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A Review on the Distribution, Nutritional Status and Biological Activity of Various Parts of *Artocarpus heterophyllus* Lam

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ABSTRACT

Artocarpus heterophyllus Lam., which is commonly known as jackfruit is a tropical fruit, belonging to Moraceae family, native to Western Ghats of India and common in Asia, Africa, and some regions in South America. It is known to be the largest edible fruit in the world. The Jackfruit is an extremely versatile and sweet tasting fruit that possess high nutritional value. Jackfruit is rich in nutrients including carbohydrates, proteins, vitamins, minerals, and phytochemicals. The jackfruit has diverse medicinal uses especially antioxidant, anti-inflammatory, antimicrobial and antiviral properties, anticancer and antifungal activity, anthelminthic activity. Traditionally, this plant is used in the treatment of various diseases especially for treatment against inflammation, malarial fever, diarrhoea, diabetes and tapeworm infection. Jackfruit is a good natural source of phytochemicals such as phenolics, flavonoids and tannins, saponins. The health benefits of jackfruit have been attributed to its wide range of physicochemical applications. The use of jackfruit bulbs and its parts has also been reported since ancient times for their therapeutic qualities. The beneficial physiological effects may also have preventive application in a variety of pathologies.

Keywords: *Artocarpus, Moraceae, Nutritional value, Phenolics, Phytochemicals.*

INTRODUCTION

Artocarpus, Morus and Ficus belongs to Moraceae, a widespread family, often called the mulberry or fig family and comprises Angiosperms or flowering plants. The plants of Moraceae are trees, shrubs, vines, or rarely herbs, with milky or watery latex and spiny fruit cover. The members of Moraceae are monoecious or dioecious with 37 to 43 genera and 1100 to 1400 species.

Artocarpus is one of the genera belonging to the family Moraceae consisting of more than 50 species distributed in the tropical and subtropical regions of Asia. It is native to Western Ghats of India, Malaysia and also found in central and Eastern Africa and South- Eastern Asia. They are monoecious, evergreen or deciduous trees with edible fruits and white latex (Prakash *et al.,* 2009).

Artocarpus heterophyllus belongs to family Moraceae. They are commonly known as jack fruit or Ceylon Jack trees (in English), panas (in Hindi), Kanthal (in Bengali), Palaa (in Tamil), phanas (in Gujarati and Marati), and chakka (in Malayalam). It is very popular in Bangladesh and considered as their National fruit. The word jackfruit comes from Portuguese jaca, which in turn, is derived from the term 'chakka' in Malayalam language. The ancient Indian language Sanskrit refers this fruit as Atibruhatphala (Devi *et al.*, 2021). The fruit is an integral part of Indian diet. The fruit is known as the 'poor man's fruit' because they are inexpensive and easily available in large quantity during summer, when food is scarce. Most species of *Artocarpus* are restricted to Southeast Asia; a few cultivated species are more widely distributed, especially *A. altilis* (breadfruit) and *A. heterophyllus* (jackfruit), which are cultivated throughout the tropics. Several species in the genus bear edible fruit and commonly cultivated are breadfruit (*Artocarpus altilis*), cempedak (*Artocarpus integer*), jackfruit (*Artocarpus heterophyllus*), kwai muk (*Artocarpus hypargyreus*), lakoocha (*Artocarpus lakoocha*), pudau (*Artocarpus kemando*), anjily or wild jack

(*Artocarpus hirsutus*), chaplaish (*Artocarpus chama*) and marang (*Artocarpus odoratissimus*). Breadfruit and jackfruit are cultivated widely in the tropical Southeast Asia. Other species are cultivated locally for their timber, fruit or edible seeds. *A. hirsutus*, is grown for fruit and timber in the Western Ghats.

History and distribution

Historical reports suggest that jackfruit tree is supposed to have originated in the rain forests of the Western Ghats in the South Western part of India. However with time, the trees have been introduced to other parts of India and tropical regions of the world. Garcia de Orta- a physician & naturalist, in his book 'Coloquious dos simples e drogasda India' written in 1563 gives reference of 'Jackfruit'. Later botanist Ralph Randles Stewart suggested that it was named after a Scottish Botanist who worked for East India Company in Bengal, Sumatra & Malaysia. In 1782, few plants from one of the French ship were taken to Jamaica. In the 1800 century it was a common fruit in Florida. It was introduced into northern Brazil in the mid of 19th century and became very popular there.

Jackfruit tree is native to India and is popular in several tropical and sub-tropical countries. Being a native tree of India and Malaysia, the plant *Artocarpus heterophyllus* was brought into Africa by Arabs and afterwards into South America and has got acclimatized in Mexico also. It has got great commercial, nutritional and medicinal value in Southeast Asia. Today the tree is widely growing in Australia, Bangladesh**,** Malaysia Central and Eastern Africa, Florida, Brazil, Burma, Indonesia, in the Caribbean islands, in parts of USA, Brazil, Pacific islands, Yap, Samoa and other islands (Hemalatha *et al.*, 2017).

Botanical description

Tree

Jackfruit tree is 15 to 20 meters (50 to 70 feet) tall at maturity and has large stiff glossy green leaves about 15 to 20 cm (6 to 8 inches) long. The tree is monoecious: tiny male flowers are borne in oblong clusters 2 to 4 in (5-10 cm) in length; the female flower clusters are elliptic or rounded. Jackfruit takes about 3-6 months to reach maturity. In the northern hemisphere, main season for its maturity is between March and September. A few fruits mature in the winter. Jackfruit trees produce a heavier yield when compared to other trees and it bears the largest known edible fruit weighing upto 35 kg. Jackfruit height increases 1.5m/year, when the tree reaches maturity, it slows to 0.5m. The tree has a life span of 60-70 years.

Flowers

The small unisexual flowers are borne on dense inflorescences that emerge directly from the trunk and branches. *Artocarpus heterophyllus* is a bisexual plant, both male and female flowers are found on the same plant. At the early stage the male flower is green in color, at the maturity it becomes yellowish. The pollen grains which are yellow in color, they gets dispersed widely. The female flower is an aggregate of the small flowers, later develop as fruits. The small unisexual flowers are borne on dense inflorescences that emerge directly from trunk and branches.

Fruit

Jackfruit is the largest fruit in the world, reaching up to 60 cm (about 2 feet) long and weighing up to 18 kg (about 40 pounds). The interior consists of large "bulbs" (fully developed perianths) of yellow, banana-flavored flesh,

massed among narrow ribbons of thin, tough undeveloped perianths (or perigones), and a central, pithy core. Each bulb encloses a smooth, oval, light-brown "seed" (endocarp) covered by a thin white membrane (exocarp). The fruit weighs upto 50 kg in which only 30 to 35% of bulb is edible. It comprises of approximately 100 to 500 seeds which make up 8-15% of whole fruit. Jackfruit consists of a lower fleshy edible (bulb), middle fused (syncarp), and an outer spiny region (spike). When fruits are ripen this fruit flakes get fleshy, outer spines widen, and flesh becomes soft and yellow in color. The thorny outer bark and axis of the fruits are not edible. Jack fruit bears a compound or multiple fruit with a green to yellow brown exterior rind which is composed of hexagonal, bluntly conical carpel that covers a thick, rubbery, and whitish to yellowish interior matrix. The flesh (aril) surrounding each seed is acidic and sweetish (when ripe) with a banana like flavor and taste. The fruit color changes from yellowish green to yellow due to the conversion of chlorophylls, anthocyanins, and carotenoids like pigments during ripening. Depending on the variety, the color of the bulb can be cream, white, light yellow, yellow, deep yellow, lemon yellow light saffron, saffron, deep saffron, or orange.

