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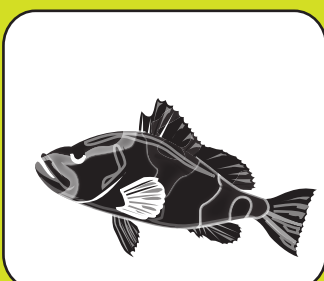
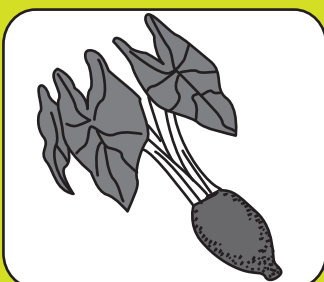
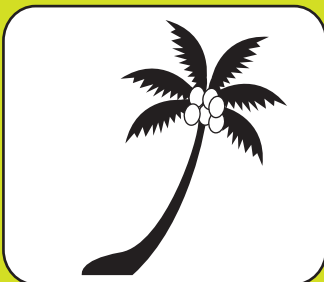
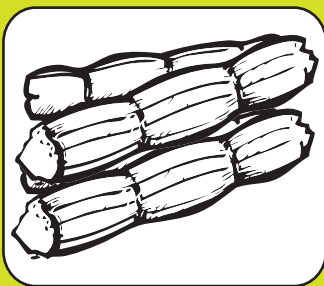
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# Jackfruit (*Artocarpus heterophyllus*), a Versatile but Underutilized food source

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## ABSTRACT

The exploration for lesser known and underutilized crops, many of which are potentially valuable as human and animal foods has been the focus for research in recent years. The aim of this review is an attempt to draw the attention of researchers and policy makers in Pacific agriculture to introduce the physicochemical and functional properties of jackfruit (*Artocarpus heterophyllus*), and also to highlight the future prospects and strategy for jackfruit production and utilization. The primary economic product of jackfruit is the fruit which is used both when mature and immature. The flesh of the jackfruit is starchy and fibrous, and is a source of dietary fiber. The presence of isoflavones, antioxidants, and phytonutrients in the fruits indicate that jackfruit has anti-cancer properties. The positive effect of unripe jackfruit for diabetes makes the door open to commercially exploit freeze-dried unripe jackfruit. The health benefits of jackfruit have been attributed to its wide range of physicochemical applications. In spite of such a vast potential and usefulness, jackfruit remains an underutilized fruit species and deserves to be given the needed thrust for research and development. A wide gap in the marketing of jackfruits and its processed value added products can be fully explored for additional income as well as food security. Encouragements should be done to the marketing as well as value added food products from this underutilized fruit tree. The focus of this review is to provide information on the research work undertaken about jackfruit, and to provide basic information for future commercialization as functional food and medicine.

**Keywords:** Jackfruit, Pacific, versatile food, physicochemical, underutilized fruit, antioxidants.

## 1.0 INTRODUCTION

The jackfruit (*Artocarpus heterophyllus*) (Figure 1), tree of the mulberry family (Moraceae) is believed to have originated in the south western rain forests of India (Bonning 2006). Around 300 B.C., the Greek philosopher Theophrastus described the tree as very large with wonderfully sweet and large fruits used for food by the sages of India (Matin 2015). The jackfruit tree is well suited to tropical lowlands, and its fruit is the largest tree-borne fruit, weighing as much as 35 kg and measuring up to 90 cm in length, and 50 cm in diameter. Jackfruit is the national fruit of Bangladesh and Indonesia (Matin 2015). It is a popular food item in tropical regions of India, Bangladesh, Nepal, Sri Lanka, Cambodia, Vietnam, Thailand, Malaysia, Indonesia, Myanmar and the Philippines. Jackfruit is also found across Africa, Brazil, West-central America, Jamaica, Fiji Samoa and Tonga. This tree has many names, based on locality such as *uto ni dia* (Fijian), *kathhar* (Fiji Hindi), *ulu initia* (Samoa) and *mei initia* (Tonga). The fleshy carpel of this fruit which is botanically called perianth is the edible portion. The fruit is known for its unique taste, sweetness, crispness, colour, texture, aroma or unseasonal fruit bearing capacity, the versatility of the fruit and the tree growth is easy and enormous.

