International Journal of Food Science and Nutrition
ISSN: 2455-4898
Impact Factor: RJIF 5.14
www.foodsciencejournal.com
Volume 2; Issue 5; September 2017; Page No. 73-76

Optimization of dehydrated jack seed crisp using response surface methodology with the interaction of freezing time, blanching time and moisture level for better rehydration properties

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Abstract
The intermediate processed product from jackfruit seed – Dehydrated jack seed crisp- could be a raw material for more than a dozen of commercial products like jack seed coffee, snacks, savouries, extruded snacks, nutri-mixes, and more. The independent factors for dehydrated jack seed crisp- freezing time, blanching time and moisture level for the response, better rehydration properties were optimized using Response Surface Methodology (RSM) and the Box-Behnken design was used for optimising these three factors. The freezing time, blanching time and moisture level were optimized for better rehydration properties of dehydrated jack seed crisp were studied at three different levels after considering the FSSAI standards for dehydrated products. The factors such as freezing time(10hours) blanching time(15 minutes) and moisture level(10%) were optimized for the response, rehydration time (5.57) minutes using this design. Rehydration tests of this optimized combination was performed in comparison with the control groups has shown significant differences in its sensory properties, especially in the textural characteristics.

Keywords: dehydration, jack seed, process optimization, freezing, blanching moisture, rehydration

1. Introduction

Jack is native to parts of South and South east Asia and is believed to have originated in the South Western rain forests of the Western Ghats in the Indian Sub Continent in present-day Kerala, West Bengal, coastal Karnataka, and Maharashtra, but also Indonesia [1].

Jackfruit is a climacteric fruit, which is characterized by a transient increase in ethylene synthesis and respiration at an early stage of ripening itself [2]. The ripe fruit is perishable and cannot be stored for long time because of its inherent compositional and textural characteristics. Being a cross pollinated crop, wide variation is observed for all important quantitative characteristics like fruit size, shape, colour, yield, flowering season, period of maturity, etc. There is wide variability in the seed characteristics like size, texture, shape, colour, cooking time and taste.

In the life span of average 160 days of jackfruit, the fully ripe stage will be for 3-5 days due to its climacteric characteristics. If the fruit can be preserved in this stage, the alternative of this product as a raw material throughout the year is possible. When fruit bulbs were taken out for processing, jack seeds remains as an underutilized part of this nutritious fruit. During sensory studies, it was observed that seeds of fully matured or ripe fruit had good sensory properties.

The mature jack seeds could be eaten boiled, roasted or dried and salted as table nuts, or they can be ground to make flour and blended with wheat flour for baking. Seed flour, which is high in protein and carbohydrate, has good water and oil absorption abilities, and is used as an alternative for wheat flour to reduce calorie intake [3]. It is reported that jackfruit seeds may be converted into flour after inactivating the anti nutritional factors, by drying [4]. It is also reported that the jackfruit seed flour produced may be used as thickening and binding agent in food systems [5].

In view of the fact that the dehydrated jack seed (dehydrated crispy seeds) from fully mature ripe jackfruit could be the a potential intermediate product from jackfruit seed which could facilitate the production of more than a dozen of commercially viable secondary products throughout the year and would reduce the under utilization of this edible nutritious part of jackfruit. This product was selected for further processing and standardisation.

Standardisation of each procedure is very important. The hurdle principle is based on the principle that while any single barrier to microbial growth may be inadequate for desired protection, a number of barriers together can enhance product stability [6]. As rehydration property is a major response for dehydrated products, the factors freezing time, blanching time and moisture levels were optimized for better rehydration time using Response Surface Methodology (RSM).

2. Materials and Methods

Response surface methodology is a collection of statistical and mathematical methods that are useful for the modelling and analyzing engineering problems. In this technique, the main objective is to optimize the response surface that is influenced by various process parameters. Response surface methodology also quantifies the relationship between the controllable input

parameters and the obtained response surfaces [7].

Fruit maturity ranging from 150-160 days was safely harvested from the tree. Fully mature fruits with preference to slight colour changes, widened spines, tapping sound of the fruit and sometimes slight yellowing of the last leaf were collected. The method of harvesting, can significantly impact upon the composition and post-harvest quality of fruits and vegetables. The time of harvesting and prevailing weather conditions can also influence the quality and shelf life of produce. Safe harvesting procedure using fruit harvester was used to avoid injury of the fruit. Special care was given to collect the fruit before 8 am of the day to avoid the field heat. Before sending fruit sample for ripening, attention was paid to check whether fruits were free from growth cracks and mechanical damages. After safe washing, draining of water, fruits were kept under ordinary room temperature for ripening, for 3-5 days. The experiments were started after day 3 of storage. It was assumed that, the fruit was ready for processing when the rind was fairly soft, and when the fruit released an aromatic odour. At this stage fruit bulbs and seeds are separated and seeds were taken up for processing into dehydrated jack seed crisp.

