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Research Article

STORAGE STUDIES ON JACKFRUIT FLOUR AND DEVELOPED NOODLES

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Abstract: Value addition in jackfruit calls for products suiting the urban supermarkets. Instant noodles and jackfruit flour are such products envisaged for the modern customer. Seeds and bulbs of jackfruit (cv koozha) were processed to flour and then to noodles. These products were then analysed for their shelf life in ambient conditions for 3 months. They were packed in laminated and HDPE packages and analysed for their moisture content, insect infestation, microbial growth and sensory quality. The increase in moisture content of flours was lower in HDPE packages (0.75 percent). Insect infestation was not all detected in the samples after 3 months. Bacterial and fungal contaminations observed were within permissible limit. Moisture analysis of noodles revealed that increase in moisture pick up was higher in laminated packaging. Fungal colonies detected after 3 months were within permissible limits. Sensory qualities were also acceptable after 3 months of storage, thus indicating the scope for commercialization of these products.

Keywords: *Jackfruit, Bulb, Seed, Shelflife, Noodle, Sensory*

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Introduction

Jackfruit (*Artocarpus heterophyllus* L.) is the most widespread and significant member of the genus, Artocarpus. The tree is very popular in tropical region.
It belongs to the family Moraceae and the fruit is a favourite of many, mostly due to its characteristic sweetness. It is widely cultivated in the tropical regions of India, Bangladesh, Nepal, Srilanka, Vietnam, Thailand, Malaysia, Indonesia and Philippines. It is also cultivated across Africa, Cameroon, Uganda, Tanzania, Mauritius, Brazil and Caribbean nations like Jamaica However, India is considered to be the native land of jackfruit [1]. Among the fruit crops, jackfruit tree produces abundant fruits every year, even under neglected conditions. Jackfruit is rich in fibres, calcium, phosphorous, potassium, magnesium, vitamin C and carbohydrate. It has high sugar content and antioxidant activity and less calories, which is beneficial for health [2]. In India, the fruit is not utilized properly. The bulbs are usually consumed fresh, as it has low shelf life, *i.e*. 2-3 days, after which they will start to rot. When viewed globally this is an excellent example of a food prized in some countries and allowed to go waste in others. It is yet to be realised that jack fruit has got great potential to increase shelf life through value addition. Therefore, it is necessary to process the fruit and transform it into different food products to give it an economic value [3]. Improvement in value addition not only to minimizes losses but also contributes to the income of rural farmers and would also ensure the availability of superior quality produce to the consumer at reasonable prices throughout the year [4].

Materials and methods:

Locale of the study

The experiment was conducted at the Department of Home Science, College of Agriculture Vellayani, Thiruvananthapuram, Kerala during the year 2013-2015.

Selection of cultivar

Jackfruit variety "Koozha" was selected for the study owing to its abundant availability and lower utilisation.

Raw mature jackfruits were harvested from the trees grown in the Instructional farm, College of Agriculture, Vellayani and also from the adjacent home yards, for the study purpose.

Preparation of bulb and seed flour

The flour was prepared from the raw jackfruit bulbs and seeds by milling of pre-treated bulbs and seeds and they were analysed for physical, chemical, nutritional and shelf life quality.

Preparation of Noodles

Composite flour was prepared in six different combinations of refined flour, bulb flour and seed flour. The flour treatments were extruded into noodles using a Brabender single screw food extruder. The details of combinations are presented in [Table-1].

Table-1 *Combinations of composite flour (100g)*

SN	Treatments	Refined flour (Maida)	Jackfruit bulb flour (JFBF)	Jackfruit seed flour (JFSF)
1	T_1	40	30	30
2	T_2	50	25	25
3	T_3	50	30	20
4	T_4	50	40	10
5	T_5	50	10	40
6	T_6	50	20	30

Shelf-life qualities of flour and noodles

The shelf life of a food is the time period within which the food is safe to consume and has an acceptable quality to consumers. Shelf stability of a product depends on factors like raw materials used in the products and chemical composition of the product. Shelf life studies can provide important information to product developers, enabling them to ensure that the consumers will receive high quality products for a significant period of time after production. The flours were stored in ambient conditions for three months.