The fruit is made up of three main regions. They are (1) the fruit axis (2) the persistent perianth (3) the true fruit. Due to the presence of lactiferous cells that produce latex, which helps to hold the fruits together, the axis and the core of the fruit are inedible. The perianth is made up of three regions (1) the bulb (the lower fleshy edible region) (2) the middle-fused region that forms the rind of the syncarp (3) horny non-edible region commonly known as the spikes.

Figure 1. Jackfruit

Seeds

The seed is 3/4 to 1 1/2 in (2 - 4 cm) long and 1/2 to 3/4 in (1.25 - 2 cm) thick and is white and crisp within. There may be 100 to 500 seeds in a single fruit. The seeds are let untreated or less utilized and wasted due to the bland taste and texture of the seeds.

Leaves

Leaves simple, alternate, spiral; stipules oblong or lanceolate, to 5 x 1.8 cm, caducous, leaving annular scar; petiole 1-3 cm long, Plano convex, glabrous; lamina 9-23 x 5-12 cm, usually narrow obovate sometimes elliptic, apex shortly acuminate or obtuse, base cuneate, margin entire (or 3-lobed in saplings), coriaceous, dark green above, glabrous; midrib raised above; secondary nerves 6-10 pairs, ascending; tertiary nerves broadly horizontally percurrent.

Figure 2. Jackfruit leaf

Wood

The wood is strong, hard, durable and easy to carve, with saw or machine. It changes with age from orange or yellow to brown or dark red, is termite proof, fairly resistant to fungal and bacterial decay, seasons without difficulty, resembles mahogany and is superior to teak which is used to make furniture, house construction such as, windows, doors, roofs in making oars, masts, rafters, implements and some musical instruments.

Figure 3. Jackfruit tree wood

Figure 4. Jackfruit seeds

Figure 5. Jackfruit pulp

Classification

The morphological features of particular variety of *A. heterophyllus* may vary due to many factors including variety feature, soil, climatic parameters and management practices. The nutritional qualities differ in fruits, leaves, seeds, flowers, stem and bark. Some varieties of Jackfruit have a significant difference between them, while they may exhibit only slight morphological character differences.

Jackfruits are classified based on their phenotypic and organoleptic with the variation in their flake's and seed color, shape, size, odour and period of maturity. In this fruit, the flake characteristics belong to the two categories namely Varikka and Koozha. Varikka consists of hard flakes and the Koozha consisting of soft and fibrous flakes.

In South India, jackfruits are classified into two general types: 1) *Koozha chakka*, the fruits of which have small, fibrous, soft, mushy, but very sweet carpels and 2) *Varika chakka*, more important commercially, with crisp carpers of high quality.

These types are apparently known in different areas by other names such as *Barka*, or *Berka* (soft, sweet and broken open with the hands), and *Kapa* or *Kapiya* (crisp and cut open with a knife). The equivalent types are known as *Kha-nun nang* (firm; best) and *Kha-nun lamoud* (soft) in Thailand and as *Vela* (soft) and *Varaka*, or *Waraka* (firm) in Ceylon.

The *Peniwaraka*, or honey jack, has sweet pulp, and some have claimed it the best of all. The *Kuruwaraka* has small, rounded fruits.

Cultivation and propagation of jackfruit

Climate: Jackfruit grows in a wide range of tropical to the subtropical environments. The hot and humid regions are suitable for the growth of Jackfruit tree, so jackfruit tree cannot tolerate higher altitudes (Jack fruit tree grows well in low land forests up to the height 250m but decreases in abundance at height of about 1000 m above sea level. It grows best in moist tropical environments below 1000 m.

Soil: Jackfruit can be grown on a variety of soils as long as they are well-drained sandy loam soil. The tree can grow in light and medium textured soils. A deep alluvial soil of open texture is best for Jackfruit cultivation.

Seeding: The most common method of propagation of Jackfruit is by sowing seeds. This method is easy and cost effective. Germination starts within 10days and 100% of seeds germinate within 35-40 days.

Grafting: Grafting is a most reliable method of propagation. Jackfruit seedling may serve as root stocks. It takes 6-12 months to get root stock ready for grafting. The grafted trees will bear fruits in 2-3 years after planting. Trees start fruiting quickly.

A mean annual rainfall of about 1000-2400mm is ideal for the growth of the Jackfruit tree. The effective method for irrigation of Jackfruit plants is drip Irrigation.

Harvesting: The fruits mature 3 to 8 months from flowering.

Storage: The ripe jackfruit should be stored at 85-90% relative humidity and at 11-13^{0}C. A ripe Jackfruit can stay fresh for 3 to 10 days.

NUTRITIONAL STATUS

Phytochemicals means plant (phyto) chemical referring to a wide variety of bioactive compounds that occur naturally in plants which help the body to react to free radicals and oxygen species. The protective role of phytochemicals has been associated with their antioxidant activity. This effect leads to the pathogenesis of some

chronic diseases such as CVD, some cancers, ageing and diabetes. Phenolic acids and flavonoids are higher in jackfruit seeds than jackfruit pulp.

Generally, phytochemicals have been classified into six major categories based on their chemical structures and characteristics. These categories include carbohydrate, lipids, phenolics, terpenoids and alkaloids and other nitrogen-containing compounds.

The phytochemical components of jackfruit reduces various diseases such as lowering blood pressure, preventing heart disease and strokes, preventing bone loss and improving muscle and, nerve function. The jackfruit is a rich source of phenolic compounds and phytonutrients such as lignans, isoflavones and saponins which have anti-cancer and anti-aging properties. These phytonutrients help to eliminate cancer causing free radicals from 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 vitae.

Phytonutrients are natural compounds that give plants their rich pigmentation, as well as their distinctive taste and aroma. They are essentially the plant's immune system and offer protection to humans.

The *Artocarpus heterophyllus* Lam is a rich source of phytochemicals including phenolic compounds and these offers opportunities for the development of value added products, such as nutraceutical and food products to enhance health benefits. Jackfruit is a good source of vitamin C which is an anti-oxidant that protects the body against free radicals, strengthens the immune system, and keeps our gums healthy. Jackfruit also contains niacin (vitamin B_3) which is necessary for energy metabolism, nerve function, and the synthesis of certain hormones. The Jackfruit pulp provides 4mg/100g niacin. The recommended daily amount of niacin for males is 16mg and for females is about 14mg. Jackfruit is gluten-free and casein-free, thus offer systemic anti-inflammatory benefits to skin. Jackfruit is enriched with vitamin C and it strengthens the immune systems.