Tropical fruits are constituents in the daily diets of billions of people. Jackfruit is one the most significant evergreen trees in tropical areas and countries found throughout Asia and Pacific islands, mainly in home gardens. This tree is not considered as invasive species like other species. (Rahaman *et al.* 1999; Elevitch and Manner, 2006). Although jackfruit has been a key source of nutrition for people in Asia, it is considered an invasive species in the Brazilian rain forest because jackfruit competes with native trees. The jackfruit is “an underutilized crop” in the tropical-to-subtropical climate where most of the fruits get wasted due to ignorance, lack of post-harvest technology and gaps in supply chain systems. Jackfruit contains more protein, calcium, iron, vitamins and other essential nutrients when compared to the common fruits (Prem *et al.*, 2015). Jackfruit is that is widely consumed as a fresh fruit has also been reported the therapeutic qualities since ancient times. The parts of the world facing food insecurity, the jackfruit could be manna from a tree.



**Figure 1.** The jackfruit (*Artocarpus heterophyllus*)

## 2.0 GLOBAL PRODUCTION

Fruit production is expected to rise due to the high demands worldwide due to the health benefits ascribed to fruits and their products. The major tropical fruits account for approximately 75% of global fresh tropical fruit production, and developing countries account for about 98% of the total production of tropical fruits (FAO 2010). Climate change makes the future of our food uncertain. Animals raised for meat contribute to climate change, so reducing the number of animals raised could slow climate change, but then there would be less meat to go around (Smith *et al.* 2014). The jackfruit is a multi-purpose species providing food, timber, fuel, fodder, and medicinal and industrial products. The primary economic product of jackfruit is the fruit which is used both when mature and immature. The unripe (green) jackfruit is remarkably similar in texture to chicken, thus jackfruit is an excellent vegetarian substitute for meat. The canned jackfruit is sometimes referred to as “vegetable meat” (Stukin 2016). According to the World Bank and the United Nations, rising temperatures and unpredictable rainfall have already reduced yields of major crops and could lead to food wars within decades (World Bank 2009; Measey 2015).

Jackfruit is also known as the poor man’s fruit, and is now considered as a miracle food of South and South-east Asia as it is likely to save millions of people from starvation when major staple crops

like wheat, corn and rice fail under unfavourable climatic conditions (Matin 2015). It has been hailed as a miracle food, able to withstand heat and is a potential replacement for wheat and other staple crops under threat from climate exchange. It's big and bumpy with a gooey interior and a powerful smell of decay – but it could help keep millions

of people from hunger. The international center for underutilized crops (ICUC) has been promoting the lesser known jackfruit and its use through technology development for better husbandry and marketing. Jackfruit is widely esteemed in tropical Asia where it originated as a cultigen, although it is well known and widely used and cultivated re-



**Figure 2. Jackfruit Seeds**



**Figure 3. Jackfruit bulbs**



**Figure 4. Jackfruit jam**



**Figure 5. Jackfruit wine**



**Figure 6. Dehydrated Jackfruit**



**Figure 7. Jackfruit chips**

**Courtesy Source: Google Images (Link given in reference)**

mains unutilized because it hardly undergone any scientific improvement (Williams and Haq 2000; Haq and Hughes 2002).

The production of jackfruit is becoming popular in many countries globally. China started jackfruit plantations in 1999, and devotes 180,000 hectares of land for this. Apart from China, the Philippines and Malaysia are countries that have encouraged jackfruit cultivation. The Philippines also claims to be producing one of the sweetest varieties of jackfruit, the EVIARC Sweet on 3,000 hectares. The Philippines take this fleshy fruit seriously and the government-run Agricultural Training Institute has introduced an online course on jackfruit farming (Padre 2014) and they have already claimed the production of one of the sweetest varieties of jackfruit in 3,000 hectares. In Vietnam, about 55,000 hectares of land has been used for jackfruit cultivation. Even Mexico, a relatively recent grower of jackfruit, has become an important exporter of the fruit, mainly to the U.S (Koroth 2015).

