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Developing sustainable and nutritious convenient foods from agricultural wastes: A case study on jackfruit seed-based instant and functional dessert mixes

Saranya S T[1], Krishnaja U[2], Beela G K[3], Suma Divakar[4], Anith K N[5]
[1] Department of Community Science, College of Agriculture, Kerala Agricultural University, Vellayani, Trivandrum, Kerala, India
[2] Assistant professor, Department of Community Science, College of Agriculture, Kerala Agricultural University, Vellanikkara, Thrissur, Kerala, India
[3] Professor and Head, Department of Community Science, College of Agriculture, Kerala Agricultural University, Vellayani, Trivandrum, Kerala, India
[4] Professor, Department of Community Science, College of Agriculture, Kerala Agricultural University, Vellayani, Trivandrum, Kerala, India
[5] Professor, Department of Agricultural Microbiology, College of Agriculture, Kerala Agricultural University, Vellayani, Trivandrum, Kerala, India

Abstract
Food production has been impacted by climate change and the expanding global population as a consequence of periods of drought, catastrophic weather conditions, and altered seasons. Using minor species of crops, resolving food and nutrition security hurdles, and incorporating underutilized crop species are approaches of developing an adaptive agricultural system. India has experienced a significant shift in eating habits due to globalization, shifting from traditional to fast and junk foods. Customers are becoming more value-conscious, health-conscious, and cost-conscious. The food industry offers a variety of instant meals, known as the "food revolution." This shift has led to a rise in nuclear families with two incomes, altering consumer behavior and consuming more processed food products. People are looking for innovative products nowadays and are excited to savor new flavors that are available. Agricultural products are processed so that it will provide added value in the agricultural processing chain. The potential of jackfruit seed waste (*Arthocarpus heterophyllus*) has not been utilized optimally. "*Payasam*," a rice dish cooked with sugar or jaggery in milk until gelatinized, is one well-known traditional food. This cumbersome method, which is popular in South India during festivals, gives sophisticated food goods an opportunity to become ready-to-cook instant ethnic dessert mixtures. This study provides a concise description of processing, pointing out the best treatment to develop jackfruit seed-based dessert mix. The best method for developing the Jackfruit seed-based dessert mixes were selected based on their physic-chemical qualities and sensory attributes. Incorporating jackfruit seed into the diet offers a nutritious and sustainable alternative to starch, adding a unique twist to culinary innovations.

Keywords: Jackfruit seed, dessert mix, functional, agricultural waste**,** Instant, physic-chemical

Introduction

One of the most avid edible fruits in the world is the jackfruit (*Artocarpus heterophyllus* Lam). A distinctive characteristic that sets the jackfruit tree apart from other trees in the Moraceae family is its capacity to yield more fruits than any other tree (between 70 and 200 kg per tree, depending on variety, social norms, and environmental conditions). The typical weight of a fruit is between 3.5 and 10 kg, yet certain fruits can weigh up to 25kg (Kumar *et al*., 2002) [1]. Since the dawn of time, there have been reports of the therapeutic use of jackfruit seeds and bulbs due to their special attributes. The high concentration of phytochemicals, particularly phenolic compounds, provides potential for the manufacturing of value-added products like nutraceuticals and a range of food applications, all of which can provide health-related benefits (Umesh *et al.,* 2010) [2].

Food consumption has increased due to the world's swiftly expanding population, which has rendered it challenging for established organizations, food producers, and researchers to optimize the use of already-available crop or food sources. Jackfruit is an underutilized fruit because most of them are thrown away due to supply chain limitations, illiteracy, and a lack of postharvest technologies. The market for jackfruits and their waste is quite enormous, but it might be filled with processed value-added products that might boost income and ensure food security (Sundarraj *et al.,* 2018) [3].

The need for food is rising by the increasing population and to fulfill the amount of food needs, various efforts could be made, such as utilization of agricultural products. People are constantly searching for novel products lately, and they are eager to explore the different kinds of those that are hitting the shelves. "*Payasam*" is a central traditional cuisine that is adored by every individual in society and serves as an option for every occasion. The delicious dessert requires quite a bit of effort and time to put together, which is an exhausting task. Complex food products have a tremendous chance to become instantly ready ethnic dessert mixtures that people are able to make. Potential cultivars that produce fruits of a better quality conducive to value-adding and product diversification could move jackfruit out of the "neglected" category into the commodity market for exports. Using the miracle fruit will improve prospects for self-sustainment and stable finances. Modern applications for jackfruit could be further expanded by incorporating them to convenience foods like *Payasam* Mixes available in the market. Thus, this study was undertaken with the objective of developing Instant Functional Dessert Mixes by substituting Jackfruit seeds in the place of rice, which will serve as a sustainable and nutritious alternative.