The anti-oxidant and the amount of potassium present in the jackfruit is found to assist in lowering blood pressure and helps in preventing heart disease and strokes. Potassium also helps in preventing bone loss as well as improves muscle and nerve function. Jackfruit contains vitamin B6, which triggers a reduction in homocysteine levels in the blood thus lowering the risk of heart disease.

The Jackfruit also contains various chemical constituents, free sugars, fatty acids and amino acids like arginine, cysteine, histidine, leucine, lysine, methionine, threonine, tryptophan and many others.

Fruit

Jackfruit is a good source of vitamins (A, C, thiamine, riboflavin, niacin and minerals (calcium, potassium, iron, sodium, zinc) (Swami *et al*, 2012). Jackfruit is heavy and bulky and actual recovery of bulbs or edible portion varies from 20 to 25% which is easily digestible. A 100 g portion of edible raw jackfruit provides about 95 calories and is a good source of the anti-oxidants and vitamin C, providing about 13.7 mg. The fruit is also rich in vitamin B6, potassium, calcium, and iron. The bulb of ripe jackfruit is eaten fresh and used in fruit salads. It possesses high nutritional value; every 100 g of ripe fruit pulp contains 18.9 g carbohydrate, 1.9 g protein, 0.1 g fat, 77% moisture, 1.1 g fiber, 0.8 g total mineral matter, 20 mg calcium, 30 mg phosphorus, 500 mg iron, 540 IU vitamin A, 30 mg

thiamin, and 84 calories. Jackfruit is a good source of anti-oxidant vitamin-C, provides about 13mg or 23% of RDA. Consumption of foods rich in vitamin-C helps the body develops resistance against infectious agents and scavenges harmful free radicals.

The major components identified in the aroma concentrate of hard jackfruit variety were isopentyl isovalerate (28.4%) and butyl isovalerate (25.6%). The aroma concentrate of soft jackfruit are isopentyl isovalerate (18.3%), butyl acetate (16.5%), ethyl isovalerate (14.4%), butyl isovalerate (12.9%) and 2-methylbutyl acetate (12.0%) (Maia *et al*., 2004).In Brazil, three varieties are recognized: *jaca-dura*, or the "hard" variety, which has a firm flesh, and the largest fruits that can weigh between 15 and 40 kg each; *jaca-mole*, or the "soft" variety, which bears smaller fruits with a softer and sweeter flesh; and *jaca-manteiga*, or the "butter" variety, which bears sweet fruits whose flesh has a consistency intermediate between the "hard" and "soft" varieties.

The jackfruit bulb consists of carotenoids that are important for prevention of several chronic degenerative diseases, such as cancer, inflammation, cardiovascular disease, cataract, and age-related macular degeneration. Jackfruit constitutes trans-β-carotene which is an important anti-oxidant for human health. The main carotenoids in jackfruit bulb are all-trans-lutein (24–44%), all-trans-β-carotene (24–30%), all-trans-neoxanthin (4–19%), 9-cis-neoxanthin (4–9%), and 9-cis-violaxanthin (4–10%). Jackfruit is a good source of provitamin A carotenoids. Thus increased consumption of ripe jackfruit helps to prevent and control vitamin A deficiency.

Phytoestrogens are naturally occurring polycyclic phenols found in certain plants that may, when ingested and metabolized, have weak estrogenic effects. Two important groups of phytoestrogens present in Jackfruit pulp are isoflavones and lignans. The jackfruit is a rich source of phytochemicals, including phenolic compounds, and offers opportunities for the development of value-added products, such as neutraceutical and food applications to enhance health benefits.

Table 1. Nutritional value of A. heterophyllus per 100g

Principle	**Nutrient value**	**Percentage of RDA**
Energy	95 Kcal	5%
Carbohydrates	23.5 g	18%
Protein	1.72 g	3%
Total Fat	0.64 g	3%
Cholesterol	0 mg	0%
Dietary Fiber	1.5 g	4%
Vitamins		
Folates	24 µg	6%
Niacin	0.920 mg	6%
Pyridoxine	0.329 mg	25%
Riboflavin	0.055 mg	4%
Thiamin	0.105 mg	9%

Vitamin A	110 IU	3.5%
Vitamin C	13.7 mg	23%
Vitamin E	0.34 mg	2%
Electrolytes		
Sodium	3 mg	0%
Potassium	303 mg	6.5 %
Minerals		
Calcium	34 mg	3.4 %
Iron	0.60 mg	7.5 %
Magnesium	37 mg	9.0 %
Manganese	0.197 mg	8.5 %
Phosphorous	36 mg	5.0 %
Selenium	0.60 mg	1.0 %
Zinc	0.42 mg	4.0 %
Phytonutrients		
Carotene-β	61 µg	--
Crypto-xanthin--β	5 µg	--
Lutein-zeaxanthin	157 µg	--

SOURCE: Swami *et al.*, (2012)

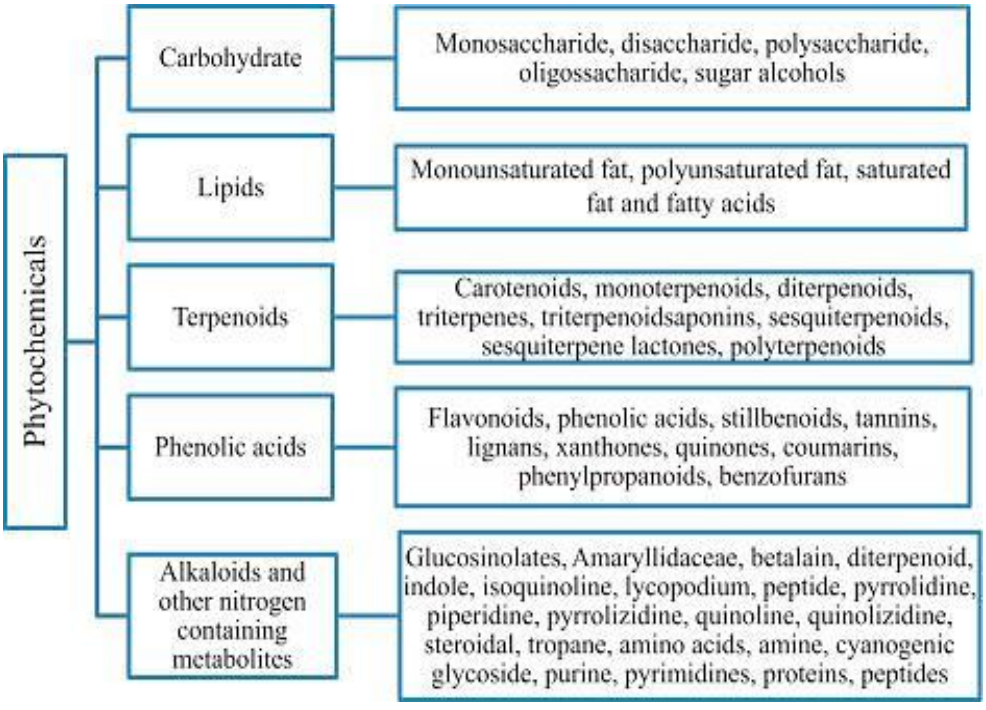

Figure 6. Types of Phytochemicals

(SOURCE: Harborne *et al.,* 1993)

Studies have shown that jackfruit contains many classes of phytochemicals such as carotenoids, flavonoids, volatile acids sterols and tannins, with varying concentrations depending on the variety. According to Wongsa and Zamaluddien, total phenolic content in jackfruit is 0.36 mg GAE/g DW (milligrams of gallic acid equivalent per gram of dry weight).

