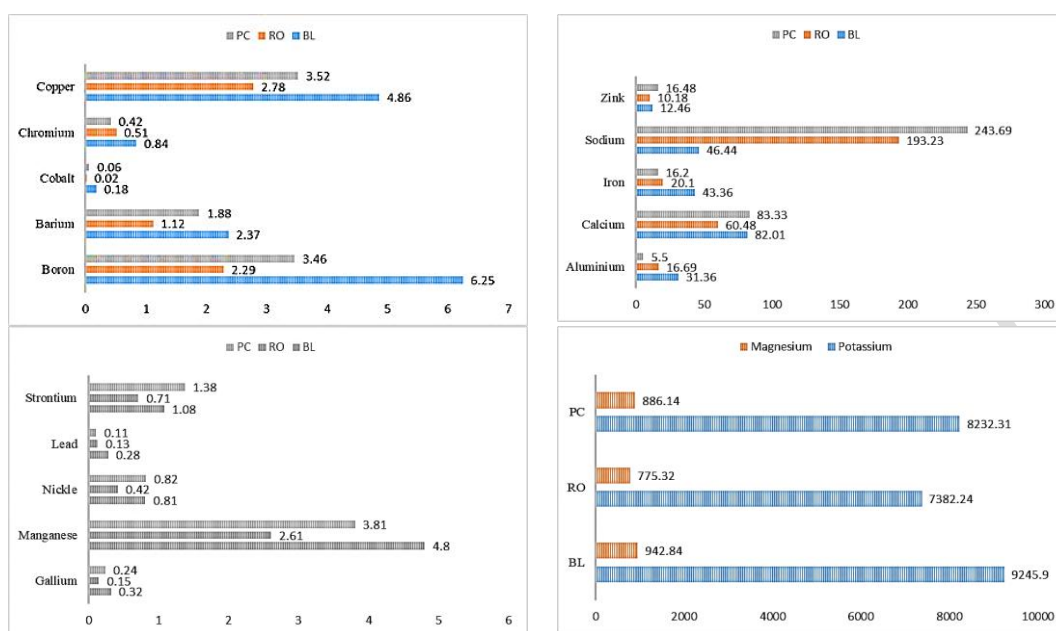


Fig 3 Elemental or Mineral composition(mg/kg) of three different heat-processed Jack Seed Flours

Yield and Acceptability of Low-Fat functional Breadsticks

Different heat-treated jack seed flours at 10 to 100 per cent level was incorporated with all-purpose flours in the preparation of Functional Breadsticks to know the level of acceptance. The treatment T9 (10:90) and T10 (All-purpose flour: Blanched Jack seed flour), the dough was unable to roll due to weak dough rolling properties with lower to zero percentage of all-purpose flour.

The yield of Breadsticks varied significantly among the treatments ranging from 100.9g (T1) to 128.06g (T9). The yield difference was mainly due to variation in the diameter along the length of the individual hand rolled raw-unbaked soft product and slow moisture escape from the interior part of the breadstick having variations in the diameter; hence the shelf life and acceptability was also low during the preliminary trails. This problem was solved by oven drying of the baked breadsticks at 60±1°C for 6±1 hr for crunchy texture with a moisture content of 5±1 per cent before packing.

Table 5 Product yield from different heat-processed Jack seed flour blended Breadsticks formulations

Treatment Combination	Product yield (g)										
	C	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
*APF + BLJSF	115.03	126.7	121.36	119.93	111.86	119.63	123.56	118.70	120.20	-	-
*APF+ ROJSF	112.57	116.33	115.10	123.97	123.93	116.60	122.33	124.73	116.13	128.06	123.57
*APF+ PCJSF	116.43	100.90	112.50	114.46	106.83	120.36	116.00	117.23	119.33	116.73	115.56

*The above values are the average of three observations.

The data obtained from the results of different sensory attributes for the product, blended with different levels of heat-processed jack seed flours such as BLJSF(M1), ROJSF(M2) and PCJSF(M3) with all-purpose flour (APF), are significantly differed ($p < 0.05$) in texture, flavour and overall acceptability respectively (Tables 6, 7 and 8).

