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Advances in value addition in jackfruit (*Artocarpus heterophyllus* Lam.) for food and livelihood security of rural communities of India

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The Food and Agricultural organization of the United Nations (FAO, 2002), have defined food security as a situation when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life. Food security has been considered as a part of livelihood security which has been defined as adequate and sustainable access to income and resources to meet basic needs *viz.*, adequate access to food, potable water, health facilities, educational opportunities, housing and time for community participation and social integration (Frankenberger, 1996). The rural livelihoods in India involve a variety of on-farm and off-farm activities culminating in to the availability of food or cash by which food or other survival necessities can be procured. Therefore, livelihood is a complex term and can have several possible sources of entitlement varying with each household (Drinkwater and McEwan, 1992). The livelihood securities of the rural communities of India are going to be a big challenge in context of population explosion and climate change. Agriculture contributes upto 14 per cent of the Indian GDP and half of the population of India directly or indirectly depends on agriculture (OECD, 2014). India shall surpass China and become world's most populated country in 2022 and the population of India shall reach as high as 1.7 billion in 2050 (UNO, 2015). Historically, loss of livelihood securities of rural communities has been a major cause of social unrest and even rebellion. The global climate change, seasonal shift and loss of agricultural genetic resources shall add up in the loss of agriculture based livelihoods of the communities. The agricultural productivity is a crucial part of food and livelihood security. The resiliency of agricultural production system is predicted to decrease in the coming times due to the above cited reasons (Mukherjee, 2016). The agriculture based livelihood securities are based on a few species. The base of agriculture production system in the form of number of species particularly the under-utilized or

negelcetd agri-horticultural speices needs to be widened (Janick, 1999). Not only this, the products of such species which are not as much accepted, need to be improved by value addition. According to the USDA (2015) a value added agricultural product has following features.

– It has undergone a change in physical state.

– It was produced in a manner that enhances the value of the agricultural commodity.

– It is physically segregated in a manner that results in the enhancement of its value and hence it is a source of enhanced revenue to the producer.

– It is a source of farm- or ranch-based renewable energy.

– It is aggregated and marketed as a locally-produced agricultural food product.

– The customer base for the agricultural commodity is expanded due to the above interventions.

In the present paper, jackfruit (*Artocarpus heterophyllus* Lam.), one of the largest fruit in the entire plant kingdom, has been proposed as an agent of livelihood security of the rural communities by value addition of its fruits.

Jackfruit is one of the most remunerative and important underutilized native fruits of India. It belongs to the family Moraceae. It is native and being grown all over the country upto the elevation of 1500m above msl (Bose and Mitra, 1996). However, the major areas of cultivation in India are the eastern and southern parts of the country. These include the states of Jharkhand, Bihar, West Bengal, Uttar Pradesh, Orissa, Chhattisgarh, Andhra Pradesh, Tamil Nadu, Kerala and Karnataka. Among the tropical fruits, Jackfruit is an important underutilized fruit and often called the poor man's fruit because of its affordability and availability in large quantities during the fruiting season. Jackfruit trees are mostly gown in the homestead garden without any management practices.The jackfruit trees are highly productive and bear regularly. Production of 300-500 kg fruits per tree depending on the age of the tree and conditions under which grown has been reported. The individual fruit weight generally varies from 0.98-57.80 kg at maturity (Nath *et al*., 2001). The fruit contributes to the livelihoods of the poor people as the fruits can be harvested from wild or locally available trees. Moreover, it has a potential to increase local income when grown in agroforestry and home garden systems.

The compound fruit of jackfruit is made of three parts *viz.*, bulb (30-32%), seeds (18%) and the rind (5-55%). The primary economic product of jackfruit is the fruit, used both when immature and when mature. The main use of jackfruit is as vegetable when still unripe; however, ripened fruits (arils) are also eaten when ripe as a dessert. The jackfruit is nutritionally very rich and contains high amount of vitamins and minerals (Table 1). The fruit is rich in carotene and carbohydrates and moderately rich in ascorbic acid (Rahim and Quddus, 2000; Samaddar, 1985 and Hossain *et al*., 1979). It also contains some minerals like calcium and potassium and Vitamin B like thiamin, riboflavin, and Niacin. The large sized seeds are boiled or roasted and eaten as such or made into cooked vegetable. The seeds are reported to be more nutritious than the bulb, being richer in protein, fat, potassium and carbohydrate with considerable amount of phosphorus and calcium (Acedo, 1992; Rahim and Quaddus, 2000). Moreover, the timber of the tree is highly valued for its strength and sought for construction and furniture. The dried leaves are stitched to make disposable plates. Thus, jackfruit provides huge opportunity for livelihood as well as nutritional and food security of the rural communities of India.

