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Effect of Processing on Storage and Microbial Quality of Jackfruit (*Artocarpus heterophyllus* Lam.) Seed Flour

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A B S T R A C T

Jackfruit is seasonal and possesses 100-400 seeds. Impact of processing on storage and microbial quality of jackfruit seed flour was investigated. Hard variety of jackfruits was procured from UAS, Dharwad campus. Seeds separated, processed employing: boiling, pressure cooking, pan roasting, microwave roasting, baking. Seeds were chopped, dried and milled to flour. Fifty grams of flour were packed in two packaging material-160 gauge polyethylene and foil-coated aluminium pouches. Samples were withdrawn at 15 days interval and assessed for infestation, colour and moisture. Microbial analysis for bacteria, fungi and *E. coli* was carried out monthly. No color change, visual infestation was observed. Flour stored in polyethylene pouches (11.26%) had significantly higher moisture content than foil-coated aluminium pouches (10.96%). Pressure cooking (12.76%) and boiling (12.72) had significantly higher moisture, followed by unprocessed (11.69%). Flour packed in polyethylene pouches had significantly higher number of bacterial and fungal colony than foil-coated aluminium pouches**.** Pressure cooked seed flour harboured significantly higher bacterial and fungal colony (18.79×10^1 and 13.68×10^1cfu/g respectively), followed by boiled and unprocessed. Pan roasted seed flour contained significantly lower bacterial (10.07×10^1cfu/g) and fungal colonies (8.39×10^1cfu/g). *E. coli* were not detected. Increased moisture and microorganisms was within permissible limit. Hence, jackfruit seed flour has good storage stability.

Introduction

Jackfruit (*Artocarpus heterophyllus* Lam.) a member of the family Moraceae is the largest tree-borne fruit. Mainly grown in tropical countries, it is native to India. In general, only pulps are considered for consumption, while rind, core and seeds are utilized as animal feed or discarded. Jackfruit seeds are oval, ellipsoid or round in shape, having length of 2-4 cm and thickness of 1.5–2.5 cm. A single fruit may comprise 100 - 400 seeds depending upon size. Seeds are edible and are either boiled or roasted for direct consumption or used for culinary purpose namely; *curry*, *bhaji*, *cutlet etc*. The seeds are also used as non conventional source of starch by industries. Being a good source of nutrients, possessing therapeutic benefits, consumption of seeds should be encouraged to enhance nutritional

security and prevent wastage. As jackfruit is highly seasonal, seeds are not available throughout the year, hence storage becomes inevitable. Foods can be preserved by various techniques like dehydrating and processing to jam, jelly, pickles and other products. Easiest of all is dehydration as it is traditional method, eco friendly, cost effective, user friendly, product becomes lighter in weight, easily blendable and can be packed and stored. Polyethylene and foil coated aluminium pouches are easily available, comfortable, economic and commonly used for storage. Hence, the present study was undertaken with the objective to assess the impact of processing on storage stability and microbial quality of jackfruit seed flour.

Materials and Methods

Hard variety of jackfruits was procured from a single tree situated on UAS, Dharwad campus in the year 2016-17. Ripe fruits were cut and seeds were separated manually and processed employing common methods of cooking:

Boiling – 50g of seeds was transferred to a vessel containing boiling water, and boiled with closed lid at 100°C till soft and cooked.

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 1 and 2, water was drained, superfluous water was removed from seeds by dabbing on absorbent paper and cooled.

Pan roasting - 50 g of seeds were roasted in a heated pan at 160°C with continuous agitation till sweet aroma developed and cooled.

Microwave roasting – 50g of seeds were microwave roasted at 480 Power till the seeds turned soft, developed sweet roasted aroma and cooled.

Baking – 50 g of seeds were baked in pre-heated oven at 180°C till soft and sweet aroma developed for 15 min and cooled. Unprocessed seeds served as control.

Flour production: Unprocessed and processed jackfruit seeds were chopped uniformly. Dried separately in a hot air oven at 45 °C until consecutive weights were constant. Dried seeds were milled separately (Airani, 2007).

