

Review Article

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Jackfruit (*Artocarpus heterophyllus* Lam) Biggest Fruit with High Nutritional and Pharmacological Values: A Review

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ABSTRACT

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Jackfruit (*Artocarpus heterophyllus* Lam) is a largest fruited evergreen tree possibly indigenous to the rain forests of the Western Ghats in the Southwestern parts of India. It is used as staple food in India and commonly known as kanthal, kathal, kathar appears in market during spring to summer. Jackfruit is an important underutilized fruit and often called the poor man's fruit commonly consumed foods in India from the ancient time by value addition of its fruits. Jackfruit contains more protein, calcium, iron, vitamins and other essential nutrients when compared to the common fruits. Jackfruit is also used as a traditional medicine for the treatment of asthma, ulcers, wound healing, dermatitis, cough, hypertension, nervousness, and constipation. In the different studies Anti-inflammatory, antibacterial and anti-diabetic properties of *A. heterophyllus* were also reported. The present review deals with general and chemical profile and its importance including pharmacological and other uses.

Introduction

Jackfruit (*Artocarpus heterophyllus* Lam) largest tree born tropical fruit in the world belongs to the family Moraceae. It is a monoecious evergreen tree possibly indigenous to the rain forests of the Western Ghats in the Southwestern parts of India (Baliga *et al.*, 2011). It is used as staple food in India and commonly known as kanthal, kathal, kathar appears in market during spring to summer. It is abundantly grown in India, Bangladesh, Malaysia, Indonesia, Thailand, Philippines and Sri

Lanka (Baliga *et al.*, 2011), and in many parts of Southeast Asia (Rahaman *et al.*, 1999). Jackfruit is the national fruit of Bangladesh and Indonesia (Matin, 2015). The word jackfruit comes from *portuguesa* word *jaca* which is derived from Malayalam word *chakka*. Among the tropical fruits, Jackfruit is an important underutilized fruit and often called the poor man's fruit commonly consumed foods in India from the ancient time by value addition of its fruits (Arora and Parley 2016). Tender green fruit is used as a vegetable and the juicy pulp of the ripe fruit is eaten fresh as dessert and used in fruit salads

(Samaddar, 1985). The seeds are eaten cooked, roasted, or fried (Sreeletha *et al.*, 2018). In recent times jams, beverages, candies, preserves, and dehydrated forms are other industrial uses for the jackfruit (Nair *et al.*, 2013). Jackfruit is also used as a traditional medicine for the treatment of asthma, ulcers, wound healing, dermatitis, cough, hypertension, nervousness, and constipation (Abdul and Martin 2015). In the different studies Anti-inflammatory, antibacterial (Khan *et al.*, 2003) antioxidant (Ko *et al.*, 1998) and anti-diabetic properties (Fernado *et al.*, 1991) of *A. heterophyllus* were also reported. The phenolic types of compounds were mainly reported as the chemical constituent of *Artocarpus* species (Hakim *et al.*, 2006). It can slow down aging and cell degeneration. Jackfruit can also provide protein and carbohydrates for the body, which will result in more strength for the individual. Jackfruit contains more protein, calcium, iron, vitamins and other essential nutrients (Table 1) when compared to the common fruits (Prem *et al.*, 2015).

Origin

The Jackfruit is originated from India; being its natural habitat in the rain forest of Western Ghats in the Southwestern part of India. Some authors argue that Jackfruit native to the rainforests of Malaysia. (Mowry *et al.*, 1958).

Distribution

It is distributed in many parts of the tropics; warm and moist regions (Bose, 1985) particularly in Asia, Africa, and South America (Abdul and Martin 2015). Haq (2006) reported that nowadays, it is an important crop of India, Burma, China, Sri Lanka, Malaysia, Indonesia, Thailand, and the Philippines. It has been introduced to many Pacific islands since post European contact and is of particular importance in Fiji, where

there is a large population of Indian descent (Prakash *et al.*, 2009). The Jackfruit plant was brought into Africa by Arabs and afterwards into South America and has got acclimatized in Mexico also. In India the jackfruit is growing in the Jharkhand, Bihar, West Bengal, Uttar Pradesh, Orissa, Chhattisgarh, Andhra Pradesh, Tamil Nadu, Kerala, Goa, Maharashtra, Karnataka and other states in the Eastern and Southern parts of the country (Ranasinghe *et al.*, 2019).