Shelf-life of flour and noodles were assessed for three consecutive months. At intervals of 1 month or 30 days randomly selected samples were analysed. Shelf life qualities of flour were assessed through changes in moisture content, insect infestation and microbial quality. Developed noodles were observed for the moisture, insect infestation, microbial growth and sensory quality during storage.

Moisture

Five grams of the sample was weighed into previously weighed moisture cups and dried in an oven at 100ºC till a constant weight was attained. Moisture content of the flour and noodles stored in HDPE and laminated packages were analysed at monthly intervals for 3 months in a similar way.

Moisture %= Initial weight (g)- Final weight (g) / Initial sample weight (g) [5]

Insect infestation

Insects are responsible for deterioration of the quality of flours by contamination with their droppings and hair. During the storage period, insect infestation was observed at monthly intervals through sieving and visual observation.

Microbial profile

The fresh as well stored flour and noodles samples were assessed for the presence of various microorganisms' *viz*. bacteria, fungi, and coliforms at monthly intervals up to three months. The microbial evaluation was done initially and at 30 days intervals up to 3 months. The growth of bacteria, fungi and coliforms were observed using Nutrient agar (NA), Potato dextrose agar with rose bengal (PDARB) and Eosin methylene blue (EMB) respectively. The evaluation was done by serial dilution of samples followed by pour plating technique suggested by Johnson and Curl [6]. The serial dilution of the samples followed by pour plating was employed to estimate the population of viable micro-organisms in the developed flour.

Sensory quality of stored noodles

Sensory evaluation plays an important role in the acceptability of a new product. It is a scientific measure of the senses like sight, smell, touch, taste and hearing by analysis and interpretation of human response to a product [7]. The samples were taken at random from HDPE and laminated packets at periodic intervals of 3 months and reconstituted and prepared with uniform recipe and presented to judges. Sensory characteristics like appearance, colour, texture, taste and overall acceptability of the noodles were assessed by a panel of judges using a five-point scale.

Statistical analysis

The data generated was subjected to analysis of variance (ANOVA) using complete randomized design. Critical difference at $p \leq 0.05$ was estimated and used to find significant difference, if any.

Results and Discussion

Shelf life quality of flour

Assessment of moisture in stored flour

Moisture provides a measure of the water content of the jackfruit bulb flour and seed flour and its total solid content. The moisture content of freshly prepared bulb flour was 7.23 percent, which gradually increased up to 7.99 (HDPE) and 8.13 percent (laminated) in final (3rd) month of storage. Similarly, seed flour had an initial moisture content of 7.97 percent which increased up to 8.75 percent (HDPE) and 8.97 percent (laminated) in 3rd month. Even though both the packaging materials revealed less increase in moisture content, their difference was significant. The variation in the percentages may be due to different water vapour transmission rates of packaging material. The selection of the right films for packaging involves the consideration of water vapour transmission rate, and gases transmission characters. Similarly, it was found that increase of moisture percent was less in HDPE packages in bulb (0.75 percent) and seed (0.77 percent) flour. The samples kept in laminated covers exhibited an increase in moisture content by 0.89 percent and 0.99 percent for bulb flour and seed flour respectively. In present findings, there was increase in moisture content in all the samples during storage. On the other hand, according to standards (IS: 7836 AND 7837 1975) the moisture content of products should be less than 9%. As reported by Oladapo *et al*. [8] packaging materials had an effect on the moisture level of roasted cashew nuts during the storage Murugkar and Jha [9] studied the influence of storage and packaging conditions on the quality of soy flour from sprouted soybean and reported that flours can be kept in Aluminium foil laminated packages for 60 days (ambient) and 45 days (accelerated). They further reported that the variation in moisture contents of these products was directly related to the water vapour transmission rate of the packaging materials. In another study by Goyal and Kumar [10], it was reported that the highest moisture content of potato flour was 5.78 % was observed in LDPE poly packs and the lowest moisture content (4.8%) was observed in HDPE packed flour stored at room temperature. There was significant effect of packaging material and storage period and combined effect of packaging material and storage period on moisture content. It also affected the hygroscopic properties of flour, as reported by Rahman *et al*. [11]. The drying process plays a significant role in the flour moisture content [12]. The lower the moisture content of flour, better the shelf stability and hence the quality [13]. It is also shelf stable in terms of moisture and microbes. It can, therefore, be concluded that raw jackfruit flour can be used as a potential raw material for the development of extruded products like noodles enriched with nutrients.