Fifty grams of unprocessed and processed jackfruit seed flour were packed individually in two packaging material *i.e.,* 160 gauge polyethylene and foil coated pouches. Pouches were stored at ambient temperature. Samples were withdrawn at 15 days interval and assessed for visual observation for infestation and colour change. Moisture uptake was analyzed in triplicates by AOAC method (Anon, 2000). Results were recorded, moisture content of flour and increase in moisture compared to zero day of storage was calculated and expressed in percentage. Microbial analysis for bacteria, fungi and *E. coli* was carried out monthly by total plate count method. The media used were nutrient agar, rose bengal agar and Eosin Methylene Blue (EMB) agar respectively. The technique used was pour plate method as described by (Diliello, 1982). A given sample was serially diluted and the appropriate aliquots were poured into different plates, followed by respective molten cool medium was poured separately and mixed uniformly by swirling plates. This ensures uniform distribution of microbial cells as the medium gradually cools and solidifies in plate. On solidification of medium the plates were inverted and incubated at 37 ± 1 ºC. The observations were recorded after 24 hr of incubation for bacteria and *E. coli* and after four to five days for fungi. Average counts of replications were expressed as number of Colony Forming Units (CFU)/g of sample by using following formula.

$$CFU/g = \frac{\text{Number of colonies} \times \text{dilution factor}}{\text{Weight of sample}}$$

Statistical analysis

Three way ANOVA was applied. Critical difference (CD) was used to test the significance between the samples. The probability fixed for the test of significance was p = 0.05, if significant then probability was further fixed for the test of significance was p = 0.01. All the analysis was done using SPSS software (version 16.0).

Results and Discussion

Visual observation and moisture uptake of processed jackfruit seed flour

During storage period of 180 days, no color change or visual infestation was observed in flour, irrespective of processing methods and packaging material used. There was an increase in moisture content of jackfruit seed flour with advancement of storage period. Moisture content increased from 10.33 per cent at 0 days to 12.25 per cent at the end of storage period of 180 days (Table 1).

Flour stored in polyethylene pouches had significantly higher moisture content (11.26 %) than foil coated aluminium pouches (10.96 %). This may be due to diffusion of gases and vapour through microscopic pores in packaging material or by activated diffusion through polyethylene pouches (Palling, 1980). Higher increase in moisture of cereal based food stored in polyethylene pouches over laminated pouches was reported by Banakar (2005) in the multigrain supplementary food and Guddad (2013) in grain based protein-energy dense mixes.

With respect to processing methods, pressure cooking and boiling had significantly higher moisture content of 12.76 and 12.72 per cent respectively, followed by unprocessed (11.69 %). Moisture content increased from 10.81 to 12.94 per cent, 9.24 to 10.60 per cent, 9.15 to 10.57 per cent and 9.47 to 10.90 per cent in unprocessed, pan roasted, microwave roasted and baked seed flour respectively from 0 to 180 days of storage. Probably the alterations in the structure of starch during wet and dry processing may lead to such a variation. Increase in moisture content was also reported by Airani (2007) in raw jackfruit seed flour stored at ambient and refrigerated conditions, Kiin-Kabari and Akusu (2014) in sun dried, roasted and boiled/oven-dried water melon seeds flour and Saha *et al.*, (2016) in solar, mechanical and oven dried jackfruit seed flour.

During storage of in polyethylene (Fig. 1) and foil coated aluminium pouches (Fig. 2), highest per cent increase was seen in pressure cooked (26.14 % and 18.68 % respectively) and boiled seed flour (26.01 and 18.03% respectively), followed by unprocessed seed flour (22.66 and 16.74 % respectively). Lower increase in per cent moisture content was seen in microwave roasted, baked and pan roasted seed flour. However, the increase was lower in foil coated aluminium pouches compared to polyethylene.