The acceptability of Blanched Jack seed-flour (BLJSF) blended breadsticks (Table.6) reported significantly like-very-much scores in overall-acceptability in the treatment T1(8.33) (10:90%, BLJSF:APF) liked very much followed by moderate likeness in the treatment T2 (6.73) (20:80%). Significantly reduced scores due to higher levels of (> 20% BLJSF) blanched seed flours might be due to raw-unacceptable flavour with a bitter taste. Similar findings were reported with lye-peeled 20% jack seed flour incorporated biscuits (Butool and Butool, 2015); this was mainly due to a reduction in anti-nutritional factors in seeds(Akinmutini, 2006). (Table 6).

In another study, severe growth retardation in experimental animals was documented in the group fed with a diet containing 65% dry heat-treated jack seed flour, compared to 22.5% flour-based diet reported comparable growth without any adverse effects on liver weight and liver function. It recommended that a small to moderate quantity of dry heat-treated jackfruit seed flour can be used to develop food products (Banerjee and Datta, 2015). Hence higher levels of BLJSF flour may not be suitable for value-added products.

Table 6 Acceptability of BLJSF incorporated Breadsticks

Variation	Appearance	Texture	Colour	Flavour	Taste	OA
T1	8.47±0.51	8.33±0.65	8.23±0.70	7.14±1.38	8.14±0.79	8.33±0.75
T2	8.38± 0.66	7.92±0.50	8.09±0.62	5.47±1.74	6.22±0.72	6.73±0.46
T3	7.14±0.72	6.40±1.15	7.19±0.69	5.33±1.79	6.35±1.19	6.51±1.02
T4	6.64±0.76	6.16±0.89	6.52±0.74	5.20±1.54	5.52±1.56	5.07±1.38
T5	5.54±1.38	5.71±0.84	5.85±1.38	4.80±1.20	3.00±1.76	3.02±1.70
T6	5.40±1.22	4.03±1.27	7±0.35	4.90±1.13	2.76±1.54	2.52±1.24
T7	6.61±0.66	4.33±1.28	6.90±0.83	4.14±1.73	2.81±1.99	2.52±1.36
T8	6.35±0.52	3.57±0.97	6.90±0.30	3.85±2.03	2.85±1.06	2.38±0.80
T9	6.35±0.52	3.57±0.97	6.90±0.30	3.23±1.41	2.38±0.86	2.00±0.54
T10	6.35±0.52	3.57±0.97	6.90±0.30	3.85±2.03	2.04±1.07	1.66±0.65
TC	8.04±0.38	7.95±0.49	8.00±0.44	7.88±0.54	8.03±0.39	8.11±0.44
F value	*	*	*	*	*	*
SE(m)	0.169	0.208	0.149	0.341	0.277	0.222
CD@5%	0.471	0.579	0.416	0.952	0.771	0.62

CD > 0.05% Non-significant, CD < 0.05% Significant, CD < 0.01% Highly significant

Concerning roasted jack seed flour (ROJSF) based Breadsticks (Table 7), all the sensory scores were significantly good in the treatments T1 to T3. The overall acceptability score for the treatments T1(8.61)(90:10%), T2 (8.90)(80:20%) and T3 (8.81)(70:30%) were liked extremely, compared to moderate likeness in the treatment T4 (7.31)(60:40%), T5 (7.33)(50:50%), T6 and T7(6.92 and 6.91)(40:60% & 30:70%) followed by slightly liked in T8 (6.31)(20:80%), T9 (6.38)(10:90%), T10 (5.64)(0:100%) which is hundred per cent ROJSF flour. The control product was liked very much with a score of 8.02 (TC) (100:0%) due to one hundred per cent all purpose-flour without seed flour, indicating that up to 30% roasted jack seed flour was acceptable. Other workers made similar remarks (Eke-Ejiofor *et al.*, 2014), hence roasting of jack seeds before flour production contributes best results compared to autoclaving or boiling and suggested that the flour could be utilised in baking and confectionary preparations along with refined flours (Table 7). This conforms with the findings of other workers, where 30-40% jack seed flour (JSF) based noodles are highly acceptable when blended with 10-20% jack bulb flour and 50% refined flour (Kuamr *et al.*, 2015). In another study, 30% seed flour-based instant vermicelli sweet-mix (Ajisha *et al.*, 2018) and 30 % JSF-based pasta were best accepted compared to 10% (Malathi Devi, 2015). This is contrary,

with 10% JSF substituted pasta having the maximum consumer acceptability, as Abraham and Jayamuthunagai (2014) reported. This might be due to varietal variations, soil-water types in which they grow and the masking effect of sugar and other ingredients incorporated during value addition.

