



PROCESSING CHARACTERISTICS AND ACCEPTABILITY OF JACKFRUIT (*Artocarpus heterophyllus* Lam.) SEEDS, PHYSICAL AND FUNCTIONAL PROPERTIES OF ITS FLOUR

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ABSTRACT

Jackfruit possess 100-400 seeds which are oval, brown and edible after processing. A study was undertaken to investigate 'processing characteristics and acceptability of jackfruit seeds and to evaluate physical and functional properties of its flour'. Ripe jackfruits procured from a single tree at University of Agricultural Sciences, Dharwad campus were cut, and seeds were separated. Seeds were processed by boiling, pressure cooking, pan roasting, microwave roasting, baking. Unprocessed seeds served as control. Effect of processing on characteristics of jackfruit seed was evaluated. Seeds were subjected to sensory evaluation by semi-trained panel members using 9 point hedonic scale. Processed seeds were converted to flour and analyzed for physical and functional properties. Results revealed that weight, volume and edible portion of seeds increased in wet processing but decreased in dry processing. Boiling resulted in better acceptability with acceptability index of 83.15 per cent. Pressure cooked and pan roasted seeds were on par with boiled seeds followed by baked seeds, while microwave roasted seeds had lower acceptability. Flour yield was significantly higher in unprocessed jackfruit seeds (42.17 ± 0.06 %). Increase in bulk density was recorded with processing. All processing methods resulted in increased water absorption and oil absorption capacity of jackfruit seed flours. Swelling capacity of jackfruit seed flour increased during moist processing (6.46 ± 0.11 % in boiled and 6.24 ± 0.10 % pressure cooked seeds) and did not decrease significantly in dry processing. The solubility of flours increased during boiling (21.07 ± 0.05 %) and decreased significantly on dry processing (15.63 ± 0.20 %). Jackfruit seed flour possess good functional property and hence can be used at domestic, commercial and industrial purpose

KEY WORDS: Dry processing, Flour, Jackfruit seed, Moist processing



INTRODUCTION

Jackfruit (*Artocarpus heterophyllus* Lam.) is the largest tree-borne fruit belonging to family Moraceae. It is native to India and grown mostly in tropical countries. Pulp is consumed, whereas seeds, rind, core are discarded. Jackfruit seeds are 2-4 cm long and 1.5–2.5 cm thick. Having oval, ellipsoid or round shape. Depending on size, single fruit may have 100 - 400 seeds. Seeds are used for consumption, culinary purpose and also as source of starch by industries. Only 10 per cent of total seeds obtained are used, while 90 per cent of them are wasted on the whole. Jackfruits being highly seasonal, seeds are available only during March to July. Being a good source of nutrients, possessing therapeutic benefits, consumption of seeds should be encouraged to prevent wastage and enhance nutritional security. Processing improves acceptability, nutritional quality, digestibility, antioxidant activity, storage quality besides reducing antinutrients in food. Though lot of studies regarding jackfruit seed/flour composition and value addition are available, systematic studies revealing the effect of processing the jackfruit seeds are scanty. Hence, the present study was undertaken with the objective to assess the impact of processing on acceptability of jackfruit seeds and to study influence of processing methods on physical and functional properties of its flour.

MATERIALS AND METHODS

Ripe jackfruits procured from a single tree at University of Agricultural Sciences, Dharwad campus were cut and seeds separated. Colour and shape were recorded by visual observation, size in terms of length, width and thickness was recorded using vernier caliper, weight and volume was noted using electronic balance and water displacement method respectively. Bulk density was calculated. Seeds were processed employing common methods of cooking: **a) Boiling** – 50g of seeds was transferred to a vessel containing boiling water and boiled with closed lid at 100°C till soft and cooked. **b) Pressure cooking** – 50 g of seeds was transferred to a vessel containing 20 ml water. Pressure cooked at 121°C till soft and cooked. From a and b, excess water was drained and superfluous water was removed by absorbent paper. **c) Pan roasting** - Seeds were roasted at 160°C in a pan till sweet aroma developed. **d) Microwave roasting** – 50g of seeds were microwaved at 480 Power till the seeds turned soft, sweet and developed aroma. **e) Baking** – Seeds were baked in pre-heated oven at 180°C for 15 min till soft and sweet aroma developed. All processed seeds were cooled. Unprocessed seeds served as control.