Effect of storage on microbial quality of processed jackfruit seed flour

Growth of bacteria and fungi was significantly higher in wet processed flour stored in polyethylene pouches (Table 2 and 3). Initially there was no growth of microorganisms upto 30 days in moist processed and upto 60 days in dry processed seed flour. This may be due to higher temperature used for processing which might have deactivated or killed microorganisms present in flour.

Table.1 Effect of storage on moisture content of processed jackfruit seed flour

Days	Unprocessed			Boiling			Pressure cooking			Pan roasting			Microwave roasting			Baking			Combined mean		
	P	F	Mean	P	F	Mean	P	F	Mean	P	F	Mean	P	F	Mean	P	F	Mean	P	F	Mean
0	10.81	10.81	10.81	11.65	11.65	11.65	11.67	11.67	11.67	9.24	9.24	9.24	9.15	9.15	9.15	9.47	9.47	9.47	10.33	10.33	10.33
15	10.89	10.88	10.89	11.76	11.74	11.75	11.78	11.76	11.77	9.30	9.28	9.29	9.21	9.19	9.20	9.53	9.51	9.52	10.41	10.39	10.40
30	10.97	10.94	10.96	11.87	11.80	11.84	11.88	11.83	11.86	9.35	9.32	9.34	9.27	9.24	9.26	9.58	9.55	9.57	10.49	10.45	10.47
45	11.12	11.00	11.06	12.05	11.88	11.97	12.04	11.89	11.97	9.42	9.39	9.41	9.33	9.30	9.32	9.65	9.63	9.64	10.60	10.52	10.56
60	11.36	11.14	11.25	12.32	12.03	12.18	12.37	12.06	12.22	9.54	9.45	9.50	9.45	9.42	9.44	9.77	9.68	9.73	10.80	10.63	10.72
75	11.60	11.22	11.41	12.58	12.15	12.37	12.60	12.18	12.39	9.65	9.53	9.59	9.57	9.47	9.52	9.88	9.78	9.83	10.98	10.72	10.85
90	11.79	11.31	11.55	12.83	12.33	12.58	12.85	12.36	12.61	9.76	9.60	9.68	9.68	9.52	9.60	10.01	9.84	9.93	11.15	10.83	10.99
105	12.04	11.45	11.75	13.15	12.49	12.82	13.25	12.55	12.90	9.95	9.64	9.80	9.87	9.58	9.73	10.20	9.89	10.05	11.41	10.93	11.17
120	12.27	11.58	11.93	13.53	12.65	13.09	13.59	12.76	13.18	10.11	9.76	9.94	10.04	9.69	9.87	10.36	10.02	10.19	11.65	11.08	11.36
135	12.48	11.98	12.23	13.77	12.99	13.38	13.79	13.02	13.41	10.23	9.89	10.06	10.15	9.81	9.98	10.49	10.14	10.32	11.82	11.31	11.56
150	12.72	12.16	12.44	13.92	13.22	13.57	13.98	13.31	13.65	10.38	10.09	10.24	10.31	10.04	10.18	10.66	10.36	10.51	12.00	11.53	11.76
165	13.02	12.39	12.71	14.35	13.52	13.94	14.36	13.58	13.97	10.52	10.34	10.43	10.44	10.25	10.35	10.79	10.60	10.70	12.25	11.78	12.01
180	13.26	12.62	12.94	14.68	13.75	14.22	14.72	13.85	14.29	10.73	10.47	10.60	10.68	10.45	10.57	11.03	10.76	10.90	12.52	11.98	12.25
Mean	11.87	11.50	11.69	12.96	12.48	12.72	12.99	12.53	12.76	9.86	9.69	9.78	9.78	9.62	9.70	10.11	9.94	10.03	11.26	10.96	

Factors	F value	S. Em. ±	C. D. at 1%
Processing methods (A)	1,030.40	0.045	0.126**
Packaging material (B)	66.863	0.026	0.073**
Interaction A × B	2.947	0.064	0.178*
Days (C)	91.406	0.067	0.186**
Interaction A × C	1.616	0.163	0.454*
Interaction B × C	2.632	0.094	0.262**
Interaction A × B × C	0.121	0.231	NS