Botanical Description

The jackfruit scientifically known as *Artocarpus heterophyllus* (Table 2) is close relative of cempedak (*Artocarpus champeden*), breadfruit (*Artocarpus altilis*) and tarap (*Artocarpus adoratissimus*) which belongs to the family moraceae (Haq 2006). The word *Artocarpus* is a compilation of two Greek words, *artos*, which means bread, and *karpos*, which means fruit (Jones *et al.*, 2013). The species nickname of jackfruit, *heterophyllus*, is a compilation of two Greek words, *hetero*, meaning different, and *phyllus*, which means leaf (Gupta 2011). This implies existing variation in the shape and size of the leaves. Jackfruit (Raihandhany *et al.*, 2018)

The Tree

Jackfruit is a handsome evergreen tree grows in the tropics typically attains a height of, 10-20 m and a stem diameter of 30–80 cm. It has a relatively short trunk with heavy side branching usually begins near the ground and appears a very dense treetop. Stem of this plant is straight rough whereas bark is green or black, 1.25 cm thick. The canopy shape is usually conical or pyramidal in young trees and becomes spreading and domed in older trees. All parts of the tree exude sticky white latex when wounded. Leaves are Leathery, elliptic to ovate stiff, large (upto 16 cm long) in length alternate, entire, simple glossy deep

green, often deeply lobed on young shoots of juvenile (Burkill, 1997). Jackfruit timber is a good wood for furniture, construction material, and musical instruments since it resists bacterial, fungal and termite attacks (Orwa *et al.*, 2001).

Flowers

This species is monoecious greenish flowers, having male and female inflorescences in separate flower heads. Female spike appears on stout stems that sprout from older branches and the trunk. Male spikes are found on younger branches above female spikes. Male spikes are dense, fleshy, cylindrical to club shaped, and up to 10 cm (4 in) in length. Flowers are tiny, pale green when young, turning darker with age. Female flowers are larger, elliptic or rounded, with a tubular calyx. The flowers are reportedly pollinated by insects and wind, with a high percentage of crosspollination (Sharma 1964).

Fruits

Jackfruit (*Artocarpus heterophyllus* Lam) produces heavier yield than any other tree species, and bear the largest known edible fruit (up to 35 kg) The heavy oblong-cylindrical fruit is borne primarily on short stems from the trunk and interior part of main branches is considered to be califlorous The fruits are compound or multiple fruit (syncarp) with a green to yellow brown exterior rind that is composed of hexagonal, bluntly conical carpel apices that cover a thick, rubbery, whitish to yellowish wall. They are typically 30–40 cm in length but sometimes up to 90 cm with the diameter 13–50 centimeters. Commonly jackfruit weighted 4.5–30 kg, although a weight of 50 kg has been also reported (Matin 2015). They take 3–6 months to reach maturity. In the Northern Hemisphere, main season for its maturing is between March and September. A few fruits

mature in winter. Jackfruit has a relatively high productivity, 10-200 fruits about 25.71 t/ha. The compound fruit of jackfruit is made of three parts viz., bulb, seeds and the rind i.e. 30-32, 18 and 50-55 percent respectively (Srivastava *et al.*, 2017). The ripe jackfruit is sweet and has an exotic flavour considered being delicious and nutritious fruit (Swami *et al.*, 2016) and it comprises carpel, seed embedded in carpel and the skin, rind, sheath, core and unfertilized floral parts or undeveloped perianths.

Seeds

Jackfruit is composed of rind, edible bulbs of yellow flesh and seeds. Seeds of jackfruit are light brown to brown in color, rounded, 2–3 cm in length by 1–1.5 cm in diameter, and enclosed in a thin, whitish membrane (Menaka *et al.*, 2011). Madruga *et al.*, 2014 reported that well succulent, aromatic and flavorful yellow sweet jackfruit bulbs contains about 100 to 500 seeds, which represent around 8 to 15% of the total fruit weight. Most of the time, the seeds are left untreated or discarded as wastes due to the bland taste and texture of the seeds (Kooch *et al.*, 2016) however, are far less utilized with occasional uses as dessert, minor ingredients in culinary recipes or eaten as a snack after boiling, steaming or roasting (Sy Mohamad *et al.*, 2019).

Value addition of Jackfruit

Sharma *et al.*, 2014 stated that Value addition is the process of increasing the economic value and consumer appeal of an agricultural product by changing or transforming its original state 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..