Assessment of insect infestation in stored flour

The assessment of the incidence of insect pest in the stored flours revealed that there was no insect infestation in the HDPE and laminated covers. For grain infestation, moisture is the most significant factor that influences the flour quality during storage. Generally, moisture content below 9% restricts infestation. In this study also moisture content was less in both type of flours and this might have restricted the growth of insects. Ogedegbe and Edoreh [13] reported that, food products that were left undisturbed on the shelves for long periods were particularly susceptible to infestation. The main factors which could have contributed to infestation could be the residual populations from old stock, unclean storage containers, unhygienic condition of the warehouses with high moisture content, mix-up of bags of flours in stores and markets, lack of knowledge of the insect pests and alternate hosts.

Assessment of microbial quality of jackfruit flour

Jackfruits (bulb and seed) were subjected to adequate heat treatment like blanching and boiling during processing for ensuring the absence of pathogenic microorganisms and as far as possible through preventing their multiplication by pre-treatments. The details of microbial analysis are presented in [Table-3]. The study revealed that there was no bacterial and fungal attack in both type of flours initially as well in the first and second month. After 3 months, bacterial and fungal contaminations were observed in bulb and seed flour, but it was within the permissible levels. It may be due to increase in moisture content, characteristics of packaging material and storage conditions. There was no presence of coliforms observed in fresh as well as stored samples. Total plate count of fungi was 1.5 $x10^2$ and 2.0 $x10^2$ in bulb and seed flour, which could be due to the ability of fungi to grow in low moisture and high carbohydrate content. Total microbial count was found to be more in seed flour. The reason for this phenomenon could be that seed flour contains more protein and fat and so chances of proteolytic and lipolytic organisms to grow on them is more. There are different threats on food quality due to microbial infestation. Spoilage by microorganisms is the primary cause of the end of shelf life of products hence reducing initial microbial populations is a strategy to extend shelf life [14]. Ojure and Quadri [15] reported that total plate count of the plantain flour was observed to be 2.1 x 10^2 cfu/g and fungal count was observed to be 1.1x 10^2 cfu/g. However, no coliforms or staphylococcal was detected in plantain flour. Nasheeda [16] reported that the bacterial population of banana powder packed in poly propylene covers ranged between 5.6-6.88 x 10^3 cfu/g.

Table-2 *Moisture analysis of flour during storage (%)*

SN	Treatments	Initial		1st month		2nd month		3rd month		Increase (%)	
		HDPE	Laminated	HDPE	Laminated	HDPE	Laminated	HDPE	Laminated	HDPE	Laminated
1	Bulb	7.23	7.23	7.44	7.55	7.64	7.88	7.99	8.13	0.75	0.89
2	Seed	7.97	7.97	7.99	8.12	8.34	8.65	8.75	8.97	0.77	0.99
CD (0.05)		0.14		0.23		0.56		0.74			

(Results are expressed as mean values of three replicates)

Table-3 *Microbial profile of jackfruitflour*

Treatments	Bulbs			Seeds		
	Bacteria cfu/gx10^6	Fungi cfu/gx10^2	Coliforms cfu/gx10^6	Bacteria cfu/gx10^6	Fungi cfu/gx10^2	Coliforms cfu/gx10^6
Initial	-	-	-	-	-	-
1st month	-	-	-	-	-	-
2nd month	-	-	-	-	-	-
3rd month	1.0	1.5	-	1.5	2.0	-

(Results are expressed as mean values of two replicates)