*Significant at 5 % level
**Significant at 1 % level NS = Non - significant
P-Polyethylene pouch, F- Foil coated aluminium pouch

Table.2 Total bacterial count (x 10^1) in processed jackfruit seed flour

Days	Unprocessed			Boiling			Pressure cooking			Pan roasting			Microwave roasting			Baking			Combined mean		
	P	F	Mean	P	F	Mean	P	F	Mean	P	F	Mean	P	F	Mean	P	F	Mean	P	F	Mean
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	6.50	1.50	4.00	9.00	4.50	6.75	12.50	3.00	7.75	0	0	0	0	0	0	0	0	0	4.67	1.50	3.08
60	9.00	3.50	6.25	13.00	10.50	11.75	10.50	8.00	9.25	5.50	1.00	3.25	3.50	1.50	2.50	4.00	1.50	2.75	7.58	4.33	5.96
90	15.00	8.50	11.75	20.00	13.00	16.50	18.00	12.50	15.25	12.50	3.50	8.00	10.50	5.50	8.00	10.00	3.50	6.75	14.33	7.75	11.04
120	20.50	11.50	16.00	22.50	17.50	20.00	24.00	15.50	19.75	19.50	8.00	13.75	17.50	8.50	13.00	14.00	8.50	11.25	19.67	11.58	15.63
150	29.50	14.00	21.75	31.00	17.00	24.00	38.00	24.00	31.00	26.50	12.50	19.50	29.00	19.50	24.25	31.50	17.00	24.25	30.92	17.33	24.13
180	47.00	29.00	38.00	54.00	25.50	39.75	60.50	36.50	48.50	37.00	15.00	26.00	39.50	24.50	32.00	45.00	25.00	35.00	47.17	25.92	36.54
Mean	18.21	9.71	13.96	21.36	12.57	16.96	23.36	14.21	18.79	14.43	5.71	10.07	14.29	8.50	11.39	14.93	7.93	11.43	17.76	9.77	13.77

Factors	F value	S. Em. ±	C. D. at 1%
Processing methods (A)	1,172.00	0.10	0.28**
Packaging material (B)	9,315.33	0.06	0.16**
Interaction A × B	41.781	0.14	0.40**
Days (C)	13,924.30	0.11	0.31**
Interaction A × C	107.439	0.27	0.75**
Interaction B × C	1,107.66	0.16	0.43**
Interaction A × B × C	22.953	0.38	1.06**

Note: *E. coli* was not detected
**Significant at 1 % level
P-Polyethylene pouch,
F- Foil coated aluminium pouch

Table.3 Total fungal count (x 10^1) in processed jackfruit seed flour

Days	Unprocessed			Boiling			Pressure cooking			Pan roasting			Microwave roasting			Baking			Combined mean		
	P	F	Mean	P	F	Mean	P	F	Mean	P	F	Mean	P	F	Mean	P	F	Mean	P	F	Mean
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	2.50	1.00	1.75	3.50	1.00	2.25	4.50	2.00	3.25	0	0	0	0	0	0	0	0	0	1.75	0.67	1.21
60	5.00	2.00	3.50	9.00	2.50	5.75	10.50	5.00	7.75	3.50	0.00	1.75	4.00	0.00	2.00	5.00	0.00	2.50	6.17	1.58	3.88
90	10.00	4.50	7.25	13.50	6.00	9.75	15.50	8.50	12.00	6.50	1.50	4.00	8.00	1.00	4.50	8.50	2.00	5.25	10.33	3.92	7.13
120	14.00	7.50	10.75	16.50	10.00	13.25	19.50	14.00	16.75	18.00	7.50	12.75	16.00	8.00	12.00	15.00	6.50	10.75	16.50	8.92	12.71
150	18.00	11.00	14.50	21.50	14.50	18.00	31.50	18.50	25.00	20.00	10.50	15.25	24.50	13.50	19.00	25.00	14.00	19.50	23.42	13.67	18.54
180	27.00	16.50	21.75	34.50	20.50	27.50	37.00	25.00	31.00	31.00	19.00	25.00	31.00	17.00	24.00	37.00	23.00	30.00	32.92	20.17	26.54
Mean	10.93	6.07	8.50	14.07	7.79	10.93	16.93	10.43	13.68	11.29	5.50	8.39	11.93	5.64	8.79	12.93	6.50	9.71	13.01	6.99	10.00