Jackfruit has great potential for value addition for minimizing post-harvest losses and enhancing the non-seasonal availability (Satheeshan *et al.*, 2019). The value added products prepared from different parts of jackfruit are presented in Table 3

Nutritional Value of the jackfruit

Jackfruit contain high amount of vitamins and minerals (Table 2). The fruit is rich in carotene and carbohydrates and moderately rich in ascorbic acid (Hossain *et al.*, 1979). Jackfruit also contains minerals like calcium and potassium and Vitamin B complex group like thiamin, riboflavin, and Niacin and. The seeds of jackfruit are reported to be more nutritious than its bulb. Seeds are rich in

protein, carbohydrate fat, potassium and with fair amount of phosphorus and calcium (Rahim and Quaddus, 2000). Jackfruits are a good source of vitamin C. According to United State of Agriculture Department report (2016) Jackfruit has the unique nutritional values (table 4)

Phytonutrients and their health benefit

The phytonutrients can prevent the formation of cancer cells in the body, can lower blood pressure, can fight against stomach ulcers, and can slow down the degeneration of cells that make the skin look young and vital Sajesh *et al.*, 2015. The phytonutrients present in jackfruit are presented in Table 5.

Table.1 Nutritional profile of various fruits (values per 100 g)

Nutrient	Jackfruit	Pineapple	Mango	Banana	Fig
Energy (kcal)	95	50	60	89	74
Carbohydrates (g)	23	13	15	22.84	19.18
Sugars (g)	19.08	9.85	13.7	12.23	16.26
Dietary fiber (g)	1.5	1.4	1.6	2.6	2.9
Fat (g)	0.64	0.12	0.38	0.33	0.30
Protein (g)	1.72	0.54	0.82	1.09	0.75
Thiamine (mg)	0.105	0.079	0.028	0.031	0.060
Riboflavin (mg)	0.055	0.032	0.038	0.073	0.050
Niacin (mg)	0.92	0.5	0.669	0.665	0.400
Pantothenic acid (mg)	0.235	0.213	0.197	0.334	0.300
Vitamin B ₆ (mg)	0.329	0.112	0.119	0.4	0.113
Folate (µg)	24	18	43	20	6
Vitamin C (mg)	13.8	47.8	36.4	8.7	2.0
Calcium (mg)	24	13	11	-	35
Iron (mg)	0.23	0.29	0.16	0.26	0.37
Magnesium (mg)	29	12	10	27	17
Manganese (mg)	0.043	0.927	0.063	0.27	0.128
Phosphorous (mg)	21	8	14	22	14
Potassium (mg)	448	109	168	358	242
Sodium (mg)	2	1	1	1	1
Zinc (mg)	0.13	0.12	0.09	0.15	0.15
Water (g)	73.5	86.00	81.81	74.91	79.06

Source: Adapted from United States Department of Agriculture (2016, May) report

Table.2 Scientific nomenclature of Jackfruit (Singh *et al.*, 1963)

Kingdom	Plantae planta, plantes, plants, vegetal
Subkingdom	Tracheobionta, vascular plants
Super division	Embryophyta
Division	Magnoliophyta, angiosperms, flowering plants, phanérogames
Class	Magnoliophyta dicots, dicotylédones, dicotyledons
Subclass	Alismidae / Hamamelidae
Order	Rosales/ Urticales
Family	Moraceae, mulberries
Genus	Artocarpus breadfruit
Species	Heterophyllus `Artocarpus heterophyllus Lam

Table.3 Value added food product made by jackfruit

Stages of fruit	Value added products
Unripe	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, Gulab Jamun, Icecream, Custard, Cake, Freeze dried pulp
Seeds	Seed powder, Starch flour, Culinary preparation, Pakoda, Kheer

Source: Srivastava *et al.*, (2017)

Table.4 Nutritional profile of jackfruit (100 g edible portion)