Processing characteristics like change in weight and volume of seeds were noted, leached out solids and edible portion were calculated. Processed seeds were subjected to sensory evaluation by semi-trained panel members of Department of Food Science and Nutrition, College of Community Science, UAS, Dharwad using 9 point hedonic scale. Processed seeds were milled to flour and analyzed for physical properties like yield and bulk density and functional properties like water absorption capacity, oil absorption capacity, swelling power and solubility. Mean, standard deviation and analysis of variance (One way ANOVA) was applied to the results. Statistical analysis was conducted using SPSS software (version 16.0).

RESULTS AND DISCUSSION

Physical parameters, processing characteristics and acceptability of jackfruit seed

Jackfruit seeds were brown in colour, oval in shape and comparatively smaller in size with length and width of 3.52 ± 0.18 and 1.77 ± 0.15 cm. The values were in comparison with results reported by Butool and Butool (2013) and Islam *et.al* (2015). Slightly lower values for length (2-3 cm) and width (1-1.5 cm) of seeds were mentioned by Abraham and Jayamuthunagai (2014). These variations can be attributed to the differences in variety, maturity index, location and climatic conditions of cultivation. On an average seeds weighed 5.47 ± 0.76 g, had volume of 5.25 ± 0.32 ml and bulk density of 1.06 ± 0.05 g/ml.

Weight, volume and edible portion of seeds increased in wet processing and decreased in dry processing (Table 1-See Appendix). Pressure cooking significantly increased weight and volume of the seeds by 5.20 ± 0.03 per cent and 10.53 ± 0.03 per cent respectively whereas microwave roasting decreased significantly (13.77 ± 0.06 % and 12.82 ± 0.04 % respectively). Direct contact of seeds with water in moist treatment resulted in absorption of water and thus increase in weight and volume. On the contrary, dry processing resulted in loss of moisture and volatile compounds. Further, higher increase in weight and volume lesser leached out solids might have led to significantly higher edible portion in pressure cooked seeds (97.38 ± 0.03 %). Open pan roasting at 160°C for 15 min led to a greater escape of moisture and higher decrease in weight (20.10 ± 0.04 %) and volume (17.75 ± 0.03 %). The seeds



which are enclosed in fleshy endosperm cells have a thick cell wall with stored polysaccharides which are heat liable, the loss of these during heating results in separation of brown spermoderm from seeds thus reducing the amount of edible portion.

Table 2(See Appendix) indicates acceptability of processed jackfruit seeds. The processed seeds did not differ significantly with respect to appearance. However, boiled seeds had significantly higher scores for all sensory parameters like color (7.29), flavor (7.48), taste (7.48), texture (7.57), overall acceptability (7.71) with acceptability index of 83.15. This may be due to softening of texture and increased sugar content during boiling. Acceptability index of pressure cooked seeds (78.30) and pan roasted seeds (76.91) were on par with boiled seeds followed by baked seeds (75.44). Microwave roasted seeds scored significantly lower scores for all sensory parameters like color (6.48), flavor (6.10), taste (5.90), texture (5.57), overall acceptability (6.60) and had lower acceptability with acceptability index of 68.17, may be due to hardening of texture and ununiform cooking due to rapid processing. However, all processed seeds were within acceptable range of sensory evaluation that is between liked very much to liked moderately. All the sensory parameters were significantly and positively correlated to reducing, non reducing and total sugars and negatively correlated to starch and dietary fiber (Table 3-See Appendix).

Physical and functional properties of processed jackfruit seed flour

Flour yield was significantly higher in unprocessed jackfruit seeds (42.17 ± 0.06 %) as indicated in Fig 1(See Appendix). Among processing methods, significantly lower flour yield observed in moist processed seeds (boiling – 31.46 ± 0.05 %, pressure cooking - 34.70 ± 0.07 %) may be due to leached out solids along with other water soluble components, whereas microwave roasted jackfruit seeds yielded significantly higher amount of flour among processing methods (39.68 ± 0.05 %). Flour yield depends on type of raw material, initial moisture, composition, variety, size, pre-treatments, processing technique and equipments used. Removal of brown spermoderm during processing may be the reason for lower flour yield in processed seeds.