Factors	F value	S. Em. ±	C. D. at 1%
Processing methods (A)	444.38	0.10	0.27**
Packaging material (B)	5819.00	0.06	0.16**
Interaction A × B	10.40	0.14	0.38**
Days (C)	8812.31	0.10	0.29**
Interaction A × C	52.71	0.26	0.71**
Interaction B × C	475.30	0.15	0.41**
Interaction A × B × C	8.08	0.36	1.01**

**Significant at 1 % level
P-Polyethylene pouch,
F- Foil coated aluminium pouch

Fig.1 Increase in moisture content of processed jackfruit seed flour stored in polyethylene pouches

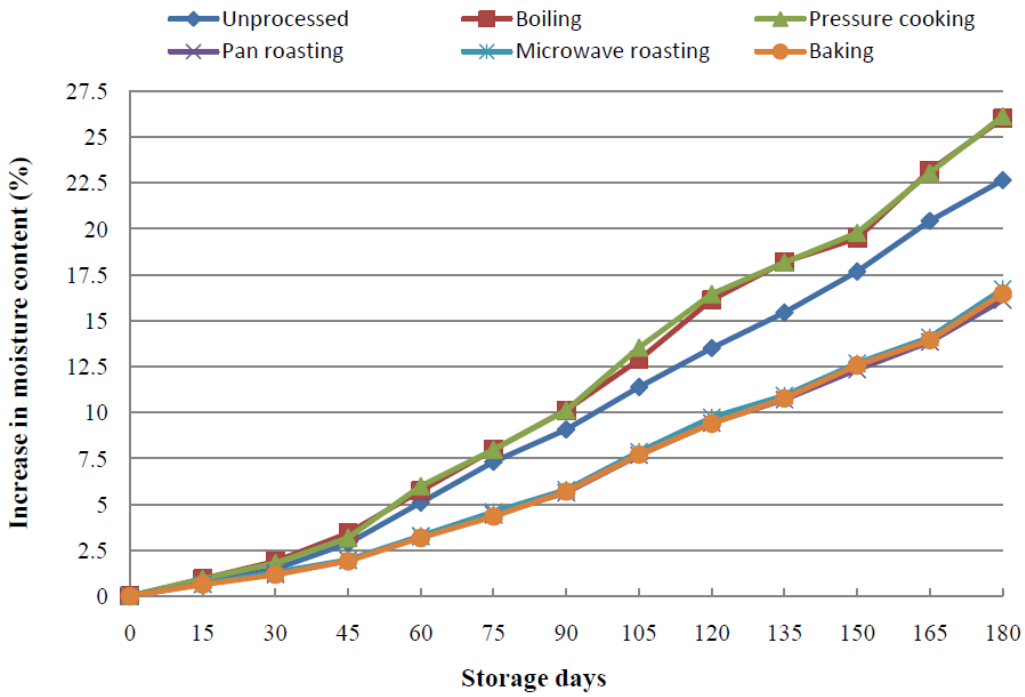
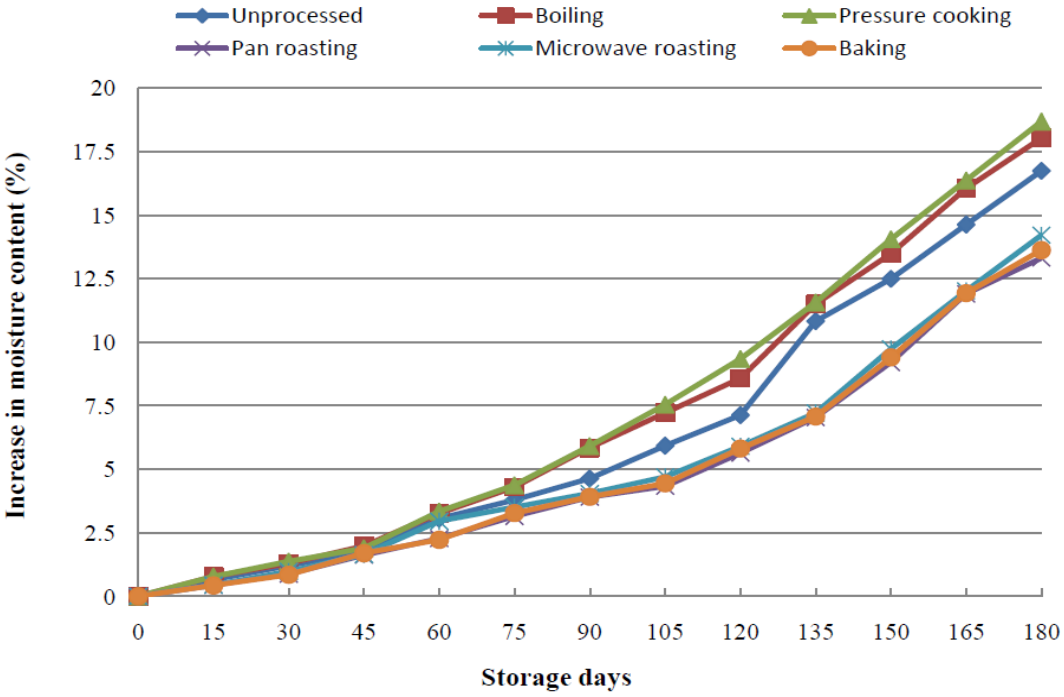