2.1. Optimisation of blanching time, freezing time and moisture level of dehydrated seed crisp for better rehydration properties

The collected seeds were put into the cabinet drier, for one hour, at 60ºC, to remove the excess moisture on its outer coat. As a result, it allowed easy removal of thick outer coat manually by using a stainless steel knife or mechanically by using a potato/cashew peel remover. Following this, seeds were sent to a mechanical vegetable shredder, and the material was completely shredded off.

To process jackfruit seed crisp, shredded seeds were subjected to blanching. Blanching is one of the most widely used pre-treatments in the drying of vegetables. It is also known as scalding, parboiling or precooking. The object is to soften the texture and also to reduce the number of microorganisms by as much as 99% [8]. *A. Heterophyllus Lam*. seed, the trypsin inhibitor showed a decrease in the inhibition activity when it was heated to 100°C, 75% of the activity was lost. Moreover, the inhibitory activity was not sensitive to pH over the range from 4.0 to 8.0, except at extreme pH condition [9]. Hence, to control its trypsin inhibition property and to denature the anti-nutrient factor lectin as well as to obtain better textural properties, microbial fall, shredded seeds of different sizes were sent for blanching with boiling water. The blanching time assessed was 10, 15 and 20minutes with a pH 3.5 for optimum quality end product.

The seed shreds were then subjected to freezing operation. The seed shreds were loosely packed in polythene pouches and sealed. These pouches were kept under -18ºC at different freezing periods such as 8,10 and 12 hours and observations were recorded. Thereafter the trays were set with cabinet drier for dehydration of seed crisps. The moisture content of fresh jackfruit seeds ranges from 45-62% according to the cultivar and season of availability. The samples were sent to a hot air drier and dehydrated at 90ºC to control the moisture level up to 7%, 10% and 13 %.

Response Surface Methodology and the Box-Behnken design were used for optimising the three factors. This was studied at three different levels, and a total of 15 runs were used for the study according the design. Moisture levels particulars were 7, 10 and 13%. Three freezing periods (8, 10 and 12 hours) and three blanching periods (10, 15 and 20 minutes) were also selected as per the study design (Table.1)

Table 1: The levels of variables chosen for the Box-Behnken design.

Factors	Symbol	Coded Variable Level		
		Low	Centre	High
		-1	0	+1
Moisture (%)	X_1	7	10	13
Freezing time (Hours)	X_2	8	10	12
Blanching time (Minutes)	X_3	10	15	20

Table 2: Box-Behnken design for optimisation of freezing time, blanching time and moisture level for better rehydration time.

Run	Moisture (%)	Freezing time (Hours)	Blanching time (Minutes)	Rehydration time (Minutes)
1	7	8	15	7
2	13	8	15	5
3	7	12	15	5
4	13	12	15	5
5	7	10	10	10
6	7	10	20	4.5
7	13	10	10	10
8	13	10	20	3
9	10	8	10	10
10	10	12	10	8
11	10	8	20	7
12	10	12	20	3
13	10	10	15	5.5
14	10	10	15	6
15	10	10	15	5.5

2.2. Rehydration tests for quality evaluation

In this dehydration method, processed forms were less bulky and less delicate to handle and could be stored in room temperature with suitable packaging options. The samples optimized combination, using this design, such as freezing time (10hours) blanching time (15 minutes) and moisture level (10%) for the response, rehydration time (5.57 minutes) were further proceeded for quality evaluation.

The reconstitution tests were conducted for dehydrated seed crisps in comparison with the control groups. In reconstitution, water is added to the product which is restored to a condition similar to that when it was fresh [8]. The trial particulars were, T1- Sample of simple dehydrated crisp up to 10% moisture without any pre-treatments, T2- Dehydrated sample up to 10% moisture with the pre treatment of 15 minutes blanching and T3 was the sample from optimized combination of freezing time (10hours) blanching time(15 minutes) and moisture level (10%). Finally a sample of 35 grams from the packed final product of T1,T2 and T3 each were weighed out of the previous day's production. These samples were put to separate beakers and added 275 ml of cold water and 3.5grams of salt. The covered beakers with the water were brought to boil for 5 minutes. The samples were turned on to a petri dish [8]. A sensory evaluation was conducted for the samples using 9 point hedonic scale and the scores were obtained from a 10 member expert panel.