Table 1: Nutritive value of jackfruit (100 g)

Constituent	Average value
Moisture (%)	76.2
Energy (cal)	88.0
Protein (g)	1.90
Fat (g)	0.10
Fibre (g)	1.10
Carbohydrates (g)	19.8
Potassium (mg)	107.0
Calcium (mg)	20.0
Phosporus (mg)	41.0
Iron (mg)	0.56
β Carotene (mg)	175.0
Thiamine (mg)	0.03
Riboflavin (mg)	0.13
Niacin (mg)	0.40
Vitamin C (mg)	7.0

(Source: Devi *et al*., 2014)

The total jackfruit production in India has been recorded to be around 2.04 million tonnes (NHB, 2015). Out of this a significant portion goes waste beacuase of its highly perishable nature and seasonal glut. The post harvest losses in jackfruit are around 30-35 per cent during the peak season (Lakshminarayan, 2017).

Therefore, jack fruit has great potential for value addition for minimizing post-harvest loses and enhancing the non-seasonal availablity. More than 100 items can be prepared from jack fruit right from immature stage to well ripened stage (Table 2). The importance of the fruit, seed and rind is known very little to the growers and consumers. Absence of organised marketing strategies among the growers results in wastage of major quantity of the jackfruit produced. Hence, value addition is important to utilize the surplus fruits available during the season as well to improve the livelihood of the farmers by producing value added products.

Value addition is the process if changing or transforming a product from its original state to a more valuable state (Sharma *et al.*, 2014). Value addition to agricultural products is the process of increasing the economic value and consumer appeal of an agricultural commodity. Various value-adding technologies such as processing and preservation techniques, dehydration and drying technology, freezing technology, packing, labeling, etc. can be applied to agricultural produce to increase its value. The value added products from unripe, half ripe and ripe jackfruit and seed are discussed here and presented in Table 2.

Value added products from unripe jackfruit :

Chips :

Raw or unripe jackfruits are used for preparing chips. Slices of suitable sizes are cut and blanched into hot water at 95° C for 5 minutes. Then the slices are dried at 60° C for 1 hour and 70° C for next 6 hours. Finally the slices are fried at 160° C in edible oil. The slices are removed from the pan when they turn light yellow in colour and mixed with salt and packed (Bhuyan *et al.*, 2013).

Pickle :

Unripe jackfruits are used for preparing pickle. Small pieces are made from bulbs and seeds and they are mixed with oil, salt and spices before packing.

Brined product :

Mature green jackfruits are washed with clean water, peeled and cut into small pieces. Then they are kept in 8 per cent salt, 1.25 per cent acetic acid, 0.1 per cent KMS and 91.65 per cent water solution. Then the materials is poured into air tight plastic container and stored in cool and dry place (Bhuyan *et al.*, 2013).

Ready to cook (*RTC*) *jackfruit* :

The jackfruit is washed, peeled and cut into suitable sized pieces. These pieces can be preserved and packaged with minimal processing to prepare ready to cook jackfruit products.

Dehydrated jackfruit :

The unripe mature bulbs can be blanched and dehydrated for further use throughout the year.

Value added product from half-ripe jackfruit :

Jackfruit candy :

For candy preparation half-ripe jackfruit (medium hard flesh) is selected and washed. Then it is cut into 1x 0.5x 0.5 cm pieces and blanched in hot water at 95° C for 4 minutes. After that the pieces are immersed in 2 per cent calcium lactate and 0.1 per cent KMS for 2 hours and drained. The pieces are then dipped into sugar solution of 25, 35, 45, 50, 60 and 70 Brix at 12 hours interval. The slices are drained and washed with clean water to remove adhering syrup followed by drying at 70° C in a cabinet dryer until the moisture content reaches to 10 per cent. The product is packed in polypropylene pouch and stored at room temperature (28-32° C) (Bhuyan *et al*., 2013).