Table- 4 *Moisture content of noodles during storage period (%)*

Treatments	Initial		1st month		2nd month		3rd month		Increase (%)	
	HDPE	Laminated	HDPE	Laminated	HDPE	Laminated	HDPE	Laminated	HDPE	Laminated
T_1	6.40	6.40	6.54	6.71	6.76	6.96	7.13	7.24	0.73	0.84
T_2	6.45	6.45	6.65	6.77	6.92	6.98	7.22	7.31	0.77	0.86
T_3	6.41	6.41	6.64	6.73	6.92	6.97	7.22	7.43	0.81	1.02
T_4	6.40	6.40	6.52	6.73	6.72	6.98	7.24	7.29	0.84	0.89
T_5	6.47	6.47	6.68	6.77	6.85	6.92	7.35	7.46	0.88	0.99
T_6	6.45	6.45	6.62	6.68	6.83	6.91	7.31	7.39	0.86	0.94
CD (0.05)	0.013		0.019		0.021		0.024			

Shelf life quality of noodles

Moisture

Measurement of moisture content in food is very important with respect to shelf stability. The initial moisture levels of noodles were 6.40, 6.45, 6.41, 6.40, 6.47, and 6.45 for T1, T2, T3, T4, T5, and T6 treatments respectively. After the three months of storage, the value of moisture increased in T1 (7.13, 7.24), T2 (7.22, 7.31), T3 (7.22, 7.43) T4 (7.24, 7.29), T5 (7.35, 7.46) and T6 (7.31, 7.39) in HDPE and laminated covers respectively. Moisture analysis of the products showed that product packed in HDPE covers showed less moisture content in all the treatments. The results of the study are presented in [Table-4]. In the present investigation, moisture content of developed treatments ranged from 6.40-6.47 percent. The reason in variation may be because the developed treatments had different ratios of RF, RJBF and RJSF. Meanwhile, the moisture content of commercial noodles was found to be 5.79 percent. Lower moisture content in commercial noodles may be because of the additives that are added to maintain the moisture level. Though all treatment showed almost similar moisture content, their values were found to be higher in T5 (6.47) and it was on par with T6 with a score of 6.45. This indicates that the seed flour possibly has a higher moisture content with more hygroscopicity than bulb flour.

This observation is in line with the findings of Akanbi *et al*. [17] who had observed that moisture content of bread starch (BS) and wheat flour (WF) noodles ranged from 4.65 (60% BS:40% WF) to 5.45% (100% BS:0% WF). An inference can therefore be drawn that RJF noodles apart from being healthy and free of additives, also conform to the standards of world food and health regulatory agencies. With the progression of storage period, the moisture content increased from its initial value. This is in line with the findings of Wani *et al.* [18] who reported an increase in moisture content in roasted wheat flour and cauliflower noodles from 9.55 to 10.92 percent in 3rd month. They further stated that this might have resulted from the differences in the level of water added to dough containing various levels of cauliflower leaf powder before mixing. Studies further revealed that both the packaging materials did not show much increase in the moisture content however there was lesser increase in HDPE packaged product than laminated covers. This might be due to the high-water vapour transmission rate of laminated covers.

Microbial study of stored noodles

Microbial population in processed foods is an important factor, which determines the quality and safety of the product. When foods are processed, there are chances of contamination through various means including processing or conditions of storage. These microbes multiply and cause spoilage of the products. Hence assessment of microbial population of the noodles is an essential step in the development of new products. It is evident from the [Table-5]. that during the three months of storage period, no bacterial colonies were found to appear in the developed products. But fungal colonies were observed in T2 in the second (1.5 x 10^3cfu) and third (3.0 x 10^3cfu) months. Even though fungi were detected, it was present only in negligible levels within the permissible limits. The reason could be due to mishandling and contamination during processing. No other treatments showed microbial and fungal growth during period of study, emphasizing that, developed product were shelf stable for three months. No coliforms were detected during storage period in all the treatments. Simpson [19] suggested processed foods and other food materials provide ample scope for contamination with spoil age organisms, thus necessitating microbial quality assessment, as an integral part of processing. The microbiological safety of food is achieved as much as possible by ensuring the absence of pathogenic microorganisms and preventing their multiplication by all possible means [20]. Adequate heat- treatments ensures that vegetative-pathogens free food products.