Increase in bulk density was recorded with processing (Fig 2-See Appendix), which may be due to heat processing (Ejiofor *et al.*, 2014 in jackfruit seed flour and Akubor and Obiegbuna, 2014 in African breadfruit kernel flour) and higher protein content. The results were in comparison with the values reported by

Chowdhury *et al.* (2012); Abraham and Jayamuthunagai (2014) who reported bulk density values of 0.61 g/ml to 0.81 g/ml in jackfruit seed flour. The bulk density is used to determine handling requirement.

Effect of processing on functional properties of jack seed flour is presented in Table 4(See Appendix). All processing methods resulted in increased water absorption and oil absorption capacity of jackfruit seed flours. Water absorption capacity was significantly higher in wet processed jackfruit seed flour compared to dry processing, pressure cooking having significantly higher value (282.71 ± 0.02 %) compared to unprocessed seed flour (182.36 ± 0.03 %). The results were in comparison with that reported by Ejiofor *et al.* (2014) in processed jackfruit seed flour and Akubor and Obiegbuna (2014) in African breadfruit kernel flour. Water absorption capacity may differ due to molecular structure of flours, protein concentration, interaction with water, conformational characteristics, hydrophilic groups, particle size, degree of milling, presence of husk, damaged starch, protein content and carbohydrates (Kaushal *et al.*, 2012). In the present study, oil absorption capacity of unprocessed jackfruit seeds flour was 89.93 ± 0.20 per cent which increased on processing. Dry processed seeds (115.80 ± 0.92 % to 164.76 ± 1.17 %) had significantly higher oil absorption capacity than wet processed seeds (101.05 ± 0.08 % to 101.26 ± 0.72 %). The results were in comparison Abraham and Jayamuthunagai (2014) and Akubor and Obiegbuna (2014) and Ejiofor *et al.* (2014). Increased oil absorption capacity of processed flours may be attributed to denaturation and dissociation of constituent proteins that may occur on heating which unmasks the non-polar residues from the interior of the protein molecule. The swelling capacity of jackfruit seed flour increased during moist processing (6.46 ± 0.11 % in boiled and 6.24 ± 0.10 % pressure cooked seeds) and did not decrease significantly in dry processing (Table 4-See Appendix). The solubility of flours increased during boiling (21.07 ± 0.05 %) and decreased significantly on dry processing (15.63 ± 0.20 % to 17.49 ± 0.41 %). Similar changes were observed by Ejiofor *et al.* (2014).

Table 5(See Appendix) indicates particle size distribution of processed jackfruit seed flour. Irrespective of processing, higher proportion of jackfruit seed flour was passed through 85 mesh BSS standards sieve having particle size 180 μ m. It ranged from 46.08 ± 1.50 per cent in unprocessed seed flour to 31.96 ± 1.92 per cent in pressure cooked seed flour. Higher proportion of pressure cooked seed flour was



finer with particle size of 200 μm ($33.98 \pm 0.89\%$). Very less quantity of unprocessed and processed seed flour could be passed through 300 mesh BSS standards sieve having particle size 53 μm ($0.47 \pm 0.38\%$). On an average higher proportion of jackfruit seed flour was coarser, may be due to usage of domestic mixer for converting dry seed chips to flour. Mechanical milling if employed might result in finer flour.

CONCLUSION

Boiled jackfruit seeds are highly acceptable followed by pressure cooked and pan roasted. Flour yield is maximum from unprocessed seeds. Unprocessed and processed jackfruit seed flour poses good functional property and hence can be used for value addition at domestic, commercial and industrial level for the replacement of cereal flours in traditional and conventional products or formation of novel products.

