An Effective Utilization of Jackfruit (*Artocarpus heterophyllus*) by Products in Various Aspects – A Mini Review

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ABSTRACT

India offers a wide variety of fruits and vegetables over different seasons that can confound us with its rich biodiversity. Jackfruit is a tropical fruit belonging to the family of Moraceae and genus, Artocarpus it has sweet bulbs with seeds in the inner portion and a spine-like structure in the outer portion. Jackfruit principally ripens from March to June or from April to September. During the monsoon season, the production of the fruit is at its peak. Jackfruit has an astonishing nutrient profile which contains vitamin C, flavonones, antioxidants, minerals, anti-inflammatory, immune-modulatory, and anti-diabetic properties. The parts such as seed, fruits, pulp, and latex are useful in various fields like pharmaceuticals, Leather and Food Industries, Biogas, Briquette, and bio-char production, and some conventional and emerging technologies are developed to extract the functional ingredients from the tissues of the fruit. Due to a lack of awareness and post-harvest storage, processing facilities and a short period of shelf life high quantity of jackfruit is being wasted. This article gives a brief review of the effective utilization of jackfruit and its by-products in various aspects to bridge the knowledge gap between the people and farmers about the utilization of jackfruit waste.

Keywords: *Jackfruit, nutrient profile, emerging, conventional technologies, processing of jackfruit, functional ingredient, Leather, Food Industry, Utilization, by-products.*

1.INTRODUCTION

1.1.Origin

The species jackfruit (*Artocarpus heterophyllus*) belongs to the family of Moraceae (Mulberry, Fig, and Bread fruit). It's believed that its origin is in the south western rainforests of India and it is native to the Western Ghats of India, Sri Lanka, the Philippines, Malaysia, and Indonesia. The second biggest producer of jackfruit in the world is India and it is referred to as the motherland of jackfruit. Jackfruit plays a vital role in the agriculture and culture of India and it was cultivated around 3000-6000 years ago. Depending on the variety, the flowering stage starts in the mid-November to mid-February and fruits are available for sale in the market from March-August [1].

It is an evergreen tree of height 10-15 cm native to evergreen forests at an altitude of 450-1200 m with milky latex. The male head is sessile, the female head is syncarpous. It has sheaths of sweet yellow which is 3-5 mm thick[2,3]. It produces the largest edible fruit (up to 35 kg). The 100 g of ripe fruit contains 11-19 g of carbohydrates, 287-323 mg of potassium, and 30.0-73.2 mg of calcium. During its season, it is plentiful and it is commonly called "poor man's food"[4] . It requires a soil pH of 4.3-8 and a temperature of 19 to 29˚C. The altitude of about 1600 m above sea level, with 1000-2400 mm of annual rainfall [5] . Inflorescence of male and female occurs on the same tree as it is monoecious. Above the female spikes, male spikes are present on young branches. The male flower is smaller in size, at the young stage it is pale green and turns dark green with age. Female flowers are larger with a tubular calyx. The length of the leaves is up to 16 cm. The exterior rind of jackfruit may be green or yellow-brown. This multiple fruit or compound fruit (syncarp) is about 30-40 cm. Seeds are enclosed with a whitish membrane and light brown colour [6].

1.2. Jackfruit production

The arrival of mukkani (Mango, Jackfruit, Banana) is indicated by the onset of summer. Bananas will be plenty in all seasons and the other two are not plenty. Jackfruit, one of the fruits among mukkani, is recognized for its trademark sweetness. Jackfruit farming is common in Pudukkottai, Pattukkotai, Chidambaram, Nagercoil, and more in Panruti, District of Cuddalore [7]. Jack fruit is declared the national fruit of Bangladesh and the state fruit of Kerala. The production of jackfruit is worldwide and in India, the area of cultivation and production is being increased year by year the details are stated below (Table.1).