New technologies, and increasing moves by farmers and some non-government organizations to popularize this fruit, through jackfruit festivals, are helping raise awareness regarding its production

and economic value in its home country. While its rind is inedible, this starchy fruit with short spikes can be eaten in many ways, from on its own, when ripe and firm, to being a key component in curries, fried and freeze-dried and made into chips, and as a popular component of desserts. The wood of the tree is used for parts of musical instruments like Indonesia's gamelan to the Philippines' kutiyapi, a lute, and even India's veena (Padre 2014). The jackfruit has been ignored by countries where it grows enormously, but it is being used to mint dollars by nations such as China, Vietnam, Malaysia and others. They are using the humble jackfruit to create value-added products to earn significant foreign exchange while others are happy either wasting the fruit or cutting down whatever jack trees are remaining there (Lal *et al.* 1986).

### 3.0 COMMERCIAL PRODUCTION

The commercial production of jackfruit has begun in China, Philippines and Malaysia are countries where the government has encouraged jackfruit cultivation, with an aim and potential of this versatile fruit to dominate the market in future. A list of

**Table 1.** Proximate nutrient composition

Nutritive Value per 100 g.					
Principle	Nutrient Value	Percentage of RDA	Vitamins	Nutrient Value	Percentage of RDA
Energy	95 Kcal	5%	Folates	24 µg	6%
Carbohydrates	23.5 g	18%	Niacin	0.920 mg	6%
Protein	1.72 g	3%	Pyridoxine	0.329 mg	25%
Total Fat	0.64 g	3%	Riboflavin	0.055 mg	4%
Cholesterol	0 mg	0%	Thiamin	0.105 mg	9%
Dietary Fiber	1.5 g	4%	Vitamin A	110 IU	3.5%
			Vitamin C	13.7 mg	23%
			Vitamin E	0.34 mg	2%
Minerals	Nutrient Value	Percentage of RDA	Electrolytes	Nutrient Value	Percentage of RDA
Calcium	34 mg	3.4%	Sodium	3 mg	0%
Iron	0.60 mg	7.5%	Potassium	303 mg	6.5%
Magnesium	37 mg	9%			
Manganese	0.197 mg	8.5%			
Phosphorus	36 mg	5%			
Phosphorus	21 mg	3%			
Selenium	0.6 mg	1%			
Zinc	0.42 mg	4%			

Source: USDA National Nutrient data base



the world's famous fruit, from apples to oranges, shows historical roots in South America and Europe shows boom in the production. But the production of jackfruit has stagnated in recent years, due to the lack of government-funding and education. The popular crops like wheat, rice and corn need lots of irrigation and pesticides but the jackfruit is a perennial, therefore it doesn't require constant replanting and attention (Zerega 2014). The cultivation of jackfruit plantations remains largely un-commercial. The tree itself requires relatively little care once it's been established.

A jackfruit tree can live for 100 years and bear 100 to 250 pieces every year. Jackfruits can be dried, roasted, added to soups, chips, jams, juices, and ice cream. The seeds (Figure 2) can be boiled, roasted or ground into flour. The Jackfruit's opportunity to increase cultivation, improvement of cultivars in terms of taste quality and availability year round, production of diversified processed products and use of its by-products, skin and seeds through use of mass media and policy advocacy at all administrative levels. Jackfruit is widely grown in some parts of the Pacific, especially Fiji Islands. However, the consumption of jackfruits is disproportionate to the fruit production in the Pacific Islands. It is the largest edible tree-grown fruit and can be delicious additions to the diet, but some people can be put off by their unfamiliar, strong flavor and taste. Jackfruit curry and Jackfruit with crabs are the major dishes serve in Pacific Islands (Malolo *et al.* 2001). The jackfruit spoils easily and there is lack of support for a cold-storage system to transport this fruit (Padre 2014).

In Pacific Island countries this medium hardwood timber is used for cabinet making, picture frames, oars and musical instruments (Elevitch and Manner 2006). Even the tree itself is valuable: high-quality, rot-resistant timber for furniture and musical instruments (Prem *et al.* 2015). Jackfruit is heavy to transport and should be harvested when mature only 3–5 days from ripening. For more remote areas, where the local market is small, processing the fruit may be necessary. In the above case there are ample opportunities for value addition in jackfruit in all stages of maturity right from immature to well ripened stage. It can't be denied that there are few small and marginal entrepreneurs who are involved in value addition. The potential value of fruits to the economy of the region has yet

to be fully realized. The nature of the producers such as farmers scattered over an island and cannot organize themselves neither for the purpose of improving their bargaining power for better prices nor for commercial production. However, in order to establish it in large scale, this article's objective is to make a strong awareness among the local folk of Fiji, about functional, physiochemical and commercial importance of underutilized indigenous fruit. This article also aims to create awareness among producers, entrepreneurs, and consumers not only about the therapeutic qualities but also about the industrialization of jackfruits and its processing.