APPENDIX

Table 1 Processing characteristics of jackfruit seeds

Treatment	Processing characteristics (%)			
	Change in weight	Change in volume	Leached out solids	Edible portion
Boiling	5.20 ± 0.03^b	10.53 ± 0.03^b	3.12 ± 0.04^a	94.45 ± 0.05^b
Pressure cooking	8.85 ± 0.05^a	14.29 ± 0.03^a	1.44 ± 0.05^b	97.38 ± 0.03^a
Pan roasting	-20.10 ± 0.04^e	-17.75 ± 0.03^e	-	76.32 ± 0.04^e
Microwave roasting	-13.77 ± 0.06^c	-12.82 ± 0.04^c	-	80.49 ± 0.03^c
Baking	-18.82 ± 0.03^d	-14.22 ± 0.03^d	-	76.92 ± 0.03^d
F value	298162	661260	6996	201736
S. Em. \pm	0.16	0.12	0.10	0.14
C. D. at 1 %	0.36**	0.26**	0.23**	0.32**

**Significant at 1 % level

**Table 2 Effect of processing on acceptability of jackfruit seeds**

Treatment	Appearance	Color	Flavor	Taste	Texture	Overall acceptability	Acceptability index
Boiling	7.38 ± 0.80	7.29 ± 0.90 ^a	7.48 ± 0.87 ^a	7.48 ± 0.93 ^a	7.57 ± 1.16 ^a	7.71 ± 0.85 ^a	83.15 ^a
Pressure cooking	6.86 ± 1.24	6.90 ± 0.83 ^{ab}	7.00 ± 1.00 ^a	6.86 ± 1.06 ^a	7.24 ± 1.26 ^{ab}	7.33 ± 0.73 ^{ab}	78.30 ^{ab}
Pan roasting	6.86 ± 1.39	7.00 ± 1.18 ^{ab}	6.86 ± 1.28 ^a	7.10 ± 1.34 ^a	6.67 ± 1.24 ^b	7.05 ± 1.12 ^b	76.91 ^{ab}
Microwave roasting	6.76 ± 1.14	6.48 ± 1.29 ^b	6.10 ± 1.30 ^b	5.90 ± 1.55 ^b	5.57 ± 1.12 ^c	6.00 ± 1.22 ^c	68.17 ^c
Baking	7.10 ± 1.14	6.86 ± 1.39 ^{ab}	6.76 ± 0.94 ^{ab}	6.76 ± 1.58 ^a	6.57 ± 1.29 ^b	6.71 ± 1.10 ^b	75.44 ^b
F value	0.99	1.38	4.36	4.09	8.30	8.56	5.184
S. Em. ±	0.50	0.50	0.48	0.57	0.53	0.45	4.76
C. D. at 5%	NS	0.70*	0.67*	0.81*	0.74*	0.62*	6.68*

*Significant at 5 % level

NS - Non Significant

**Table 3 Correlation between sensory parameters and chemical composition of jackfruit seeds**

Chemical composition	Sensory parameters						
	Appearance	Color	Flavor	Taste	Texture	Overall acceptability	Acceptability index
Reducing sugars	0.709**	0.909**	0.946**	0.942**	0.925**	0.914**	0.940**
Non reducing sugars	0.410	0.537*	0.680**	0.489	0.772**	0.729**	0.688**
Total sugars	0.565*	0.733**	0.857**	0.707**	0.921**	0.884**	0.861**
Starch	-0.651**	-0.488	-0.560*	-0.372	-0.539*	-0.512	-0.553*
Insoluble dietary fibre	-0.417	-0.592*	-0.727**	-0.561*	-0.800**	-0.780**	-0.732**
Soluble dietary fibre	0.219	0.228	0.115	0.259	0.061	0.068	0.123
Total dietary fibre	-0.358	-0.520*	-0.661**	-0.486	-0.737**	-0.717**	-0.665**