Table-5 *Microbial profile - Fungal colonies cfu/g(x10^2)*

SN	Treatments	Initial	1st month	2nd month	3rd month
1	T_1	ND	ND	ND	ND
2	T_2	ND	ND	1.5	3.0
3	T_3	ND	ND	ND	ND
4	T_4	ND	ND	ND	ND
5	T_5	ND	ND	ND	ND
6	T_6	ND	ND	ND	ND

Results are expressed as mean values of two replicates) ND- not detected

Sensory stability of stored noodles

Sensory evaluation is a very organized holistic approach to product assessment. It encompasses evaluation by all senses but emphasizes the individual perception.

Appearance of stored noodle

The appearance of the final food product that goes to shelf is of utmost importance. Various factors contribute to the perception of the organoleptic characteristics of a food product.

All three situations are extremely important to the consumer and hence to the processor [21]. In the present investigation there was a considerable change in the value of appearance and there were decreasing trends observed in scores during storage, though it was acceptable to judges. Any product is universally accepted to be in the best form while fresh. The study came out with high scores for T5 (4.59) among all the six treatments for appearance though control scored a slightly higher value 5.00). This may be because T5 had higher seed flour and seed flour was whiter in colour than bulb flour which had a slightly yellowish appearance. The score for T4 was lower for appearance because this treatment contained more amount of bulb flour which turned slightly brown after drying, which may be due enzymatic browning. Statistical analysis showed that there was decrease in scores for appearance during storage, though the product was acceptable to judges.

Table-6 *Evaluation of appearance of noodles during storage*

SN	Treatments	Initial	1st month	2nd month	3rd month	CD (0.05)
1	T_1	3.79	3.74	3.64	3.53	0.063
2	T_2	3.87	3.80	3.79	3.72	0.052
3	T_3	3.71	3.68	3.49	3.26	0.071
4	T_4	2.98	2.94	2.80	2.16	0.074
5	T_5	4.59	4.43	4.42	4.21	0.067
6	T_6	4.42	4.37	4.28	4.13	0.064

Results are expressed as mean scores of sensory panel

Colour of stored noodles

Colour is one of the important parameters used by the consumers to evaluate visual quality and is useful for better marketability of noodles [22]. In this study there was change in colour of noodles during storage periods and the colour scores were found to decrease after each month in all six developed treatments. However, it did not make the product unappealing. White colour and a translucent appearance have been linked with high quality noodles [23]. Colour of the noodles was found to be superior in T5 and T6 which contained higher amount of seed flour. Seed flour was white in colour than bulb which had slightly yellowish colour. Since a certain amount of yellow colour develops as a result of natural pigments in bulb flour, control was found to be superior in colour in comparison to all the samples because refined flour is white in colour because of getting bleached. In this context it can be inferred that natural colour can score values on par to commercial noodles. Colour always had an important implication on the minds of people as far as food is concerned. Colour plays a substantial role in terms of organoleptic features. The aim is to preserve natural colour or maintain the unique characteristic colour of a food product during long term storage. The statistical analysis shows that there was significant change in score of colour of noodles during storage periods and the colour scores were found to decrease after each month in all six developed treatments. This however did not make the product unappealing.

Table-7 *Evaluation of colour of noodles during storage*

SN	Treatments	Initial	1st month	2nd month	3rd month	CD (0.05)
1	T_1	3.89	3.86	3.83	3.78	0.094
2	T_2	3.72	3.61	3.66	3.60	0.098
3	T_3	3.55	3.49	3.50	3.19	0.135
4	T_4	3.37	3.35	3.32	3.05	0.129
5	T_5	4.77	4.75	4.71	4.68	0.076
6	T_6	4.74	4.71	4.64	4.66	0.054

(Results are expressed as mean scores of sensory panel)

Texture of stored noodles

As far as noodles are concerned, texture plays a noteworthy role. Texture analysis hold the second most significant sensory attribute of a food product [24].