Seeds

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). According to United States of Agriculture Department report (2016) Jackfruit has the unique nutritional values. The jackfruit seeds are around 10–15% of the total fruit weight and have high carbohydrate and protein contents. Seeds are normally discarded or steamed and eaten as a snack or used in some local dishes. The fresh seeds cannot be kept for a long time, seed flour can be an alternative product, which can be used in some food products. The jackfruit seeds are a good source of starch (22%) and dietary fiber (3.19%). Jackfruit seeds contain lignans, isoflavones, and saponins that are called phytonutrients, and their health benefits are wide-ranging from anticancer to antihypertensive, anti-aging, anti-oxidant, anti-ulcer, etc. The seeds of fruit have been reported to be a good source of nutrients, containing approximately 14% protein and 80% of carbohydrates. The seeds are also rich in starch which is approximate 60-70% of its dry weight. Jackfruit seed powder is rich in manganese and magnesium elements. Seeds also contain lectins namely jacalin and artocarpin. Jacalin has been proved to be useful for the evaluation of the immune status of patients infected with human immunodeficiency virus

Wood

Tetracyclic triterpenoids, 9,19-cyclolanost-3-one-24,25-diol and 9,1-cyclolanost-3-one-24, 2S diol along with cycloartenone and cycloartenol, flavonoids such as Artoheteroids A-D, morin, artocarmin A, albanin A, euchrenone A, norartocarpanone and steppogenin have been isolated from *A. heterophyllus*. A new prenylated flavonoid, 3-prenyl luteolin (1) was isolated from *A. heterophyllus* wood extract. The wood contains yellow coloured morin, colourless cyanomaclurin and a new yellow colouring matter, artocarpin. Two new natural compounds,2,3-dihydro-5,7-dihydroxy-2-(2-hydroxy-4-methoxyphenyl)-4H benzopyran-4-one and 6-[(1S,2S)-1,2-dihydroxy-3-methylbutyl]-2-(2,4-dihydroxyphenyl)-5-hydroxy-7-methoxy-3-(3-methyl-2-buten-1-yl)-4H-1-benzopyran-4-one were also isolated from the ethanol extract of *A. heterophyllus* wood. Zheng *et al.*, isolated furano flavone,7-(2,4-dihydroxyphenyl)-4-hydroxy-2-(2-hydroxypropan-2-yl)-2,3dihydr furo(3,2-g)chromen-5-one (artocarpfuranol), together with 14 known compounds, dihydromorin, steppogenin, norartocarpetin, artocarpanone, artocarpesin, artocarpin, cycloartocarpin, cycloartocarpesin,artocarpetin, brosimone I, cudraflavone B, carpachromene, isoartocarpesin, and cyanomaclurin were isolated from the wood of *A. heterophyllus*. Zheng et al., isolated phenolic compounds, including one isoprenylated 2-arylbenzofuran derivative, artoheterophyllin A, and three isoprenylated flavonoids, artoheterophyllin B, artoheterophyllin C, and artoheterophyllin D from the ethanol extract of the twigs of *A. heterophyllus*.*Zheng,et al*. isolated new phenolic compounds, artoheterophyllins E-J, 4-geranyl-2',3,4',5-tetrahydroxy-cis-stilbene, and 5-methoxymorican M. In a study by Septama, et al., dihydromorin and norartocarpetin were isolated from *A. heterophyllus* heartwoods.

Leaves

An 2-arylbenzofuran derivative, artocarstilbene B and benzaldehyde derivative, (E)-3, 5- dihydroxy-4-(3-methylbut-1-enyl) benzaldehyde were obtained from the leaves of *A. heterophyllus*. Seven prenylated chromones and five prenylated flavonoids, including two new prenylated chromones, artoheterophines A and B were isolated.

PHARMACOLOGICAL ACTIVITY

The yellowish bulbs of the fruit are fleshy, fibrous and rich in sugars, as well as carotenoids. The bulbs are a rich source of carbohydrates, minerals, carboxylic acids, dietary fibres and vitamins such as thiamine (Vitamin B1) and ascorbic acid (Vitamin C). The ripe bulbs are sweet, cooling, aphrodisiac, laxative and are also used as brain tonic. The young fruits are astringent, acrid, and carminative. These phytonutrients have wide range of health benefits, especially anti-microbial, anti-cancer, anti-hypertensive, anti-ulcer, anti-oxidant, and anti-aging properties.

It is rich in dietary fiber, which makes it a good bulk laxative. This fiber content helps to protect the colon mucous membrane by decreasing the exposure time and as well as binding to the cancer-causing chemicals in the colon. This fresh fruit has small amounts of vitamin A, and flavonoid pigments such as carotene-β, xanthine, lutein and cryptoxanthin-β.

These compounds play vital role in anti-oxidant and vision functions. Jackfruit has abundance of important minerals. It is rich in magnesium, which is important for the absorption of calcium and helps strengthen the bones and prevents bone related disorders such as osteoporosis. Iron in jackfruit helps to prevent anemia and aids in proper blood circulation and copper plays an important role in thyroid gland metabolism.

They contain anti-oxidant phenyl flavones. The fruit provides 2 MJ of energy per kg/wet weight of ripe perianth. It contains high levels of protein, starch, calcium, and thiamine. The prenyl flavonoids present in jackfruit had shown strong antioxidant properties and is expected to act against lipid peroxidation of biological membranes.

Vitamin A is required for maintaining integrity of mucous membranes and skin. Consumption of these fruits rich in vitamin A and carotenes have been found to protect from the lung and oral cavity cancers. It is one of the rare fruits that is rich in the B-complex group of vitamins. It contains very good amounts of vitamin B-6 (pyridoxine), niacin, riboflavin, and folic acid. This fresh fruit is good source of potassium, magnesium, manganese and iron. Potassium is an important component of cell and body fluids that helps in controlling heart rate and blood pressure.

The root is found effective against asthma, skin diseases, diarrhoea and fever. The presence of phytonutrients further enhances the scope for the development of value added products.

Jackfruit seeds and are thin, smooth white with coriaceous testa. Seeds account for about 10-15% of total fruit weight and have high carbohydrate and protein contents. The jackfruit seeds are nutritious, rich in fat, carbohydrates, minerals and potassium. The elements such as manganese and magnesium have also been detected in the seed powder. The seed contains two lectins namely Artocarpin and Jacalin. The occurrence of Jacalin (lectin) in the Jackfruit seeds was first reported in 1979 which is a tetrameric two chain lectin with a molecular mass of 65KDa combining a heavy α-chain (133 amino acids) with light ß-chain(20-21 amino acids). Jacalin is the major

protein representing over 50% in jackfruit seeds and can bind to human IgA and T-antigen. In addition to Jacalin, Artocarpin, a polyspecific lectin which can react with a variety of monosaccharide is also present in Jackfruit seeds.