Table 7 Acceptability ROJSF incorporated Bread Sticks

ROJF Variation	Appearance	Texture	Colour	Flavour	Taste	OA
T1	8.04±0.66	8.92±0.32	8.00±0.59	8.04±0.46	8.86±0.31	8.61±0.49
T2	8.00±0.54	8.00±0.63	8.25±0.63	7.90±0.59	8.35±0.57	8.90±0.30
T3	8.07±0.50	8.23±0.49	8.15±0.37	8.07±0.50	8.15±0.43	8.81±0.40
T4	8.04±0.49	8.07±0.59	8.01±0.50	7.26±0.53	7.11±0.53	7.31±0.33
T5	7.65±0.45	7.64±0.46	7.76±0.43	7.19±0.40	7.54±0.56	7.33±0.50
T6	7.35±0.57	7.02±0.58	7.45±0.58	7.07±0.61	7.09±0.58	6.92±0.39
T7	7.06±1.44	7.11±1.46	7.11±1.46	7.11±1.46	7.09±1.44	6.91±1.63
T8	7.14±0.55	6.14±0.79	6.21±0.71	6.14±0.79	5.76±1.44	6.31±1.63
T9	6.97±0.43	6.78±0.83	6.44±0.68	6.76±0.73	6.53±0.75	6.38±0.72
T10	7.09±0.30	5.52±1.24	5.61±1.24	6.21±1.30	5.14±1.46	5.64±1.17
TC	8.00±0.31	7.67±0.53	8.03±0.50	7.95±0.38	8.52±0.67	8.02±0.57
F value	*	*	*	*	*	*
CD	0.392	10.778	0.46	0.474	0.548	0.523
SE(m)	0.14	0.174	0.165	0.17	0.197	0.188

CD > 0.05% Non-significant, CD < 0.05% Significant, CD < 0.01% Highly significant

The Pressure-cooked seed flour (PCJSF) incorporated breadsticks exhibited a significantly higher level of acceptability, with a liked-very-much score ranging from 8.80 (T1)(90:10%), 8.9 (T2)(80:20%), 8.45(T3)(70:30%) to 8.04 (T5)(50:50%). Up to 50% pressure cooked jack seed flour (PCJF) blended breadsticks liked very much compared to moderate likeness in the treatments T6 (6.95), T7(6.78) (30:70%), T8(6.54) (20:80%), T9(6.66) (10:90%) and T10(6.73) (0:100%) which is hundred per cent PCJF seed flour (Table 8). This may be due to reduced anti-nutritional factors in the quicker pressure cooking process and conforms with the findings where jack seeds boiled for 60 min reported 50% reduction in oxalates, phytin, and 44 % reduction in saponin, 32% reduction in tannin (Akinmutini, 2006) due to leaching. Hence pressure cooking saves energy than longer boiling treatments besides higher level of acceptance.

Table 8 Acceptability of PCJSF incorporated Breadsticks

PCJF Variation	Appearance	Texture	Colour	Flavour	Taste	OA
T1	8.38±0.49	8.04±0.38	8.09±0.70	8.14±0.72	8.33±0.61	8.8±0.40
T2	8.33±0.48	8.28±0.46	8.14±0.72	8.09±0.70	8.28±0.56	8.9±0.30
T3	8.07±0.55	8.07±0.63	8.09±0.53	7.95±0.74	7.88±0.63	8.45±0.61
T4	8.19±0.98	7.61±0.72	8.02±0.92	7.19±0.74	7.58±0.64	8.04±0.26
T5	8.02±0.60	7.38±0.56	7.50±0.59	7.31±0.46	7.69±0.43	8.04±0.26
T6	7.81±0.74	7.9±0.40	7.90±0.43	7.28±0.46	6.83±0.57	6.95±0.58
T7	7.97±0.64	7.04±0.41	7.52±0.67	7.04±0.38	6.69±0.66	6.78±0.62
T8	7.81±0.51	6.98±0.66	8.09±0.53	6.90±0.60	6.42±1.04	6.54±1.01
T9	7.69±0.46	6.9±0.51	7.81±0.40	7.26±0.73	6.52±0.98	6.66±0.81