#### 4.0 PHYSICOCHEMICAL AND FUNCTIONAL PROPERTIES

“Functional foods” provide more than simple nutrition; they supply additional physiological benefit to the consumer. The interior of the ripe fruit consists of large, pleasant flavored, sweet yellow bulb, massed among narrow ribbons of thin, though underdeveloped, and a central pith core which consists 25-30% of the total fruit (Ejiofor *et al.* 2014). The jackfruit and its derivatives such as wafers, chips, seed flour, peel, and so on could be considered a functional food because it has valuable compounds in different parts of the fruit that display functional and medicinal properties (Swami *et al.* 2012). Prebiotics are non-digestible food ingredients which are present in jackfruit seed in the form of phenolic compounds and about 6.03 mg/g extracted non-reducing sugar (Soong and Philip 2009; Nualla-ong *et al.* 2009). The fruit is made of soft, easily digestible flesh called bulbs (Figure 3) made up of simple sugars like fructose and sucrose that when eaten replenishes energy and revitalizes the body instantly. 100 g of jackfruit only contains 94 calories (Swami *et al.* 2012). Jackfruit consist about 29% pulp, 12% seeds and 54% rind (Berry and Kalra, 1988). It provides about 2MJ of energy per kg-wet weight of ripe perianth (Ahmed *et al.* 1986). Jackfruit has been reported to contain high levels of protein, starch, calcium and thiamine (Burkill 1997; Ejiofor *et al.* 2014). It is also rich in energy, dietary fibre, minerals and vitamin. Nevertheless, it contains no saturated fats or cholesterol making it a healthy fruit to savour.

The jackfruit can be not only used for several culinary operations but the seed powder also has a lot of potential in food jackfruit can, cosmetics,

pharmaceuticals, paper, bio-nanotechnology industries, especially its uses as thickener and binding agent. The jackfruit seed contains 4.27% ash, 6.73% protein, 73.34% starch, 0.80% fat and 1.6% fiber (Goswani *et al.* 2010). Odoemelam (2005) reported that the jackfruit seed flour have, (16%) W/V least gelation concentration, 230% water absorption capacity (WAC), 280% Oil absorption capacity (OAC) and 0.6g/ml bulk density. Jackfruit seed powder contains manganese and magnesium elements (Barua and Boruah 2004). The major components of the flours were carbohydrates (78.0%) and the proximate analysis showed that protein (11.2%) and lipid (0.99 %,) (Tulyathan *et al.* 2002). The flour blends could be used as a protein supplements and functional ingredients in human diets. Jackfruit seed flour has a great potential in new food formulation along with wheat flour. (Chowdary *et al.* 2012). Due to its high carbohydrate content and other nutrients, they can be added along with wheat flour to baked products for value addition without affecting the functional and sensory properties of the final product (Theivasanthi and Alagar 2011; Ejiofor *et al.* 2014). The proximate nutrient composition of the flesh of per jackfruit (Table 1), had been published in USDA National Nutrient data base.

The dietary habits are specific to populations and vary widely. It is necessary to study the disease-preventive potential of functional micronutrients in the regional diets. The medicinal plants with increased levels of essential vitamins and nutrients such as vitamin E, vitamin C, lycopene, bioflavonoids, thioredoxin, provide a rich source of compounds like antioxidants that can be used as functional foods (Devasagayam *et al.* 2004). The overall value and safety of jackfruit as an intact fruit or of various extracts derived from jackfruit components also measure the same as medicinal plant (Lansky 2007; Ejiofor *et al.* 2014). Jackfruit contains vitamin A, vitamin C, thiamin, riboflavin, calcium, potassium, iron, sodium, zinc, and niacin among many other nutrients. Jackfruit is a rich source of potassium with 303 mg found per 100 g (Swami *et al.* 2012; Mushumbusi 2015; Jackfruit nutrition facts). Due to the above reasons jackfruit is considered as functional food or medicinal plant or simply a versatile food source.