Sr. No	Composition	Young fruit	Ripe fruit	Seed
A	Proximate analysis			
1	Water (g)	76.2 to 85.2	72.0 to 94.0	51.0 to 64.5
2	Protein (g)	2.0 to 2.6	1.2 to 1.9	6.6 to 7.04
3	Fat (g)	0.1 to 0.6	0.1 to 0.4	0.40 to 0.43
4	Carbohydrate (g)	9.4 to 11.5	16.0 to 25.4	25.8 to 38.4
5	Fibre (g)	2.6 to 3.6	1.0 to 1.5	1.0 to 1.5
6	Total sugars (g)	–	20.6	–
B	Minerals			
1	Total minerals (g)	0.9	0.87 to 0.9	0.9 to 1.2
2	Calcium (mg)	30.0 to 73.2	20.0 to 37.0	50.0
3	Magnesium (mg)		27.0	54.0
4	Phosphorus (mg)	20.0 to 57.2	38.0 to 41.0	38.0 to 97.0
5	Potassium (mg)	287 to 323	191 to 407	246
6	Sodium (mg)	3.0 to 35.0	2.0 to 41.0	63.2
7	Iron (mg)	0.4 to 1.9	0.5 to 1.1	1.5
C	Vitamins			
8	Vitamin A (IU)	30	175 to 540	10 to 17
9	Thiamine (mg)	0.05 to 0.15	0.03 to 0.09	0.25
10	Riboflavin (mg)	0.05 to 0.2	0.05 to 0.4	0.11 to 0.3
11	Vitamin C (mg)	12.0 to 14.0	7.0 to 10.0	11.0

Source: Gunasena *et al.*, (2000), Swami *et al.*, (2012)

Table.5 Phytonutrients in different parts of Jackfruit

S. N.	Phytonutrients	Phytochemicals	Plant Part
1.	Carbohydrate	Starch, Sugar, Dietary fiber	Fruit,Seed
2.	Protein	Arginine, Cystine, Histidine, Leucine, Lysine, Methionine, Threonine, and Tryptophan	Fruit,Seed
3.	Mineral	Calcium,Magnesium,Phosphorus,Potaasium,Sodium,Iron	Seed,Fruit
4.	Vitamins-	Vitamin A, Vitamin E,Thiamine, Ribofalvin, Vitamin C	Fruit
5.	FattyAcids	Capric,Myristic,Lauric,Palmitic,Oleic,Stearic	Fruit
6.	Organic acid	Acid-Malic acid,Citric acid	Fruit
7.	Carotenoids-	2-carotene, 1-carotene, 1-Zeacarotene, Dicarboxylic Carotenoid	Fruit
8.	Flavonoids	Artocarpetin, Artocarpetin, Artonins A, Morin, Artocarpanone, Artocarpesin	Fruit
9.	Lectin	Jacalin	Seed
10.	Volatiles	Isopentylisovalereate, Butyl isovalearte, Butyl Acetate	Seed,Fruit
11.	Tannins		Stem,Leaf

Source: Trindade and Lopes, 2006; Arora and Parley, 2016

Table.6 Pharmacological Activities of *Artocarpus heterophyllus* (Arora and Parley 2016)

Pharmacological activities	Plant parts	Phytoconstituent	Reference
1. Anti-infective			
Anti-Fungal	Leaf,Seed	Chalcone	Trinidad and Lopes (2006)
Anti-viral	Seed	Oxyresveratrol	Chaunasa and Lipipun, (2008)
Anti-bacterial	Bark of stem,root, leaves and fruit	Isoprenyl Flavone	Loizzo and Tundis, (2010)
2. Anti-cancer			
	Wood	Isoprenoid Flavonoids	Lanskey and Pawlus, (2008)
3. Inflammotary diseases			
Anti-inflammatory	Fruit	Flavonoids	Chanda and Dutta, (2009);
Wound healing	Leaf	Lectin	Chahud and Haddad, (2009)
4. Anti-Diabetic			
	Leaf	Prenyl Flavonoids	Kotowaroo and Mahomoodally, (2006)
5. Miscellaneous			
Anti-Oxidant	Fruit,Seed	Prenyl Flavones	Gupta <i>et al.</i> , (2011)
Anti-Malarial	Bark of root and stem	Prenylated Flavonoids	Boonlaksiri and Kong5seree, (2000)
Anti-Diarrheal	Bark of root and stem	Prenylated Flavonoids	Henirich and Heneka, (2005)
Anti-carcinogenic	Leaf	Flavonoids	Sato and Fujii, (1996)
Anti-Platelets	Root, Seed	Flavonoids	Jagpat and Bapat, (2010)
Anti-Tubuculer	Root,Stem	Prenylated Flavonoids	Boonphong and Kittakoop, (2007)
Anti-atherosclerosis	Fruit, Root	Flavonoids	Jagpat and Bapat, (2010)
Anti-arthritis	Leaf, Fruit	Flavonoids	Ngoc and Catrina, (2005)

Source: (Arora and Parley 2016)

Carbohydrates

Jackfruit contains more carbohydrates and sugars as it ripens Singh *et al.*, 1991 reported that jackfruit perianth and seed contains a high percentage of starch. The starch and dietary fiber content of the flesh increase with the fruit maturity (Rahman *et al.* 1999). Chrips *et al.*, (2008) find carbohydrate variation from 37.4% to 42.5% in different varieties of jackfruit seed. Swami *et al.*, 2012 reported that low caloric content (94) in 100 g of jackfruit.