The wood is used in convulsions and is nervine, anti-diabetic, sedative. The seeds contain ß-carotene, α-carotene, ß-zeacarotene, α-zeacarotene and crocetin which are mostly present in the trans form.

A sticky, white milky latex is exuded from all parts of tree when it gets injured. The entire tree has several medicinal properties. The plant has anti-bacterial, anti-inflammatory, anti-diabetic, anti-oxidant, anti-fungal, and immune dilatory properties.

Anti-inflammatory activity

The anti-inflammatory properties of phenolic compounds isolated from the ethyl acetate extracts of *A. heterophyllus* fruits. Three phenolic compounds were characterized as artocarpesin [5,7,2′,4′-tetrahydroxy-6-(3-methylbut-3-enyl) flavone], norartocarpetin (5,7,2′,4′-tetrahydroxyflavone) and oxyresveratrol [trans-2,4,3′,5′-tetrahydroxystilbene] by spectroscopic methods. The anti-inflammatory properties of these isolated compounds were evaluated by determining their inhibitory effects on the production of proinflammatory mediators in lipopolysaccharide (LPS)-activated RAW 264.7 murine macrophage cells. These three compounds exhibited potent anti-inflammatory activity. The results indicated that artocarpesin suppressed the LPS-induced production of nitric oxide (NO) and prostaglandin E2 (PGE2) through the down-regulation of inducible nitric oxide synthase (iNOS) and cyclooxygenase 2 (COX-2) protein expressions. Extracts of jackfruit pulp showed anti-inflammatory activity by suppressing the lipopolysaccharide (LPS)-induced production of nitric oxide and prostaglandin E2 reactive oxygen species in RAW264.7 cells.

Anticancer activity

Swami *et al*. reported about the dietary supplementation with jackfruit pulp help to prevent and control the development of certain cancers. Organic extracts obtained from jackfruit pulp reduced the number of revertants caused by aflatoxin B1 (AFB1) and proliferation of cells M12.C3.F6.

Anti-osteoporotic activity

Cathepsin-K (Cat-K) is known to play a pivotal role in osteoclast-mediated bone resorption and is evidenced as an important target for the treatment of osteoporosis. Flavonoids from *A. heterophyllus* found to have suppression capabilities against Cat-K with IC50 values ranging from 1.4 to 93.9 μM.

Anti-fungal activity

Ethyl acetate extract of *A. heterophyllus* fruit flour showed activity against all the fungal species studied. A zone of inhibition of 12 mm was noted against *Aspergillus niger* for aqueous extract. The largest zone of inhibition of 29 mm was observed against *C. albicans* in ethylacetate extract. Chloroform extract produced a zone of inhibition of 25mm against *R. oryzae* and *C. albicans*. Hexane extract showed negative result for all fungal species tested except *P. chrysogenum.*

Anti-bacterial activity

The crude methaolic extracts of the stem and root, barks, stem and root heart-wood, leaves, fruits and seeds of *Artocarpus heterophyllus* and their subsequent partitioning with petrol, dichloromethane, ethyl acetate and butanol gave fractions that exhibited a broad spectrum of antibacterial activity. The butanol fractions of the root bark and fruits were found to be the most active. Methanolic extracts of 13 plants were studied for their antibacterial activity against cariogenic bacteria. Among them, the extract of *Artocarpus heterophyllus* showed the most intensive activity.

Anti-viral Properties

Jackfriut lectin (JFL) from *A. heterophyllus* has been found to have inhibitory activity *in vitro* with a cytopathic effect toward Herpes Simplex Virus type HSV-2. Varicellazoster virus (VZS) and cytomegalovirus (CMV) (Wetprasit and *et al*.2000). Several plant lectins have been shown to inhibit infectivity of viruses.

Anti-oxidant and anti-diabetic activities

Lipid peroxidation is a marker of cellular oxidative damage initiated by reactive oxygen species. It was reported that diabetics are highly sensitive to oxidative stress. In STZ-diabetic animals, STZ generates nitric oxide, which is a powerful free radical oxidant resulting in an increase in lipid peroxides as noticed in this study due to cellular oxidation. The production of lipid peroxides was more in Ethanol extract than in n-Butanol extract and significantly declined in GLB-treated Streptozotocin-diabetic rats. The presence of quercitin flavonoid (resembles isoquercitrin present in Jack fruit Extract) that could attenuate the diabetic state by decreasing oxidative stress and preserving pancreatic ß-cell integrity. Abnormalities in lipid profile are common complications found in 40% of diabetics.

Anti-diabetic and anti-oxidant activity of aqueous fruit extracts of *Artocarpus heterophyllus.* Studies show that fruit has anti-oxidant activity which is measured by hydroxyl radical and hydrogen peroxide scavenging activity, and chelating effect of ferrous iron.

Anthelminthic activity

The ethyl acetate ethanol and aqueous extracts of *A. heterophyllus* seed exhibited significant anthelminthic activity in comparison with the control *in vitro*. Amongst all the extracts, Ethyl acetate extracts showed a good activity. It indicates that certain non-polar constituents are responsible for the activity. This anthelmintic activity is mainly due to the presence of secondary metabolites namely alkaloids, flavonoids and triterpenoides.

Anti-oxidant Effect

The anti-oxidant properties of prenylflavones, isolated from *Artocarpus heterophyllus* Lam., were evaluated. Cycloheterophyllin andartonins A and B inhibited iron-induced lipid peroxidation in rat brain homogenate and scavenged 1, 1-diphenyl-2- picrylhydrazyl. They also scavenged peroxyl radicals and hydroxyl radicals that were generated by 2, 2'-azobis (2-amidinopropane) dihydrochloride and the Fe^{3+}- ascorbate- EDTA-H_2O_2 system, respectively. However, they did not inhibit xanthine oxidase activity or scavenge superoxide anion, hydrogen peroxide, carbon radical, or peroxyl radicals derived from 2,2'-azobis(2,4-dimethylvaleronitrile) in hexane.

Cycloheterophyllin and artonins A and B inhibited copper-catalyzed oxidation of human low-density lipoprotein, as measured by fluorescence intensity, thiobarbituric acid reactive substance and conjugated-diene formations and electrophoretic mobility.

Sexual behavior

Roasted seeds of *Artocarpus heterophyllus* Lam. (Family: Moraceae) showed aphrodisiac activity. In a sexual behavior study using receptive female rats, an oral administration of 500 mg/kg dose markedly inhibited libido, sexual arousal, sexual vigour and sexual performance within 2 hr. Further, the treatment induced a mild erectile dysfunction. These actions on the sexual behavior was not due to general toxicity, liver toxicity, stress or reduction in blood testosterone level but due to marked sedative activity.