Table1. Year wise All India -Area of cultivation and production details of Jackfruit

Year/Estimate	Area (ha)	Production (Tonnes)
2016-17	150	1694
2017-18	185	1830
2018-19/Ist Estimate	187	1857
2018-19/IInd Estimate	187	1803
2018-19/IIIrd Estimate	187	1815
2019-20/Ist Estimate	191	1895
2019-20/IInd Estimate	189	1835

2020-21	188	1893
2021-22/Ist Estimate	187	1877
2021-22/IInd Estimate	188	1946

Source: National Horticultural Board

Indian Production of JACK FRUIT

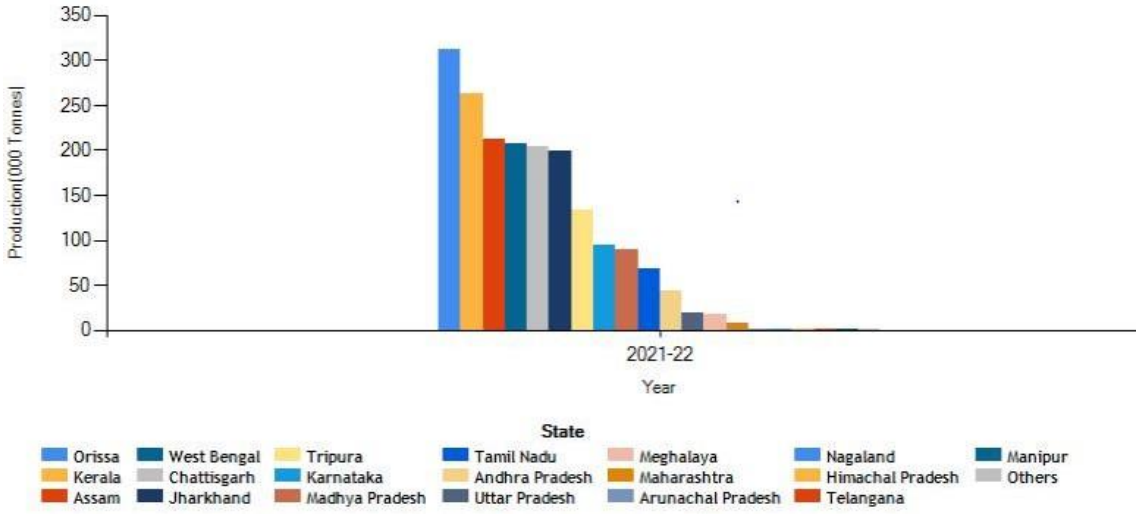
Production(000 Tonnes)

		2021-22	
Sr No.	**State**	**Production**	**Share(%)**
1	Orissa	312.18	16.63
2	Kerala	263.00	14.01
3	Assam	212.16	11.31
4	West Bengal	207.14	11.04
5	Chattisgarh	204.14	10.88
6	Jharkhand	199.96	10.66
7	Tripura	133.88	7.13
8	Karnataka	94.96	5.06
9	Madhya Pradesh	88.88	4.74
10	Tamil Nadu	69.01	3.68
11	Andhra Pradesh	44.41	2.37
12	Uttar Pradesh	18.60	0.99
13	Meghalaya	17.49	0.93
14	Maharashtra	7.06	0.38
15	Arunachal Pradesh	1.11	0.06
16	Nagaland	1.09	0.06
17	Himachal Pradesh	0.64	0.03
18	Telangana	0.62	0.03
19	Manipur	0.30	0.02
20	Others	0.03	0.00
	Page Total	**1,876.66**	

Source: National Horticulture Board (NHB)

***2021-22 (1st Adv. Estimate)**

Fig.1.Indian Production of Jackfruit and its share in the year 2021-22



Source: National Horticultural Board

Fig.2.Jackfruit Production in Different States

There are different types of varieties found in India and they have been referred to as Gulabi, Champpa, and Hazari (local varieties). A table-purpose jackfruit with excellent pulp and large fruits are NJT1, NJT2, NJT3, NJT4, and culinary-purpose fruits are NJC1, NJC2, NJC3, NJC4. In Assam- Pakikhua, Khoja. In Western Ghats- Muttam, Varikka, Rudrakshi. In South India (Kerala, Tamil Nadu, Karnataka) - Varrik, Koozha, and Navarrika are available. The biggest Jackfruit (34.4kg) has been recorded in the Guinness World Record in the name of a Hawaiin farmer and also in Melambattu village of Tamil Nadu jackfruit of weight (81 kg) is grown in the Karunakaran orchard. Some improved varieties of jackfruit have also been developed and released by some institutions/research centers. The details of such varieties are in (Table.2) [1].