*Correlation is significant at 0.05 level

**Correlation is significant at 0.01 level

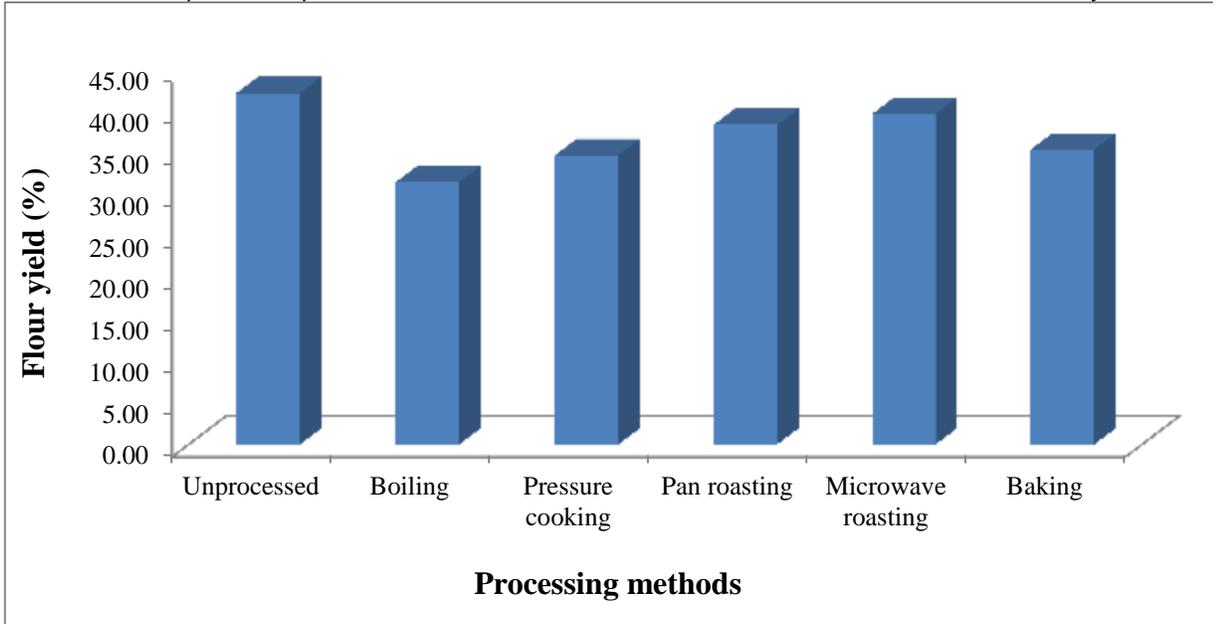


Fig 1 Flour yield (%) of processed jackfruit seeds

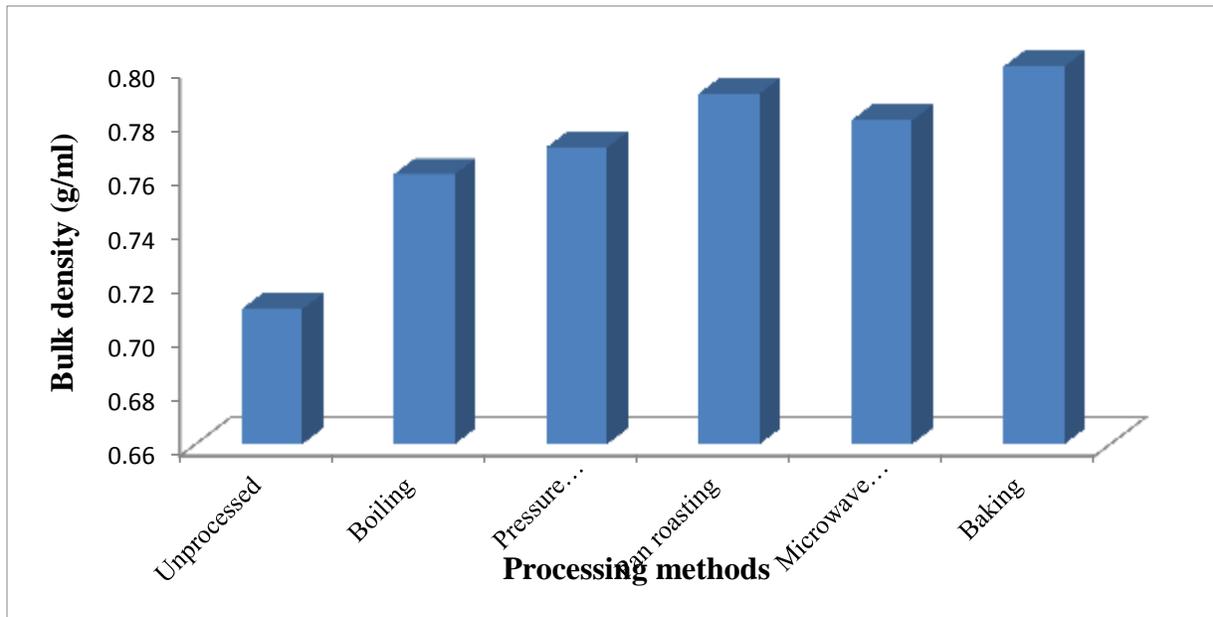


Fig 2 Bulk Density (g/ml) of processed jackfruit seeds

**Table 4 Effect of processing on functional properties of jackfruit seed flour**

Treatment	Functional properties (%)			
	Water absorption capacity	Oil absorption capacity	Swelling capacity	Solubility
Unprocessed	182.36 ± 0.03 ^f	89.93 ± 0.20 ^e	5.04 ± 0.06 ^b	20.09 ± 0.21 ^b
Boiling	260.30 ± 0.04 ^b	101.05 ± 0.08 ^d	6.46 ± 0.11 ^a	21.07 ± 0.05 ^a
Pressure cooking	282.71 ± 0.02 ^a	101.26 ± 0.72 ^d	6.24 ± 0.10 ^a	20.51 ± 0.28 ^b
Pan roasting	201.37 ± 0.03 ^d	115.80 ± 0.92 ^c	4.90 ± 0.02 ^b	15.63 ± 0.20 ^e
Microwave roasting	200.94 ± 0.02 ^e	130.88 ± 0.47 ^b	4.65 ± 0.45 ^b	17.49 ± 0.41 ^c
Baking	201.95 ± 0.03 ^c	164.76 ± 1.17 ^a	4.92 ± 0.06 ^b	16.31 ± 0.22 ^d
F value	58736	4461	18.95	258.82
S. Em. ±	0.12	0.82	0.23	0.29
C. D. at 1%	0.25 ^{**}	1.76 ^{**}	0.49 ^{**}	0.63 ^{**}

^{**}Significant at 1 % level

**Table 5 Particle size distribution of processed jackfruit seed flour**

Treatment	BSS standards [Sieve opening (μm)]						
	60(250)	85(180)	100(150)	150(105)	200(75)	240(63)	300(53)