Maintaining a healthy thyroid gland and preventing anemia

Copper (10.45 mg/kg) plays an important role in thyroid gland metabolism, especially in hormone production and absorption and jackfruit is loaded with this important micro minerals. Jackfruit also contains iron (0.5 mg/100 g), which helps to prevent anemia and also helps in proper blood circulation.

Inhibition of melanin biosynthesis

Jack fruit wood extract and the phytochemical artocarpanone was effective and inhibited both mushroom tyrosinase activity and melanin production in B16 melanoma cells. Artoheterophyllin A, artoheterophyllin B, artoheterophyllin C, and artoheterophyllin D isolated from the twigs also possess a tyrosinase inhibitory activity.

APPLICATIONS

Artocarpus heterophyllus Lam is a rich source of several high-value compounds with potential beneficial physiological activities. It is well known for its anti-bacterial, anti-fungal, anti-diabetic, anti-inflammatory, and anti-oxidant activities. Jackfruit has anti-oxidant properties that plays vital role to cure the human disorder and improving health such as improving cardiovascular health, skin health, stomach ulcer, improving digestion, strengthening the bone, preventing anemia, and maintaining a healthy thyroid gland.

Jackfruit contains a wide range of phytonutrients such as carotenoids that can act as anti-oxidants. Anti-oxidants are the compounds that are able to delay, retard or prevent oxidation process. They protect the body and biomolecules from the damage caused by generation of excess free radicals. Jackfruit contains functional compounds that have capability to reduce various diseases such as high blood pressure, heart diseases, strokes, and bone loss. It is also capable of improving muscle and nerve function, reducing homocysteine levels in the blood.

Roots- Studies proved that the Jackfruit roots are good for the treatment of asthma, skin diseases, fever, and diarrhea. The root extract heals fever and diarrhea. The butanol fraction of root, bark and fruit extracts was active against a range of bacteria and protozoa.

Bark- The heartwood shows two active compounds such as 6-(3methyl-l-butenyl)-5, 2’ and 4’-trihydroxy-3-isoprenyl-7- methoxyflavone and 5,7,2’, 4’-tetrahydroxy-6-isoprenylflavone. These isoprenylflavones are potent compounds for the prevention of dental caries.

Leaves- Leaves from the Jackfruit tree are useful for curing fever, wounds, boils and skin diseases when heated. The ash of Jackfruit leaves heal ulcers. Tender jackfruit leaves and young male flower clusters may also be cooked and served as vegetables. The leaves are used as a casing material for baking dishes and they are also secured together in the form of a round plate and used as a single use biodegradable. Extracts of leaves have been found to promote glucose tolerance when tested on diabetics. Hot water extraction of leaves contains flavonoids, anthocyanins, tannins, and proanthocyanidin which increase the glucose tolerance of diabetics. The hot water extract of mature leaves are utilized in Ayurvedic treatment for hyperglycemia and diabetes. The flavonoids present in the extract have been identified to be responsible for the non-toxic hypoglycemic action.

Latex- The latex of the fruit are used in treating dysopia, ophthalmic problems, and pharyngitis. The latex mixed with vinegar heal absesses, snake bites and glandular swellings.

Seeds- The seed starch is believed to be useful in relieving biliousness, while the roasted seeds regarded as an aphrodisiac. The seeds and pulp of Jackfruit are used as cooling and nutritious tonic. Jackfruit seeds are very nutritious and an important source of diet. They are boiled or roasted and eaten like chestnuts, or cooked in some local dishes. The seeds are also marketed in canned forms, in boiled form like beans, in brine and in tomato sauce. The seed flour is rich is protein and carbohydrates and contains a good water as well as oil absorption abilities, and it is also used as an alternative to wheat flour. Lectins present in the seeds have shown antifungal properties.

Fruits- The ripe sweet bulbs of the fruit can be processed into ice cream, jam, jelly, alcoholic beverages, nectars and fruit powder. Jackfruit pulp can be eaten fresh and used in the fruit salads. They possess high nutritional value. The bulbs of ripe Jackfruit are consumed fresh or processed into canned products, ice cream, jelly, jam, alcoholic beverages, nectars or fruit powder, can be processed by ripe, sweet bulbs of Jackfruit. The Jackfruit powder is used in instant soaps, snacks, Bakery products, Dairy products, beverages, Pasta, candy, baby foods.

Various value added products developed from the jackfruit are candy, finger chips, fruit bars, fruit leather, halvah, papad, beverages, toffee and milk based srikhand, ice cream and kulfie. Half ripened bulbs can be processed into bulb powder and this is then utilized for the preparation of traditional snacks such as, pakoda, biscuits and muffins. Jackfruit jam is full of natural sugars and low in calories, making it an ideal food source to reduce the body weight. Jackfruit wine protects against antioxidant and DNA damage and could become a valuable source of antioxidant rich neutraceuticals. The ripe Jackfruit contains a good amount of fermentable sugar, which may be exploited for the commercial production of vinegar and wine. The fermented Jackfruit preserves vitamin C.

The dehydrated jackfruit is a nutritious snack item when made from ripe jack fruit pulp. The Jackfruit chips are rich in vitamin E. Jackfruit leather is dried sheets of the fruit pulp which can be used as an ingredient in the manufacture of cookies, cakes and ice creams. The raw fruits are used in vegetable curries and pickles. The rind is a good source of pectin.

Jackfruit is also a good source of vitamin C, which protects the skin from the damage that occurs as a consequence of the natural aging process and prolonged exposure to sun. Some studies have also reported the anti-inflammatory effects of isolated bioactive compounds from the fruits of *Artocarpus heterophyllus*.

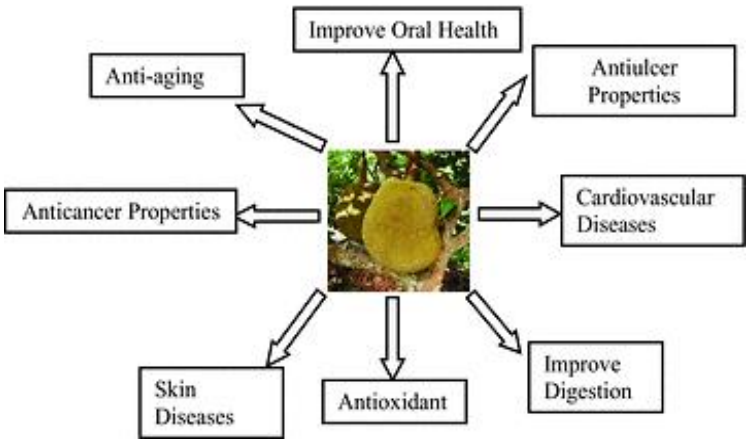

Figure 7. Principal Functional and Medicinal Effects of Jackfruit

SOURCE: (Swami *et al*., 2012)

The functional components of jackfruit is to reduce the various diseases such as lowering blood pressure, preventing heart disease and strokes, preventing bone loss and improving muscle and, nerve function, reducing homocysteine levels in the blood. 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.