T10	6.88±0.56	7.11±0.63	7.26±0.53	6.95±0.38	6.52±0.41	6.73±0.49
TC	8.42±0.53	8.11±0.49	8.166±0.65	7.66±0.45	6.52±0.32	8.50±0.74
F value	*	*	*	*	*	*
SEM	0.131	0.12	0.137	0.131	0.144	0.126
CD@5%	0.365	0.334	0.383	0.365	0.402	0.351

PCJF-Pressure cooked jack seed flour, OA=Overall acceptability

The treatment T6 to T10 showed “moderate” to “like slightly”, i.e., T6(6.95)40:60%, T8(6.54)20:80%, T9(6.66)10:90%, T10(7.78) (0:100%) due to reduced taste might be due to the thermostability of the tannins in the seed bulk during pressure cooking led to mild bitterness (D’mello, 1995; Okwu, 2002). The mild bitterness could be overcome by incorporating elevated levels of sugar and salt and spices in the recipe. Similar observations were reported (Joy *et al.*, 2019) in the fermented (48 hours and dried at 60°C) jack seed flour blended wheat flour cookies (30% wheat flour and 70% jack seed flour) had similar sensory scores for flavour (6.86), colour (6.70), taste (6.88), crispness (6.48) with overall acceptability (7.06). Others documented that up to 60% jack seed flour was best accepted in jack seed flour-based burfi (Dey and Amin., 2017) and 70% in Cookies (Joy *et al.*, 2019). This higher level of acceptance might be due to the masking effect of added khova and sugar. Other researchers reported that 25% seed flour is preferred (Hossain, 2014) in bread and biscuits. Bread made with less than 30% jack seed flour showed good overall acceptability (Butool and Butool, 2015) and suggested for baked products lacking dietary fibre (Islam *et al.*, 2015). Correspondingly, 20% lye peeled (3 % sodium hydroxide) Jack seed flour-based biscuits were on par with control compared to lower scores for 50% seed flour-based biscuits in all the sensory qualities as reported by Samata Airani (2007).

Among the treatment combinations (APF: PCJSF), from T1(8.80) (90:10%) to T5(8.90), 50:50% were liked very much in overall acceptability. This confirms that up to 50% PCJSF incorporated breadsticks were best rated due to the detoxification of trypsin inhibitors (Akinmutini, 2006) in pressure cooking compared to roasted and blanched seed flour-based breadsticks. Incorporating jack seed flour enhances crude fibre other nutrients as a functional food ingredient

Scale-up studies

Based on the acceptability of the three heat-treated jack seed flours, the scale-up study was conducted by incorporating a maximum level of (50%) PCJF jack-seed flour with all-purpose flour. The recipe was optimised for commercial production (Table. 6 and 7). The nutritional composition of pressure-cooked jack seed flour (PCJSF) based low-fat breadsticks showed a moisture content of 4.33g/100g, protein 9.78g/100g, fat 7.03g/100g, total ash 3.09g/100g, carbohydrates 75.55g/100g and energy 405 K.cal/100g (Table.8). It can be preserved like other breadsticks.

Table 9 Jack seed flour (PCJSF)-based Breadsticks for Commercial production

Sl No	Ingredients	Percentage
1	PC-Jack seed flour	50
2	All-purpose flour	50
3	Fat	10
4	Powdered sugar	10
5	Ajwan seeds	2
6	yeast	2
7	Salt	2
8	Milk powder	10
9	Water to mix	70

	Total (g) ingredients	206
	Baked product (g)	123.44

Table 10 Proximate composition of best-accepted PCJSF incorporated Breadsticks

Parameter	Result
Moisture(g/100g)	4.33
Protein(g/100g)	9.78
Fat(g/100g)	7.03
Total ash(g/100g)	3.09
Carbohydrates(g/100g)	75.55
Energy (K.cal/100g)	405.00