Fig.2 Increase in moisture content of processed jackfruit seed flour stored in foil coated aluminium pouches



Flour packed in polyethylene pouches had significantly higher number of bacterial colony (17.76 × 10^1 cfu/g) than that of foil coated aluminium pouches (9.77 × 10^1 cfu/g) irrespective of storage period and processing techniques (Table 2)**.** Among processing methods pressure cooked seed flour harboured significantly higher bacterial colony (18.79 × 10^1 cfu/g), followed by boiled (16.96 × 10^1 cfu/g), unprocessed seed flour (13.96 × 10^1 cfu/g). Pan roasted seed flour contained significantly lower bacterial colonies (10.07 × 10^1 cfu/g). Significantly higher numbers of fungal colonies were observed on flour packed in polyethylene pouches (13.01 × 10^1 cfu/g) than that in foil coated aluminium pouches (6.99 × 10^1 cfu/g) irrespective of storage period and processing techniques (Table 3). Among processing methods pressure cooked seed flour had significantly higher fungal colony of 13.68 × 10^1 cfu/g, followed by boiled (10.93 × 10^1 cfu/g). Unprocessed (8.50 × 10^1 cfu/g) and pan roasting (8.39 × 10^1 cfu/g) had significantly lower fungal colony (Plates 5 and 6).

This may be because, water content in food ingredients affects durability of food against microbial attack (Saha *et al.,* 2016). The higher the water content, more likely that the food is easily damaged, wherein the water content can be utilized by microorganisms, especially mold to grow and multiply (Fellows and Hampton, 1992 and Astaman, 2007). The increase in moisture content during storage might have created favourable conditions for growth of micro organisms in terms of water activity or aerobic conditions. Growth of microorganism was also reported by Thomaz *et al.,* (2014) in guava seed flour. Arpit and John (2015) reported that as incorporation level of jackfruit seed flour increased, yeast and mould count also increased significantly in formulated chocolate cake. Colonies of *E. coli* were not detected in the flour.

Though in this study, increase in moisture content and growth of microorganisms was observed, the increase was within the permissible limit. Hence, it can be concluded that jackfruit seed flour has good storage stability.

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