Jackfruit peel extract contains phenolics, flavonoids in which prenylflavonoids, hydroxycinnamic acids and glycosides are the predominant bioactive compounds. Tyrosinase inhibitory activity of morachalcone A from wood of *A. heterophyllus* was determined by Nguyen, *et al*. Similarly, bioactive compounds from *A. heterophyllus* wood showed strong mushroom tyrosinase inhibitory activity with IC50 values lower than 50 μM, more potent than kojic acid, a well-known tyrosinase inhibitor. It was also found that norartocarpetin and artocarpesin in the twigs and woods of *A. heterophyllus*, contributed to the tyrosinase inhibitory activity (10).

Table 2. Phytonutrients in fruit part of *Artocarpus heterophyllus*

S. No.	Phytonutrients	Phytochemicals
1.	Carbohydrate	Starch, Sugar, Dietary fiber
2.	Protein	Arginine, Cysteine, Histidine, Leucine, Lysine, Methionine, Threonine, and Tryptophan
3.	Mineral	Calcium, Magnesium, Phosphorus, Potassium, Sodium, Iron
4.	Vitamins	Vitamin A (Retinol), Vitamin E (Tocopherol), Vitamin B1 (Thiamine), Vitamin B2 (Riboflavin), Vitamin C (Ascorbic acid)
5.	Fatty Acids	Capric, Myristic, Lauric, Palmitic, Oleic, Stearic
6.	Organic acid	Acid-Malic acid, Citric acid
7.	Carotenoids	2-carotene, 1-carotene, 1-Zeacarotene, Dicarboxylic Carotenoid
8.	Flavonoids	Artocarpetin, Artocarpetin, Artonins A, Morin, Artocarpanone, Artocarpesin
9.	Volatiles	Isopentyl isovalerate, Butyl isovalerate, Butyl Acetate

Table 3. Pharmacological Activities of *Artocarpus heterophyllus* (fruit)

Pharmacological activities	**Phytoconstituent**	**Reference**
Anti-bacterial	Isoprenyl Flavone	Loizzo and Tundis, (2010)
Anti-inflammatory	Flavonoids	Chanda and Dutta, (2009)
Anti-Oxidant	Prenyl Flavones	Gupta *et al.,* (2011)
Anti-atherosclerosis	Flavonoids	Jagpat and Bapat, (2010)
Anti-arthritic	Flavonoids	Ngoc and Catrina, (2005)

METHODS FOR ESTIMATION OF PHYTOCHEMICALS

Various extraction methods were followed for the estimation of phytochemicals from the fruits of *A. heterophyllus* in different studies until now. The methods carried out involves the collection of fully ripened fruits, which was cleaned and separated into pulp and seeds. The pulps obtained were blended properly by mechanical blender and was filtered through cheesecloth and stored at freezing temperature for further use.

The Jack fruit pulps were extracted by homogenizing in different solvents such as acetone, methanol, ethanol, and water in an orbital shaker for 24 hour at room temperature. This homogenates were centrifuged at 15,000 rpm at 4^0C for 10 minutes and the supernatants were recovered and stored at 20^0C.

Total Phenolic content

The total phenolic content of jackfruit pulp in four different solvents were determined spectrophotometric ally using the Folin-Ciocalteu assay.

According to the studies of Jagtap *et al.,* (2010) ethanol was the best solvent for extracting phenolic compounds followed by water, methanol, and acetone. The Jack fruit pulp contains lower amounts of total phenolics as compared to *A. odoratissimus* flesh. The seeds of the Jackfruit showed higher amounts of total phenolic content than the edible portions. The studies of Shafiq *et al.,* (2017) the total phenolic content of the analyzed ripe jack fruit pulp extracts illustrated that high phenolics content is present in the methanolic extract, followed by the aqueous extract, ethyl acetate- methanol extract and acetone extract. However ethyl acetate extract showed the minimum phenolics content.

Total *Flavonoid content*

Total flavonoid content of the crude jack fruit extracts was determined by the aluminium chloride colorimetric protocol. The fibers had the highest flavonoid content in methanol and distilled water samples) that were incubated with a solvent for 48 hours, while the peels showed the highest flavonoid content in samples that were homogenized and centrifuged. The methanolic extract gave the highest composition in all parts. The fiber had the highest flavonoid content in the 48 hours extraction in both methanol and distilled water while the peels had the highest compositions in homogenized extracts.

Tannin

In the studies conducted by Adan *et al.*, (2020) the amount of tannin in the Jackfruit pulp was estimated using the Folin–Ciocalteu method. According to this study, homogenization method was found to be the best method for extraction of tannin while distilled water was proved to be the best extraction solvent for tannin. The fiber consistently gave high values in all extraction methods and solvents. There was a significant variation in the extraction solvents used with distilled water and 70% methanol recording high values compared to the methanol. This could be attributed to the fact that tannin compounds are soluble in water.

Estimation of Ascorbic acid

Ascorbic acid content in the Jackfruit extracts were determined by UV-VIS spectrophotomete. The acetone extract of ripe Jackfruit pulp exhibits the maximum ascorbic acid content of dry extracts, followed by methanol, aqueous, ethyl acetate-methanol combination extracts and ethyl acetate.

DPPH (1, 1- diphenyl-2 picrylhydrazyl) Radical scavenging activity

The anti-oxidant activity of the Jack fruit pulp extract evaluated by DPPH assay showed that the methanolic and water extracts of jackfruit showed maximum activity.

FRAP (Ferric Reducing/Antioxidant Power) Assay

The radical scavenging capacity of fruit pulp decreased with increasing ripening status. The phenolic phytochemicals exhibited redox properties. Therefore the reducing ability of extracts was strongly correlated with the phenolic and flavonoid content.

DMPD (N, N-dimethyl-p-phenylendiamine) Assay

The DMPD assay has advantages as high stability of the end point, quick reaction time, cost effective. In the presence of an oxidant solution (ferric chloride) at acidic pH, DMPD is converted to stable and coloured DMPD radical cation (DMPD·+). The anti-oxidant compounds, present in sample able to transfer a hydrogen atom to DMPD·+ and caused discolouration, which was proportional to their concentration. It was observed that all Jack fruit pulp extracts exhibited lower free radical scavenging activity than the standard ascorbic acid (Jagtap *et al.*, 2010).

Proximate composition of jackfruit pulp

Various studies conducted for the analysis of moisture content, TSS (total soluble solid), ash, protein, fat, reducing and non-reducing sugar reported the jackfruit pulp contain moisture 77.2%, TSS 20%, ash 0.88%, fat 0.1% Jackfruit pulp contain little fat, reducing sugar 6.80% and non-reducing sugar 8.98% respectively. Carbohydrate content was determined by difference:

Total carbohydrates (% dry weight) = {100- moisture (%) - protein content (% dry weight) - crude fat (% dry weight) – total ash (% dry weight)}.

Determination of Total Nitrogen and Crude Protein Contents

The total nitrogen and crude protein contents determination, was done for pulp and seed samples. Determination of the crude protein contents of the seeds and the pulps was done by Biuret and micro Kjedahl according to AOAC 928.08. The total crude protein was calculated from total nitrogen using the formula

Protein content = Nitrogen content x 6.25

Determination of Crude Lipid Contents

The fat contents of the samples were determined using chloroform/methanol as a solvent according to AOAC method 991.36. The jackfruit pulps were found to have a lipid content of 0.09-0.12%.