Fig 4. Jack seed flour (PCJF)-based functional Breadsticks

Conclusion

Jack fruit seeds are rich in proteins, carbohydrates, and minerals, an excellent ingredient for developing functional foods. Seeds have a poor shelf life, wasted during the seasonal glut. In order to enhance the shelf life of jackfruit seeds and make them available throughout the year, seeds can be processed into flour which could be used as a functional food ingredient. Value addition enhances proper utilisation during glut and extends the shelf life of nutrient-rich seeds in processed products. The study revealed that 15 ± 1 min pressure-cooking of whole seeds or 16 ± 1 min open-pan roasting of size reduced seeds helps in smooth milling on drying yields 93 to 98% flour. Maximum of 10-20% of blanched (BJSF), 30% roasted (ROJSF), and up to 50 % pressure-cooked seed flour (PCJSF) could be replaced as a functional food ingredient with all-purpose flour for the commercial production of functional breadsticks instead of wastage

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

References

- 1) Ajisha K.H., Sharon C.L., Aneena E.R. and Panjikkaran S.T. Development and Evaluation of Raw Jackfruit and Jackfruit Seed Based Instant Payasam Mix. *Indian J.Sci.Res.* 2018;19(1):10-15.
- 2) Akinmutini A.H. Nutritive value of raw and processed jack fruit seeds (*Artocarpus heterophyllus*): Chemical Analysis. *Agri. J.* 2006;1(4):266-271.
- 3) Albi Abraham and Jayamuthunagai, J. An Analytical Study on Jackfruit Seed Flour and its Incorporation in Pasta. *Research Journal of Pharmaceutical, Biological and Chemical Sciences.* 2014;5(2):1597- 1610.
- 4) Amadi Joy A.C, Ezenwa, Chinyere. Nutrient Evaluation and Acceptability of Cookies Produced from Wheat Flour, Tiger Nut Milk and Fermented Jack Fruit Seeds (*Artocarpus Heterophyllus*). *Elixir Food Sci.* 2019;127, 52710-52715,
- 5) Anonymous. Health Benefits of Jackfruit and Jackfruit Seeds. 2016, from <http://www.epainassist.com/articles/healthbenefitsofjackfruitandjackfruitsee>.
- 6) AOAC . *Official methods of analysis of the association of official analytical chemists international.* USA: Maryland; 2003
- 7) Association of Official Analytical Chemists (AOAC). *Official Methods of Analysis.* Washington D.C, 1980.
- 8) Butool S, Butool, M. Nutritional quality on value addition to jack fruit seed flour. *Int. J. Sci. Res.*, 2015; 4, 2406-2411.
- 9) Dmello J.P.F., Devendra, , *Tropical Legumes in Animal Nutrition: United Kingdom* 1995; 96-133.
- 10) Duncan P.B. New Multiple Range and Multiple F-tests *Biometrics.* 1955;(11):1-42.
- 11) Eke- Ejiofor J., Beleya E.A., Onyenorah N.I. The Effect of Processing Methods on the Functional and Compositional Properties of Jackfruit Seed Flour. *Int.J. Nutri. and Food Sci.*, 2014; 3(3):166-173.
- 12) Ethnhealth. Health Benefits of Jack fruit seeds.2013, from ethnhealthcourt.com/2013/01/30/health-benefits-of-jack-fruit-seeds.
- 13) Hettiaratchi, U.P. K., Ekanayake S, Welihinda, J. Nutritional Assessment of a jackfruit (*Artocarpus heterophyllus*) meal. *Cey.Medi. J.* 2011; 56: 54-58.
- 14) Hossain, M.T. Development and quality evaluation of bread supplemented with jackfruit seed flour. *Int. J. Nutri. and Food Sci.* 2014; 3(5): 484.
- 15) Islam MD. Shariful, Rokeya Begum, Morshada Khatun, Kamalesh Chandra Dey. A Study on Nutritional and Functional Properties Analysis of Jackfruit Seed Flour and Value Addition to Biscuits. *Int. J. Eng. Res & Tech.* 2015: 4(12):139-147.
- 16) Ivana Markovic, Jelena Ilic, Dragan Markovic, Vojislav Simonovic, and Nenad Kosanic. *Journal of Hygienic Engineering and Design.* 2013;4:50-53.
- 17) Jessica, B. Nutrition in Boiled Jackfruit Seeds. 2015, retrieved from <http://www.livestrong.com/article/546837-nutrition-in-boiled-jackfruit-seeds/> retrieve on 28/09/15
- 18) Malathi Devi, T. Development of Extruded product using jackfruit bulbs and seed flours., MTEch thesis submitted to the University of Agricultural Sciences, GKVK, Bangalore; 2015.
- 19) Mayanard, A.J. *Methods in Food Analysis*, Academic Press, New York. 1970; 176.
- 20) Nilanjana Nandlal Dey and Bijal Keyur Amin..Effect of Nutritional, Sensory and Texture Properties of Jackfruit Seed (*ArtocarpusHeterophyllus* Lam.) Flour Burfi. *International Journal of Science and Qualitative Analysis.* 2017;3(4): 42-48.