Materials and methods

The seeds of the two popular jackfruit cultivars in Kerala, *varikka* cv. and *koozha* cv., were selected for the study. Mature fruits were selected in order to collect seeds and the fruit bulbs were used for making jackfruit preserve. The ripened fruit was procured from the local markets and the Instructional farm at the College. Banana, Milk powder, Coconut milk powder, Sugar and Jaggery were procured from the local market.

v_1- *Varikka*

v_2- *Koozha*

Optimization of protocol for Jackfruit Seed-based Base Material (JSBM) for development of ethnic dessert mixes

The seeds of both cultivars were cleaned manually and peeled off before processing. The pre-processed seeds were gelatinized to remove anti-nutritional factors. The seeds were finely diced, dried, ground into powder and blended with water to form a base material (batter). The batter was steamed on aluminum foil/butter paper; the sheets obtained were separated and diced into desirable shape and size, then dehydrated to a constant weight and moisture content. Thus the protocol for Jackfruit Seed-based Base Material (JSBM), which serves as the main substrate for the ethnic dessert mixes, was optimized.

Preparation of functional ingredients (osmotically dehydrated fruits)

The process involves blanching of sliced fruits, adding sugar, and letting it stand for a day to dissolve. The syrup is then boiled to increase its strength, with citric added to prevent crystallization. The fruit is preserved in the syrup for 24 hours, and then immersed for three days alternatively. The preserves are sealed in jars, covered with syrup to prevent drying out and cooled to prevent discoloration. The osmotically dehydrated fruits were then stored in dry jars after being drained out of syrup or glass containers (swami *et al.,* 2014).

Plate: 1 Osmotically dehydrated fruit

Banana preserve

Jackfruit preserve

Standardization of Instant Functional jackfruit seed-based ethnic dessert mixes

In order to formulate the jackfruit seed-based functional and instant ethnic dessert mix. The JSBM (base material prepared from jackfruit seeds) was combined with the different ingredients as follows:

f1 - JSBM + Sugar + osmotically dehydrated Jackfruit + Milk Powder

f2 - JSBM +Sugar + osmotically dehydrated Jackfruit + Coconut Milk Powder

f3 - JSBM +Jaggery + osmotically dehydrated Jackfruit + Milk Powder

f4 - JSBM + Jaggery + osmotically dehydrated Jackfruit + Coconut Milk Powder

f5 - JSBM + Sugar + osmotically dehydrated Banana + Milk Powder

f6 - JSBM +Sugar+ osmotically dehydrated Banana + Coconut Milk Powder

f7 - JSBM +Jaggery + osmotically dehydrated Banana + Milk Powder

f8 - JSBM + Jaggery+ osmotically dehydrated Banana + Coconut Milk Powder

The JSBM was combined with Milk powder/ Coconut milk powder, Banana preserve/Jackfruit preserve, Sugar/jaggery in different proportions. The dessert mixes thus obtained were packed and stored under ambient conditions.

Selection of best dessert mixes

Jackfruit seed-based dessert mixes obtained from the above mentioned 8 treatments, each from *varikka* and *koozha* cultivars were tested for physic-chemical qualities like yield ratio (dry and wet basis), rehydration ratio, solubility index, swelling power, water absorption capacity and sensory attributes to select the best treatment from each cultivar.