It is important in determining the eating quality of foods and can have a strong influence on food intake and nutrition. Perceived texture is closely related to the structure and composition of the food. In the present analysis, no considerable difference was observed regarding texture. It was observed that there was significant change in the score of texture during the storage period and rightly pointed out that though the fresh texture was not present, it was still acceptable and marketable. Sensory score for texture was high in T5 and T6 with a score of 4.89 and 4.75 and they were found to be on par. This may be because these treatments contained more seed flour. Seed four has high starch content and so their flour was finer than bulb. Highest score was obtained for control (4.91) with respect to texture which may be because; refined flour has good elastic property owing to its high amylopectin content. This observation is in line with findings of Hatcher *et al.* [25], who reported that, textural quality of noodles was found to be affected by flour particle size. Flours with fine particle produced wheat noodles with the best textural parameters. Similarly, sorghum flour with smaller particle size produced stronger and firmer noodles [26]. This suggests that the texture of the modified noodles was slightly altered by incorporating RJF. It was observed that, there was significant change in texture scores during the storage period. The results further revealed that considerable difference was found in stored noodles as values consistently decreased during storage period. The panel however did not point out any unacceptable rating.

Table-8 *Evaluation of texture of noodles during storage*

SN	Treatments	Initial	1st month	2nd month	3rd month	CD (0.05)
1	T_1	3.65	3.62	3.50	3.38	0.064
2	T_2	3.73	3.62	3.38	3.23	0.093
3	T_3	4.54	4.41	4.21	4.09	0.057
4	T_4	4.21	4.10	3.97	3.81	0.049
5	T_5	4.89	4.64	4.45	4.05	1.325
6	T_6	4.75	4.70	4.55	4.27	0.529

(Values are expressed as mean scores of sensory panel)

Taste of stored noodles

One of the most important aspects of any food product is its taste which gives an identity to consumers. During the storage period scores for taste of noodles also decreased with time. Significant difference and decreasing trend were observed, but it was not declared unacceptable by the panel. Though decreasing trends in values were observed for taste of noodles during storage period, it was not declared as unacceptable by the panel. During the storage period scores for taste of noodles also decreased with time.

Table-9 *Evaluation of taste of noodles during storage*

SN	Treatments	Initial	1st month	2nd month	3rd month	CD (0.05)
1	T_1	4.45	4.41	4.39	4.35	0.045
2	T_2	4.29	4.22	4.13	4.00	0.069
3	T_3	4.78	4.71	4.60	4.52	0.054
4	T_4	4.71	4.62	4.55	4.48	0.043
5	T_5	4.87	4.72	4.67	4.59	0.096
6	T_6	4.93	4.85	4.78	4.69	0.085

(Values are expressed as mean scores of sensory panel)

Overall acceptability

Overall acceptability comprises appearance, colour, texture and taste of developed products. In the present study, overall acceptability was found to show a decreasing trend with storage. But this also did not give a negative value to the product. The decrease in values was expected, as fresh product always differs from a stored product. Significant difference and decreasing trends were observed for values on overall acceptability of noodles during storage period, but it was declared as acceptable by the panel, in all the above parameters.

Table-10 *Evaluation of overall acceptability during storage*

SN	Treatments	Initial	1st month	2nd month	3rd month	CD (0.05)
1	T_1	3.94	3.90	3.84	3.76	0.049
2	T_2	3.9	3.81	3.74	3.63	0.064
3	T_3	4.14	4.07	3.95	3.76	0.059
4	T_4	3.81	3.75	3.66	3.37	0.048
5	T_5	4.78	4.63	4.56	4.38	0.095
6	T_6	4.71	4.65	4.562	4.43	0.084

(Results are expressed as mean of scores of sensory panel)

Conclusion

The composite flour comprising of Jackfruit seed flour and jack fruit bulb flour were seen to have appreciable shelf life and the processed noodles from this flour was also seen to be safe with respect to moisture level, microbial profile and sensory qualities, on storing till three months.

Application of research: Ascertaining the shelf life of a commercial product is as important as its development. Hence this analysis is very much relevant for taking up the commercialisation of the project

Fig-1 Jackfruit Flour and Developed Noodles

Research Category: Post Harvest Technology

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Study area / Sample Collection: Instructional farm, College of Agriculture, Vellayani

Cultivar / Variety / Breed name: Jackfruit (*Artocarpus heterophyllus* L.)

Conflict of Interest: None declared

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