3. Results and Discussion

3.1. Optimisation of freezing time, blanching time and moisture level for better rehydration time

RSM was used to optimize the conditions for better rehydration time during storage period, as it is a quality raw material for secondary products. The effect of factors like freezing time, blanching time and moisture level were studied by fitting a response surface regression model to determine the optimum level of each factor for maximum response. Using the results of the experiments, the following second- order polynomial equation giving the rehydration time as a function of freezing time, blanching time and moisture level was obtained.

Rehydration time = 5.571429 - Freez - 2.5625*Blan + 1.366071*Blan*Blan

Table 3: ANOVA for lesser rehydration time of dehydrated jack seed crisp – Predictive model.

Source	Degree of freedom	Sum of squares	Mean squares	*F* value	*P* value
Freez. time	1	8	8	9.885657	0.0093
Moisture	1	52.53125	52.53125	64.91324	<.0001
Blanch. time					
Freezx Freez					
Freezx Mois					
Freez x Blan					
Mois x Mois					
Mois x Blan					
Blan x Blan	1	6.966964	6.966964	8.609127	0.0136
Model	3	67.49821	22.4994	27.80267	<.0001
(Linear)					
(Quadratic)					
(Cross Product)					
Error	11	8.901786	0.809253		
(Lack of fit)	5	5.610119	1.122024	2.045208	0.2046
Pure error	6	3.291667	0.548611		
Total	14	76.4			

The significance of the regression model calculated is listed in table.3, in which it contains three linear, three quadratic and three interaction terms. The regression coefficient for rehydration time was found to be significant with the linear effect of Freezing time (*p* value =0.0093), Moisture level (*p* value=<.0001) and quadratic effect of Blanching time (*p* value = 0.0136) It shows the *p* value for test of significance of the effects under study by ANOVA.

3.2. Rehydration for quality evaluation

The rehydrated samples of T1 (Simple dehydrated jack seed with 10% moisture without any pre-treatments) T2 (Dehydrated sample with 10% moisture and the pre treatment of 15 minutes blanching) and T3 (Optimized sample) were subjected for sensory evaluation and the results are depicted in fig.1.

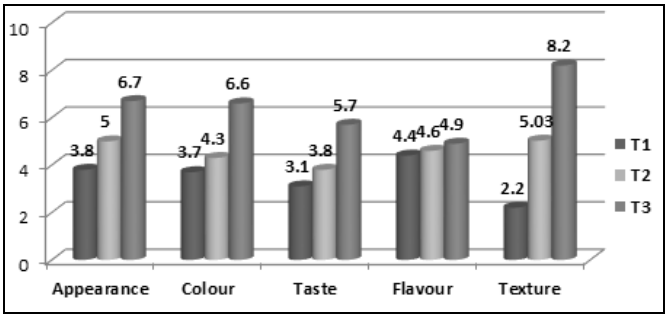

Fig 1: Sensory evaluation sores on comparison of rehydrated jack seeds.

It shows, in the case of all sensory characteristics, the optimized combination stands at the higher end, especially in its textural properties. During the rehydration experiment, 5

minutes boiling time were given for all trial samples, since the optimized rehydration time for dehydrated seed crisp was 5.7 minutes. During sensory evaluation, T1 was quite hard and woody in nature. T2 was slightly softer, but some portions remain woody and tough. The optimized combination was set at ready to eat soft texture and the rehydration was unique. This was due to the freezing process accompanied with the preliminary blanching. This result is supported with the finding of Saxena *et al.* (2013) on Dehydrated jack fruit bulb crisps, that the combined dehydration method, whereby, both freeze dehydration and hot air dehydration were employed in order to obtain high quality jack fruit crisps which can be consumed as they are, and may also be readily reconstituted as an instant product [10]. This is also supported with the finding of Srivastava and Sanjeev (2013), wherein it is stated that during freezing, water is redistributed in food by the formation of ice crystals. When water changes state from liquid to solid, there is a 9% increase in volume that is responsible for changes in textural characteristics of frozen material. When the material dries directly, the dried product will be more hygroscopic and it will reconstitute readily [8].

4. Conclusion

In the status report of Asia-Pacific Association of Agricultural Research Institutions for Jackfruit Improvement in the Asia-Pacific Region, highlighted the future prospects and strategy for jackfruit utilization as a) Appropriate methods for post-harvest handling, processing and product development for local and regional markets should be developed. b) Greater efforts need to be made for processing, value addition and product development. It is also emphasised that outreach activities need to be strengthened for popularizing the utilization of jackfruit seed flour at household level [11]. This dehydrated jack seed crisp is a simple, cost effective technology with better rehydration properties and can pave a way for the effective utilization of this underutilized part of Jackfruit.

5. References

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