Protein and Carbohydrate Contents

The protein and carbohydrate content of the pulp, ranged from 10.56 to 13.67% and 21.65 to 24.91%), respectively, while that of the seeds ranged from 14.11 to 16.26% and 31.41% -34.95%, respectively. The seeds had the highest carbohydrates and proteins content, while the pulps had the least

Estimation of Saponins

In studies to estimate the presence of saponins, Foam test was performed. The presence of saponin in higher quantities was observed in jack fruit seed and it has been known for their medicinal uses, including anti-spasmodic activity and toxicity to cancer.

Reducing power assay

The reducing power of jackfruit pulp ranged from 43.54 to 45.38 µg/ml (Ojwang *et al.*, 2018). The reducing power of dichloromethane : methanol in 1:1 extract was found to be higher than that of acetone extract, whereas FRAP was reported as 5 mg/ml for Jack fruit pulp methanolic extract.

Carotenoid Composition of Jackfruit

Studies carried out by A. F. de Faria *et al* confirmed the carotenoid composition of jackfruit by high-performance liquid chromatography and mass spectrometry detectors. The main carotenoids detected in this study were all-*trans*-lutein (24–44%), all-*trans*-β-carotene (24–30%), all-*trans*-neoxanthin (4–19%), 9-*cis*-neoxanthin (4–9%) and 9-*cis*-violaxanthin (4–10%).

CONCLUSION

This review reveals that *Artocarpus heterophyllus* Lam. is a chemically and pharmacologically studied tree having diverse secondary metabolites present in its fruits and seeds such as phenolics, flavonoids, terpenoids, steroids, glycosides, saponins, alkaloids, and tannins. Thus, jackfruit is considered to be a functionally, nutritionally, and medicinally important fruit in all respects.

Jackfruit is a good natural source of phytochemicals such as phenolics, flavonoids and tannins. That the solvent used and the extraction technique affects the levels of phytochemicals extracted and hence their functional properties (antioxidant and antimicrobial) to various magnitudes. Jackfruit is a good source of essential minerals.

The fruit was also found to be rich in minerals such as potassium, calcium, sodium and iron, which are essential in the body. The jackfruit seeds and pulp are rich in proteins and carbohydrates. *Artocarpus heterophyllus* is an excellent plant due to its multifaceted medicinal properties like anti-oxidant and anti-diabetic activity, anti-bacterial, anti-viral, anti-fungal, anti-cancer, anti-helminthic, anti-malarial, anti-osteoporotic activity, anti-inflammatory activity, sexual behaviour, maintaining a healthy thyroid gland and preventing anemia, Inhibition of melanin biosynthesis, and show wound healing effect. *Artocarpus heterophyllus* also has food value with numerous also culinary uses. The jackfruit pulp, seed, and leaves had low phytic acid, oxalates, tannin and alkaloid content and possess high flavonoid content that promote good health.

In Ayurveda the jackfruit is used as a cooling tonic and pectorial, roots in diarrhea and fever, leaves to activate milk in women and animals, as a source to treat anti-syphilic and vermifuge, leaf ash applied to ulcers wounds and the warmed leaves have healing properties if pasted on the wounds. The richness of jackfruit in bioactive natural metabolites encourages their consumption.

An activity of certain phytochemicals along with their anti-oxidant properties further supports the cause of commercial utilization of the fruit. The anti-oxidant constituents present in the fruits play important role in scavenging free radicals and reactive oxygen species which are responsible for a number of human disorders. The jackfruits and fruit products hold potential in the diet as they possess not only pleasant taste but also source of naturally and readily available source of instant energy. Studies have suggested a significant increase in the nutritional content of jackfruit-fortified products in terms of the ash, protein, dietary fiber and phytochemical contents.

The research evidence shows that the routine dietary supplementation with jackfruit not only protects against stomach ulcers and cardiovascular disease but also helps to protect certain cancers and prevent mouth and skin diseases. Side effects due to its consumption may be very rare and so far it is not reported. Using standardized jackfruit products offers consumers a way of reaping the broad spectrum of health benefits of this fruit.

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Consent for publication

The authors declare that they consented to the publication of this research work.

Authors' Contributions

All authors equally contributed to research and paper drafting.

References

Adan, A. A., Ojwang, R. A., Muge, E. K., Mwanza, B. K., & Nyaboga, E. N. (2020). Phytochemical composition and essential mineral profile, antioxidant and antimicrobial potential of unutilized parts of jackfruit. Food Res, 4, 1125-1134.

Devi, P. S., Kumar, N. S., & Sabu, K. K. (2021). Phytochemical profiling and antioxidant activities of different parts of *Artocarpus heterophyllus* Lam (Moraceae): A review on current status of knowledge. Future Journal of Pharmaceutical Sciences, 7(1), 1-7.

Gupta, D., Mann, S., Sood, A., & Gupta, R. K. (2011). Phytochemical, nutritional and antioxidant activity evaluation of seeds of jackfruit (*Artocarpus heterophyllus* Lam.). International Journal of Pharma and Bio Sciences, 2(4), 336-345.

Hemalatha, P., Pramod, N. N., Ravneel, K. (2017). Jackfruit (*Artocarpus heterophyllus*), A Versatile but Underutilized Food Source.

Harborne, J. B., Baxter H., & Moss, G. P. (1999). Phytochemical Dictionary. A Handbook of Bioactive Compounds from Plants, 2nd Edition, Taylor & Francis, London.

Jagtap, U. B., & Bapat, V. A. (2010). *Artocarpus*: A review of its traditional uses, phytochemistry and pharmacology. Journal of ethnopharmacology, 129(2), 142-166.

Ojwang, R. A., Muge, E. K., Mbatia, B., Mwanza, B., & Ogoyi, D. O. (2018). Compositional, elemental, phytochemical and antioxidant characterization of Jackfruit (*Artocarpus heterophyllus*) Pulps and Seeds from Selected Regions in Kenya and Uganda.

Prakash, O., Kumar, R., Mishra, A., & Gupta, R. (2009). *Artocarpus heterophyllus* (Jackfruit): An overview. Pharmacognosy Reviews, 3(6), 353.

Rajneesh, S., & Anu, S. (2020). Jackfruit (*Artocarpus heterophyllus* Lam) Biggest Fruit with High Nutritional and Pharmacological Values: A Review. Int. J. Curr. Microbiol. App. Sci. 9(8): 764-774.

Shafiq, M., Mehmood, S., Yasmin, A., Khan, S. J., Khan, N. H., & Ali, S. (2017). Evaluation of phytochemical, nutritional and antioxidant activity of indigenously grown jackfruit (*Artocarpus heterophyllus* Lam). Journal of Scientific Research, 9(1), 135-143.

Swami, S. B., Thakor, N. J., Haldankar, P. M., & Kalse, S. B. (2012). Jackfruit and its many functional components as related to human health: a review. Comprehensive Reviews in Food Science and Food Safety, 11(6), 565-576.

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