Variety	**Released by**	**Year**	**Locality of fruit**	**Season**	**Annual Yield/tree**	**Average Yield weight of fruits**	**Avg. weight of a fruit**	**TSS**
Palur-1 Jack Or PLR	TNAU	1992	Panikkankuppam, Panruti Taluk, South Arcot Of TN.	October	80 fruits	900 kg	12kg	19
PPI-1 Jack	TNAU	1996	Ulagumoodu, Pechiparai	April – June and November - December	105fruits		17 kg	High TSS with High ascorbic acid
PLR-2	TNAU	2007	Pathirakkotai	June-December	95-110 fruits	1600-1950 Kg		
Swarna	UAS, Bangalore	2010					6-8kg	25-26
Gumless Typepre-	IIHR, Bangalore						6.4-9kg	26-30
Konkan Prolific	Regional Fruit Research Station, Vengurle Dr.Balasaheb Sawant Konkan	2004		January-February	73fruits	420.56kg		25

	Krishi Vidyapeeth, Dapoli, Maharastra							
BARI Kanthal-1	Horticulture Research Center	2008		May-June		9.5 kg		22

2. Nutritional and Health Benefits of Rarely Utilized Parts

There are three parts in the compound jackfruit. They are a) pulp (30-32%) (b) seeds (18%) (c) rind (5-55%) [8].

2.1. Jackfruit Seed:

Nutritional Value:

A side from its pulp, not fully engaged parts of jackfruit such as seed and rind has high nutritional values. It is officially announced to have the same amount of nutritional composition as its grains [10]. It is an adequate source of dietary fiber (22%), and starch (3.19%). Jackfruit seed contains a major protein called jacalin, which contains immunological properties and it also all phytonutrients, saponins, lignans, and isoflavones [10].

Health Benefits:

As it belongs to the flavonoid group it has anti-cancer properties and angiogenesis, a antihypertensive, antioxidant, antiulcer, and anti-aging [10]. The flavonoid compound in seeds is suggested for COVID-19 treatment. Lectins like artocarpin and jacalin can be used to diagnose patients who are infected with the human immunodeficiency virus [11]. It has sterols, triterpenes which inhibit anti-inflammatory action induced in RAW 264.7 cells from 30 gmL^{-1} of the extract at a concentration [12] and cyto-toxicity.

Jackfruit Rind:

High pectin content is present high in the non-edible part of the jackfruit than in the edible part. The high pectin content from the cempedak rind was ranging from 17.6-20.5% (w/w) and jack fruit rind from 14.8-18.6 % (w/w) [13]. Extracts of jackfruit rind contain high flavonoid content and higher polyphenol than fruit peels of pomegranate, pineapple, and orange [14].

3. Utilization of Jackfruit Seed:

Jackfruit seeds are utilized widely in various aspects. Many authors have investigated the uses of seeds and they have reported as follows i) The seed accounts for 12-14% of a whole jackfruit and it is a vital by-product. Seeds make up around 10 to 15% of jackfruit [15]. Seeds are very rich in digestible starch, minerals, and proteins [16]. Seeds consist of 76.1% carbohydrates , 17.8% Protein, and 2.1% Lipids on a dry basis [17]. It is a good source of vitamins B1 &B2. The extract which is obtained from the seeds hinders the proteolytic activities of pancreatic hormones in different animals. [18]. Bulk density, gelatin concentration of seed flour, and oil absorption capacity are such functional properties obtained from seeds [19]. Jack fruit seed oil which is obtained from the traditional process

produces the extract of 2 liters from 6 kg of seeds and is rich in essential fatty acids like linoleic acid, and α-linoleic acid. They estimated 1.35g/100 g free fatty acid in jackfruit seed oil [20]. Seed starches showed a higher amount of resistant starch of about 75%.It has better water absorption capacity, better swelling, and a high gelatinization temperature of 76-88 ℃ [20]. Jackfruit seed powder could be utilized as a substitute for cocoa. The composition of the fresh seeds has moisture 57.77%, phosphorus as P2O5, 0.23%; iron as Fe2O3, 0.002%; calcium as CaO, 0.55%; ash, as 1.25%.Oven drying: Phosphorus as P2O5, 0.54%; iron as Fe2O3, 0.005%; calcium as CaO, 0.13%; ash, 1.25%.Ash:Phosphorusas P2O5, 18.24%; iron as Fe2O3, 0.17%;calcium as CaO,4.39% [21].