Assessment of Physico-chemical qualities of Instant Functional jackfruit seed-based ethnic dessert mixes

Yield ratio: Yield ratio of the developed products was analyzed using the formula.

$$\text{Yield ratio} = \frac{\text{Final weight of product (g)}}{\text{Weight of the ingredients (g)}}$$

(Krishnaja, 2014)

Rehydration ratio: To ascertain the rehydration ratio of jackfruit seed-based dessert mixes, 10 grams of the sample was taken, combined with 100 milliliters of distilled water, stirred, and allowed to stand for five minutes. Paper filters were used to filter the contents. Using the formula (Ranganna, 1995), the rehydrated sample was weighed and the rehydration ratio was computed.

$$\text{Rehydration ratio} = \frac{\text{Weight of the sample (g)}}{\text{Drained weight of the sample (g)}}$$

Solubility index: Solubility index was calculated using Anderson *et al.* (1969)'s methodology. One gram of material was suspended in 10ml of distilled water in a centrifuge tube and it was centrifuged at 3000 rpm for 30 minutes at room temperature with moderate stirring in between. After being weighed out, the supernatant was placed in a petri dish and dried at 110°C in a hot air oven. The weight of the dry soluble solids in supernatant, or g/g, is the solubility index. It is represented as a percentage of the initial sample weight.

$$\text{Solubility Index} = \frac{\text{Weight of dry solids} \times 100}{\text{Volume of supernatant Weight of sample}}$$

Swelling power: Swelling power was calculated using a slightly modified version of the approach of Leach *et al.* (1959). One gram of the material and ten millilitres of distilled water was taken in a centrifuge tube and heated for thirty minutes at 80°C. Throughout the heating process, the mixture was mixed frequently. Following heating, the suspension was centrifuged for 15 minutes at 1000 rpm. After removing the supernatant, the paste's weight was measured.

$$\text{Swelling power} = \frac{\text{Weight of the paste}}{\text{Weight of dry sample}}$$

Water absorption capacity: The technique of Sathe and Salukhe (1981) was employed to determine the water absorption capacity, with a few changes. A weighted centrifuge tube was filled with one gram of sample and ten millilitres of distilled water. After five minutes of continuous shaking, the tube was let to remain at room temperature for fifteen minutes. It was centrifuged for 30 minutes at 5000 rpm after that. The supernatant was thrown away. After gently siphoning adhering water droplets over absorbent paper while the tube was inverted, the tube was weighed again. One gram of dry sample powder was used to represent the weight of water bound by the water absorption capacity.

Statistical analysis: For the study, the data from multiple assessments were performed using KAU-GRAPES (online statistical analysis tool) for Completely Randomized Design (CRD) for functional quality and nutrient analysis of the ethnic dessert base. The Kruskal-Wallis test was used to determine the sensory evaluation scores of the dessert base based on the observed mean values.

Sensory evaluations: An integral part of any research product or product development process is sensory evaluation. It contains insightful information about a product's sensory qualities and aids in determining consumer acceptability and preferences. In this study, sensory parameters like color and appearance, texture, taste, aroma, mouthfeel and overall acceptability of jackfruit seed-based dessert mix was analyzed by a panel of 10 semi-trained members.

Plate. 2 Sensory evaluation of dessert mixes

Plate. 3 Developed dessert mixes from *Varikka cv.* and *koozha cv.* of jackfruit seeds

Results and discussion

The dessert mixes from *varikka* and *koozha* cultivars were developed by several trial-and-error methods for selecting the best processing treatments and cooking methods. The seeds of the jackfruit were gelatinized for 10 minutes each, then drained, diced finely, and dried at 70°C for two hours before being ground into a fine powder. In order to get the batter consistency desired for cooking, it was combined with water. After that, batter was spread out on thin butter paper, coiled up, and steam- or boiling-boiled for ten minutes. After separating and drying the butter paper foundation to the necessary moisture content, it was combined with a standard dehydration temperature and duration of 60°C for two hours to create instant dessert mix. The best combinations of dessert mixes were selected on the basis of functional parameters like yield ratio, solubility index, swelling power, rehydration ratio, water absorption capacity and sensory evaluation.

Physico-chemical qualities of Instant Functional jackfruit seed-based ethnic dessert mixes

Physico-chemical properties like yield ratio, rehydration ratio, solubility index, swelling power, water absorption capacity of the 16 treatments were evaluated on the basis of the procedure mentioned in selection of best dessert mix. The results of the same are depicted in table no. 01 and 02.