Unprocessed	15.76 \pm 0.74 ^b	46.08 \pm 1.50 ^a	14.12 \pm 1.80 ^a	6.54 \pm 0.33 ^c	14.02 \pm 0.48 ^e	3.96 \pm 0.04 ^b	0.07 \pm 0.01 ^d
Boiling	12.39 \pm 0.08 ^d	33.23 \pm 0.51 ^{cd}	5.24 \pm 0.65 ^e	11.27 \pm 0.88 ^{ab}	28.23 \pm 0.67 ^b	10.61 \pm 0.16 ^a	0.13 \pm 0.06 ^{cd}
Pressure cooking	12.25 \pm 0.55 ^d	31.96 \pm 1.92 ^d	8.95 \pm 0.47 ^{cd}	10.21 \pm 0.81 ^b	33.98 \pm 0.89 ^a	2.36 \pm 0.71 ^c	0.47 \pm 0.10 ^b
Pan roasting	14.51 \pm 0.93 ^c	39.48 \pm 1.00 ^b	11.25 \pm 1.12 ^b	12.28 \pm 1.54 ^a	20.81 \pm 1.12 ^c	2.38 \pm 0.14 ^c	0.23 \pm 0.09 ^c
Microwave roasting	16.99 \pm 0.74 ^a	35.22 \pm 1.60 ^c	7.33 \pm 0.90 ^d	12.60 \pm 0.61 ^a	16.50 \pm 0.53 ^d	10.10 \pm 0.48 ^a	1.02 \pm 0.03 ^a
Baking	14.73 \pm 0.31 ^{bc}	34.47 \pm 0.37 ^c	9.24 \pm 0.50 ^c	12.55 \pm 0.87 ^a	16.59 \pm 0.76 ^d	10.59 \pm 0.72 ^a	0.80 \pm 0.13 ^a
Mean	14.44 \pm 1.83	36.74 \pm 5.04	9.35 \pm 3.02	10.90 \pm 2.32	21.69 \pm 7.38	6.67 \pm 3.94	0.47 \pm 0.38
F value	26.33	49.54	27.40	19.21	304.86	234.25	67.11
S. Em. \pm	0.73	1.49	1.18	1.06	0.90	0.55	0.10
C. D. at 5%	1.12*	2.30*	1.82*	1.64*	1.38*	0.84*	0.15*

*Significant at 5 % level

Figures in parenthesis indicate sieve opening (μm)



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