4. Utilization of Jackfruit Peel:

It is reported that the peel is rich in cellulose (27.75%), protein (6.27%), pectin (7.52%), and starch (4%). As this peel is rich in the following sources Carbohydrates (24%), Fiber (17.3%), and Protein (8.7%) it is being used as feed for cattle. Jackfruit peel and axis waste have high potential as ruminant feed. After pyrolysis at a high temperature (400-700 ℃), the peel has a huge amount of volatile compounds showing that biomass is a opt precursor for the production of bio-oil. The study reveals that the best quality bio-fuel will obtain at the temperature of 550 ℃ with the highest organic content [22]. Yuvarani *et al.,* (2017) have extracted bio-ethanol from the peel through fermentation processing by using Saccharomyces Cerevisiae yeast as a micro-organism [23]. A modern method, microwave-assisted extraction, and ultrasonic extraction are used for pectin extraction [24]. This method showed superior performance at a temperature of 86℃, extraction time of 29 mins, and solid-liquid ratio of 1:48 (w/v) in pectin extraction. Zhang *et al.,* (2017) analyzed the extracts of peel, pulp, and seed of jackfruit by HPLC and the result showed that total phenolic compounds and flavanoid compounds are more in peel extract than other [25]. Jackfruit peel is used as a nano absorbent for removing Rhodamine (Rd) dye from waste water [26].

5. Utilization of Jackfruit Latex:

The latex of this fruit is used as a birdlime [21] either alone or mixed with *Schleichera trijuga* and *Ficus sap.* It is used as a household cement when it is heated [21] to mend earthenware [21] and chinaware [21,27], to seal holes in buckets [21], caulk boats [30,25]. Jackfruit latex contains resins of 82.6% - 86.4% which adds values in varnishes and it is not a substitute for rubber. It has a bacteriolytic activity like that of papaya latex [28]. Artostenone, Convertible to artosterone, with marked androgenic action can be obtained from dried fruit latex [21]. This latex promotes the healing of snakebites, abscesses, and glandular swelling when it is mixed with vinegar [21,27]. The chemical constituents of latex have been reported in manila [21,29]. To treat ulcers the jackfruit leaves ash are burnt with coconut shell, either mixed or alone with coconut oil. The root extracts are used for diarrhoea [21,31]. The seed starch is given for biliousness and the roasted seeds are regarded as aphrodisiacs [21,27].

6. Constraints in Marketing

As the cutting and cleaning process is tedious, the potential exploitation of jackfruit are affected by numerous factor such as the absence of a firm marketing system, unorganized supply chain, unavailability of subsidies, price stabilization, Foreign Exchange allowances for the small scale underutilized fruit processing farmers by the government on comparing to the major crop processing farmers are the major reason for the underutilization of fruit [32].

7. Techno Incubation Centers

Three TIC will be planned to be set up in Karnataka to provide training and technology support for business groups, and local entrepreneurs, especially for jackfruits. TIC will be a place for the utilization of essential equipment and also be the platform for the entrepreneurs to get an idea on effective setting up of a processing unit for jackfruit's value-added product. It also acts as a Common Facility Centre for the people who can utilize the facility by paying a nominal fee to process their produce and they can able to sale the product without investing more and earn profits [32].

8. Results and Discussion

Jack fruit is a tree which gives nutritional, health benefits and has many bioactive compounds. So many advantages are present in the jackfruit. The jackfruit tree has vast benefits from its every part. Researchers found that jackfruit waste also plays a vital role in bioactive compound extraction, pharmaceuticals, the food industry, and the extraction of functional ingredients. Various researches is being done on the efficient utilization of jackfruit. Some local, improved varieties have been released by the research centers' institutions to increase the production of jackfruit.

9. Conclusion

The jackfruit is cultivated all over the world. A jackfruit is still considered an underutilized fruit because of the high wastage percentage which is a non edible part than the edible parts. As the cleaning and cutting of the fruit is a tedious process, sticky latex in the fruit while cleaning makes people neglect the usage of this fruit. Farmers also found it hard that this big fruit is sold at a low price during peak seasons due to the utilization of edible parts alone by the people and the unavailability of processing and storage units for the harvested fruits. This paper is to build a knowledge gap between the farmers to prevent the underutilization of fruits. The first incubation center for jackfruit was established in Shillong (north eastern part of India) and Karnataka (south-western part of India) will have a plan to establish the incubation center for jackfruit to increase the effective utilization of jackfruit and its by-products. It also provides training for the people, and farmers which will increase the better understanding of the novel, modern technologies. The value addition of product sectors may increase the financial income and employment of the small scale farmers.

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