Proteins

The pulp of ripe jackfruit contains 1.9 g proteins per 100g and many amino acids like arginine, cystine, histidine, leucine, lysine, methionine, threonine, and tryptophan (Theivasanthi *et al.*, 2011). The protein concentration of the jackfruit seeds may vary from 5.3 to 6.8% (Chrips *et al.*, 2008). According to Swami *et al.*, (2012). The protein content has ranged from 0.57 to 0.97% and 17.8–37% in the pulp and seed of different varieties of jackfruit.

Fat

It contains no saturated fats or cholesterol making it a healthy fruit. *Artocarpus heterophyllus* is composed of more of the saturated fatty acids with a total value of 65.25%. The low fatty acid content in jackfruit is reported by Gunasena (1993) estimated fat content of 0.1 – 0.4 % and Sreeletha *et al.*, (2018) also reported similar fat content of 0.4 per cent.

Vitamins

Jackfruit is higher in Vitamin A, Vitamin E, Vitamin B5 and Vitamin B6 and it is one of the rare fruits which rich in vitamin- B complex (Burkill, 1997) and contains very

good amounts of vitamin B6 (pyridoxine), B3 (niacin), riboflavin and folic acid (Narsimhan, 1990) Jackfruit is rich in vitamin C (Swami *et al.*, 2012). Tiwari and Vidyarthi, (2015) Evaluated that vitamin contents vary in different maturity stages of jackfruit. Niacin, known as vitamin B₃, necessary for energy metabolism, nerve function, and the synthesis of certain hormones (Soobrattee *et al.*, 2005). Another heart-friendly property found in the jackfruit is due to vitamin B6 that helps reduce homocysteine levels in the blood thus lowering the risk of heart disease (Fernando *et al.*, 1991).

Minerals

The ripen jackfruit contains minerals such as calcium, magnesium (Tiwari and Vidyarthi, 2015) Samaddar, (1985) has recorded that every 100g flakes of ripe jackfruits contains 287-323 mg, potassium, 30.0-73.2 mg calcium. Sundarraj and Ranganathan (2017) also reported that jackfruit have good amount of minerals.

Pharmacological Activities

Jackfruit is a tropical tree, which has numerous health benefits of jackfruit including anti-carcinogenic, anti-microbial, anti-fungal, anti-inflammatory, wound healing, and hypoglycemic properties (Sofowara, 1993). Jackfruit contains, phytonutrients including lignins, isoflavones, and saponins. These phytonutrients have anticancer, antiulcer, and anti-aging properties (Baliga *et al.*, 2011). Sundarraj and Ranganathan (2017) reported that alkaloids, flavonoids, carbohydrates, proteins and triterpenoids the active compounds presence in jackfruit. The rich bioactive profile of jackfruit makes it a highly nutritious and desirable fruit crop. The different pharmacological activities are presented in Table 6

Future Prospect

Quality and quantity of food have become important issue at the global level. Jackfruit is grown mainly on homestead farms and it produces multiple products for food, feed, and industry. It is also contributing towards soil management for sustainable environments. Nowadays, number of scientific and economic interest emerged to commercialized and promoting jackfruit products. There are high levels of vitamins and minerals have been recorded in jackfruit. Being nutritionally rich it can be good candidate to meet the nutritional deficiency. However, it is considered as an underutilized fruit in commercial scale, mainly due to higher percentage inedible portion which leads to more waste generation, difficulty in peeling and separation of edible bulbs from the rind, lack of knowledge on proper postharvest practices, and inadequate processing facilities in regions where they are grown. There is a great need of further research on enhancing its shelf life and its commercialization and to promote this fruit. However, it is considered as an underutilized fruit in commercial scale hence, adhering to correct post harvest practices and conversion of jackfruit into minimally processed products. Using standardized jackfruit products offer consumers a way of reaping the broad spectrum of health benefit of this fruit.

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