- 21) Ocloo F.C.K., Bansa D., Boatin R., Adom T., Agbemavor, W.S. Physico-Chemical, Functional and Pasting Characteristics of Flour produced from Jackfruits (*Artocarpus heterophyllus*) seeds. *Agric. Biol. J. N. Am.* 2010;1(5): 903-908.
- 22) Okwu N.D.E. The effect of cooked *Mucuna utilis* meal as a substitute for soya bean meal in broiler finisher. Diet.B.Sc., Project. Michael Okpara University of Agric.Umudike, 2002;1-5.
- 23) Raghuramulu, N., Nair, M.K. and Kalyanasundaram, S. A Manual of Laboratory Techniques, NIN, ICMR, Hyderabad, India; 1983.
- 24) Roy Chowdhury A., Bhattacharyya, A.K., Chattopadhyay. Study of Functional Properties of Raw and Blended Jackfruit Seed Flours (A non-conventional source) for food application. 2012 retrieved from <https://www.researchgate.net/publication/285983474>.
- 25) Sajilata, M., Singhal, S., Kulkarni, P. Resistant starch -A comprehensive Reviews in Food Food Sci. and Safety. 2006; 5:1-17.
- 26) Samata Irani. Masters thesis submitted Department of Food Science and Nutrition College of Rural Home Science, UAS, Dharwad. 2007.
- 27) Sayooj Mammaly Meethal, Narinder Kaur, Jyoti Singh and Yogesh GAT. Effect of Addition of Jackfruit Seed Flour on Nutrimental, Phytochemical and Sensory Properties of Snack Bar. *Curr. Res. Nutri and Fd Sci.*, 2017; 05(2):154-158.
- 28) Selva Rani, N., Raja M., Suresh, M. Quality evaluation of musk melon seeds flour and jackfruit seeds flour for bakery products development. *The Pharma Innovation Journal.* 2019; 8(6):703-706.
- 29) Shadab Butool, Masrath Butool. Nutritional Quality on Value Addition to Jack Fruit seed flour. *Int. J. Sci.Res.* 2015; 4(4)2319-7064.
- 30) Soma Banerjee, Santa Datta D.E. Effect of dry heat-treated jackfruit seed powder on the growth of experimental animals. *Journal of Pharmacy and Biological Sciences.* 2015;10 (6) :42-46.
- 31) Sreeletha, A.S., Lini J.J, Dhanyalekshmi C.S., Sabu KR, Pratap, C R. Phytochemical, Proximate, Antimicrobial, Antioxidant and FTIR Analyses of Seeds of *Artocarpus heterophyllus* Lam. *Adv. Biotech and Micro.* 2017; 5(1):001-009.
- 32) Swami S.B., Thakor N.J., Haldankar P.M., Swami S.B., Thakor N.J., Haldankar P.M and Kalse S.B. *International Journal of Processing and Post-Harvest Technology.* 2012; 3(1) p:142-146.
- 33) Veena kumari and Suma divakar. Nutrient and chemical profile of raw jackfruit based noodles. *Food Sci. Res.*2016; 7(2):156-164.
- 34) Vinod, D., Nandkule, Dorcus Masih, Chitra Sonkar, Devendrasing, D., Patil. Development and Quality Evaluation of Jackfruit Seed and Soy Flour Noodles. *Int. J. Sci, Eng and Tech.* 2015; 3(3) :802-806.
- 35) Zuwariah, I., Noor Fadilah M.B., Hadijah H., Rodhiah, R. Comparing amino acid and chemical composition of jackfruit seed flour treatment. *Fd. Res.*2018; 2(6):539-545.