Value added products from ripe jackfruit :

The recovery of bulbs or edible portion (pulp) from jackfruit varies from 20 per cent to 25 per cent. The bulbs from the fruits are removed manually after cutting the fruit in several pieces. As the fruit contains sticky latex, small quantity of vegetable oil is applied on hands

Table 2: Value addition in jackfruit

Stage of fruit	Value added products
Unripe fruit	Pickle, Chips, Papad, Brined Jackfruit, RTC Jackfruit, Dehydrated Jackfruit, Culinary preparations, Cutlets, *Biryani*
Half ripe fruit	Candy, Preserve
Fully ripe fruit	Jam, Leather, Rind Jelly, Squash, Nectar, Canned Bulbs, RTE (Ready-to-eat) Bulbs, RTS (Ready-to-serve) Drinks, Chutney , Toffee, Wine, *Halwa, Kheer, GulabJamun*, Icecream, Custard, Cake , Freeze dried pulp
Seeds	Seed powder, Starch flour, Culinary preparation, *Pakoda, Kheer*

and then seeds are removed from bulbs.

Jam :

Jam is prepared from the pulp of ripe fruits with additives. Bulbs from a fully ripe jackfruit are blended and boiled for 5-7 minutes to extract juice. Then 700g sugar and 10g pectin is added to 1kg jackfruit pulp and cooked until the TSS reaches to 64 °Brix, then citric acid (0.25%) is added. End point is determined through flake test and the jam is poured while hot in sterilized bottle and stored at room temperature (Bhuyan *et al.*, 2013).

Jackfruit rind jelly :

Fully matured ripe jackfruit are harvested and washed with clean water. Rind is separated and cut into small pieces. Then, 1.5 lit water and 2g citric acid is added for each kg rind and the contents are boiled for 35 minutes and the juice is extracted from the rind. To this juice, 700g sugar and 200 mg citric acid is added and the juice is then cooked until the TSS reach to 65 °Brix followed by addition of citric acid. The jelly is then poured into sterilized bottle and stored at room temperature (Bhuyan *et al.,* 2013).

Jackfruit leathers :

Fully ripe jackfruit is washed and bulbs are taken after removing the seeds. These bulbs are blended with 10-15 per cent sugar and boiled for 5-7 minutes for extracting juice. After this KMS @ 0.1g/kg is added and then further boiled for 3-5 minutes. The mixture is concentrated with steam jacketed pan and spread in a stainless steel tray. The tray is put in a cabinet dryer and dried for 20 hours at 60° C until the moisture content reaches to 20 per cent. After cooling it is cut into pieces of desirable sizes and stored after packaging (Bhuyan *et al.,* 2013).

Nectar :

The bulbs are passed through pulping machine and pulp is made by mixing around 10 per cent hot water. Nectar is prepared from this pulp (Lal *et al*., 1960).

Ready to eat (*RTE*) *products* :

Ripe jackfruit bulbs can also be preserved with minimal processing into ready to eat convenience food product. But this product has a limited shelf-life and has to be stored and transported under refrigerated conditions.

Canning :

The unripe bulbs are canned with a small quantity of citric acid while the ripe bulbs can be preserved in sugar syrup or in the form of sweetened pulp for upto one year. This pulp can be used for preparing other value added products like squash, ready to serve (RTS) drink, chutney, toffee etc. and for flavouring icecreams, custard, beverages and bakery products. Other than canning, advances in processing technologies too, have pushed toward more new products (Narasimham, 1990). Freeze-dried, vacuum-fried and cryogenic processing are some modern preservation technologies for jackfruit-based value added products.

Jackfruit seed :

Jackfruit seed is used for culinary preparation as vegetables and can be processed into seed powder. Moreover, the seeds are also roasted and eaten like nuts.

Jackfruit, being rich in nutritional, medicinal and processing qualities can play a very significant role in the livelihood security of the rural communities through enhanced household income and employment generation. Jackfruit also has a great potential for commercial cultivation for fruit as well as timber and fodder. The native communities are slowly becoming aware about the potential importance of jackfruit and its value addition in their food and livelihood security. Some small-scale industries have also started the process of value addition of jackfruit. However, there is a great scope of establishing large scale jackfruit processing industries in the country because of significant production of this fruit. Technologies for processing and value addition of jackfruit need to be promoted and commercialized for ensuring availability of the fruit throughout the year and for avoiding the wastage of this fruit subsistence as well as nutrition. Emphasis should be given on imparting trainings to more and more farmers on value addition in jackfruit. At the same time, capacity building of marginal farmers in processing jackfruits and other such underutilized fruits should also be focused upon.

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