Table 1: Physico-chemical qualities of *varikka* cultivar-based dessert mixes (dry and wet basis)

Treatment	Yield ratio (Dry)	Yield ratio (Wet)	Rehydration ratio	Solubility index	Swelling power	Water absorption capacity
f_1v_1	1.277	3.067^{c}	0.413	0.971	1.733^{a}	2.633^{a}
f_2v_1	1.287	3.150^{bc}	0.407	0.969	1.386^{b}	2.616^{a}
f_3v_1	1.297	3.200^{bc}	0.417	0.979	1.373^{b}	2.230^{abc}
f_4v_1	1.367	3.466^{b}	0.390	0.974	1.363^{b}	1.960^{c}
f_5v_1	1.393	3.866^{a}	0.407	0.969	1.680^{a}	2.513^{a}
f_6v_1	1.283	3.133^{bc}	0.417	0.966	1.800^{a}	2.406^{ab}
f_7v_1	1.327	3.416^{bc}	0.430	0.970	1.240^{b}	2.530^{a}
f_8v_1	1.290	3.133^{bc}	0.463	0.959	1.920^{a}	2.063^{bc}
±SE(m)	0.027	0.121	0.017	0.005	0.09	0.143
CV (%)	3.57	6.33	7.228	0.907	10.011	10.467
CD	NS	NS	NS	NS	0.271	0.429
t-value	NS	NS	NS	NS	2.12	2.12

Treatments with same letters are not significantly different.

Values are mean of triplicates

Table 2: Functional qualities of *koozha* cultivar-based dessert mixes (dry and wet basis)

Treatment	Yield ratio (Dry)	Yield ratio (Wet)	Rehydration ratio	Solubility index	Swelling power	Water absorption capacity
f_1v_2	1.277	3.150	0.470	0.975	2.200^{a}	2.233
f_2v_2	1.340	3.367	0.430	0.946	1.900^{ab}	2.283
f_3v_2	1.323	3.233	0.420	0.976	1.800^{b}	2.603
f_4v_2	1.320	3.217	0.433	0.965	1.720^{b}	2.200
f_5v_2	1.363	3.700	0.460	0.956	1.653^{bc}	2.473
f_6v_2	1.353	3.400	0.420	0.972	1.226^{d}	2.463
f_7v_2	1.353	3.467	0.447	0.967	1.360^{cd}	2.347
f_8v_2	1.313	3.250	0.447	0.962	2.146^{a}	2.283
±SE(m)	0.028	0.136	0.018	0.01	0.109	0.163
CV (%)	3.595	7.051	7.083	1.859	10.829	11.924
CD	NS	NS	NS	NS	0.328	NS
t-value	NS	NS	NS	NS	2.12	NS

Treatments with same letters are not significantly different.
Values are mean of triplicates

Physico-chemical and functional qualities are the intricate relationship between the molecular adherence, composition, structure, physical and chemical characteristics of food ingredients, as well as the context in which these are related and assessed, is represented by the fundamental physical and chemical characteristics (Kaur *et al.,* 2006). The table 01 and 02 shows the values obtained for physico-chemical parameters of each cultivar. The yield ratio of developed dessert mixes ranged from 1.27 to 1.39 percent on dry basis and 3.06 to 3.86 percent on wet basis. According to Veenakumari (2015), the yield ratio of an extruded product made from jackfruit ranged from 0.86 to 0.97 percent which indicates similarity in the reported values. The developed dessert mixes had rehydration ratio ranged from 0.39 to 0.47 percent. A study conducted by Kaushal *et al.* (2016) [4] observed that with the increase in drying temperature (50 – 70 ◦C), the rehydration ratio of jackfruit samples dried at 50◦C was 0.43 whereas jackfruit samples dried at 70◦C was 0.40. The result and reported values are analogous. Solubility index of the developed dessert mixes ranged between 0.94 to 0.97 percent. A study investigated by Airani (2007) [5], suggested that water soluble index Jackfruit seed flour was 1.80%, the result and reported values are similar. Swelling power of the developed dessert mixes ranged from 1.2 to 2.2 percent. The values obtained from this study are close to the range reported by Ocloo (2010) who gave a value of 4.7 percent. The water absorption capacity of dessert mix ranged from 1.9 to 2.6 percent. According to a study by Tharani (2018), the rinds of *varikka* and *koozha* jackfruits had a water absorption capacity of 4.88% and 4.98%, the reported values are comparable.

Evaluation of sensory qualities of Instant Functional jackfruit seed-based ethnic dessert mixes

Sensory evaluation of jackfruit seed-based instant and functional ethnic dessert mix was carried out by cooking 15g of dessert base (JSBM) with 20g of milk/coconut powder in 200ml water, 10 g of sugar/jaggery and 5g of osmotically dehydrated jackfruit/banana respectively. The results of sensory evaluation are depicted in the table no. 03 and 04.

Table 3: Sensory evaluation of *varikka* cultivar based dessert mix

Treatment	Appearance	Texture	Aroma	Taste	Mouthfeel	Overall Acceptability
f_1v_1	8.2^{a}	7.2	7.3	8.0^{ab}	7.6	7.6
f_2v_1	8.3^{a}	7.2	7.2	6.2^{c}	6.7	7.1
f_3v_1	7.8^{abc}	7.1	7.0	7.4^{abc}	7.4	7.3
f_4v_1	7.2^{bc}	6.6	7.0	6.7^{ac}	6.5	6.8
f_5v_1	8.3^{a}	7.9	7.7	8.0^{b}	7.7	7.9
f_6v_1	7.8^{abc}	6.9	6.8	6.7^{abc}	6.9	7.0
f_7v_1	8.1^{ab}	7.7	7.2	7.2^{abc}	7.1	7.4
f_8v_1	7.0^{c}	6.6	7.1	6.4^{c}	6.1	6.6
x^2	14.405	8.926	3.368	14.308	7.443	8.426
P-value	0.044	0.258	0.849	0.046	0.384	0.297

Treatments with same letters are not significantly different.

Table 4: Sensory evaluation of *koozha* cultivar based dessert mix

Treatment	Appearance	Texture	Aroma	Taste	Mouthfeel	Overall Acceptability
f_1v_2	7.8	7.3	7.6	8.2^{c}	7.0	7.5
f_2v_2	7.7	7.2	6.8	7.3^{abcd}	6.4	7.0
f_3v_2	7.6	7.1	7.6	7.8^{abc}	7.0	7.4
f_4v_2	7.7	7.7	7.1	6.6^{abde}	6.4	7.1
f_5v_2	8.0	7.8	7.9	7.9^{ac}	7.6	7.8
f_6v_2	7.1	6.7	6.5	6.0^{de}	5.7	6.4
f_7v_2	7.5	6.9	6.8	6.4^{bde}	6.6	6.8
f_8v_2	6.9	6.6	5.8	5.6^{de}	6.0	6.1
x^2	4.668	3.785	10.537	23.306	9.332	10.116
p-value	0.7	0.804	0.16	0.002	0.23	0.182

Treatments with same letters are not significantly different.

Sensory evaluations are the assessment, and interpretation of reactions to food items as perceived by the gustatory, tactile, visual, and olfactory senses. It can be viewed as a field of study that examines particular features of a food ingredient or product by contrasting and comparing similar products (Hossain, 2014). The tables 03 and 04 represents, the values obtained for sensory evaluation of each cultivar. From the tables it is clear that the treatment f_5v_1 and f_5v_2 had the highest acceptability for appearance and the treatment f_5v_1 was on par with f_1v_1 and f_2v_1. As for the sensory attribute texture, f_5v_1 and f_5v_2 had the highest and f_4v_1, f_8v_1, f_8v_2, had the lowest score. The treatment f_5v_1 and f_5v_2 had the highest score for aroma and mouthfeel among other treatments. Taste is a complicated phenomenon that influences its acceptability, delight, and overall satisfaction. The treatment f_5v_1 and f_5v_2 had the most acceptability, the treatments f_2v_1 (7.6), f_8v_1 (6.6), f_3v_1 (7.1), f_6v_1 (7) and f_7v_1 (7.4), f_6v_2 (6.4), f_8v_2 (6.1) were on par with each other.

Conclusion

The functional and instant ethnic dessert mixtures made from jackfruit seeds are convenient to put together and rich in dietary supplements. In contrast to commercially available dessert mixes, specially developed mixes offer a good source of nutrients. As a result, the convenient and productive ethnic dessert mixtures developed from jackfruit seeds might be considered an innovative product. As consumer knowledge of sustainable living rises, so does the capacity to produce creative, nutritious and ready-to-eat food products. Now that consumers are aware of the connection between food, health, and the impact on the environment, they can adopt a credible dietary pattern. The development of fruit by-products for value-added products has sparked scientific interest. The development of such instant ethnic dessert mixes will make dessert (*payasam*) preparation, handling, storage, and packaging more convenient for both home and entrepreneurs. With the acceptable physico-chemical and organoleptic properties, the food industries can utilize the agricultural produce like jackfruit seeds which is generally considered as waste.

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