The beneficial effects of fruits and vegetables for prevention of certain diseases are now widely accepted due to the presence of bioactive compounds in them (Galaverna *et al.* 2008). Recent years have seen increased interest on the part of consumers, researchers, and the food industries into how food

**Table 2.** Putative use of jackfruit in local medicine.

No.	Plant part	Use
1	Roots	Root extracts is used in treating skin diseases, asthma and diarrhoea.
2	Leaves	Leaf extract is given to diabetics as a control measure. An extract from leaves and latex cures asthma, prevents ringworm infestation and heals cracking of feet. A tea made with dried and powdered leaves is taken to relieve asthma.
3	Flowers	Crushed inflorescences are used to stop bleeding in open wounds.
4	Fruits	Ripe fruits are used as laxatives.
5	Pulp	The jackfruit pulp and seeds are nutritious tonic and useful in overcoming the influence of alcohol on the system.
6	Seed	Increased consumption of ripe jackfruit kernels alleviates vitamin A deficiency. Extract from fresh seeds cures diarrhoea and dysentery. Extract from seeds (or bark) helps digestion.
7	Bark	An extract from bark (nonedible portion) or roots helps cure dysentery. Ash produced by burning bark can cure abscesses and ear problems.
8	Latex	Mixed with vinegar, the latex promotes healing of abscesses, snakebites and glandular swellings.
9	Wood	The wood has a sedative property; its pith is said to aid abortion.

Source: Haq (2006) University of Southampton

products can help maintain health (Vinuda *et al.* 2010). Various jackfruit plant parts, including the bark, wood, leaves, fruit, and seeds, may exhibit a broad spectrum of antibacterial activity. Jackfruit seeds may therefore be developed into therapeutic agents capable of treating infectious diseases and preventing food contamination by food-borne pathogens. Jackfruit seed has antibacterial effect and it inhibits the growth of *E. coli*, *F. moniliforme*, *S. cerevisiae* and *B. megaterium* (Swami *et al.* 2012).

The phytochemical components of jackfruit to reduce the various diseases such as lowering blood pressure, preventing heart disease and strokes, preventing bone loss and improving muscle and,

nerve function have been studied (Mushumbusi 2015). One cup of jackfruit can supply the body a very good amount of this powerful antioxidant (Umesh *et al.* 2010). The jackfruit is a rich source of phenolic compounds, and is also rich in 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 (Ko FN *et al.* 1998). Jackfruit is gluten-free and casein-free, thus offer systemic anti-inflammatory benefits to skin. The human body does not make vitamin C naturally, but jackfruit is enriched with vitamin C and it strengthens the immune systems. Vitamin C is a powerful nutrient which helps to protect against viral and bacterial infections. Vitamin C also helps

**Table 3.** Potentiality of jackfruit for value addition

Types	Stage of fruit	S. No	Items that can be prepared	Remarks
A	Immature	1	Culinary preparations	Fresh consumption
		2	Cutlets	Fresh consumption
B	Half mature	3	Pickle	Can be preserved
		4	Cutlets	Fresh consumption
		5	Pulao/ Biryani	Fresh consumption
C	Fully mature	6	Papad	Can be preserved
		7	Cutlets	Fresh consumption
		8	Chips	Can be preserved
		9	Pakoda	Fresh consumption
D	Well Ripened	10	Pulp (Base material)	Can be preserved
		11	Halwa	Can be preserved
		12	Gulab Jamun	Fresh consumption
		13	Sweet vada	Fresh consumption
		14	Leather	Can be preserved
		15	Jam	Can be preserved
		16	Custard	Fresh consumption
		17	Wine	Can be preserved
		18	Squash	Can be preserved
		19	Kheer/Pudding	Fresh consumption
E	Seeds	20	Mocktail	Fresh consumption
		21	Cake	Fresh consumption
		22	Culinary preparations	Fresh consumption
		23	Pakodas	Fresh consumption
		24	Kheer/Pudding	Fresh consumption
		25	Starch flour	Can be preserved

Source: Technical Bulletin No: 41 ICAR

to strengthen the immune systems function by supporting the function of white blood cells (Mukprasirt and Sajjaanantakul 2004). Vitamin C is vital to the production of collagen, a protein that provides skin with structure and gives it its firmness and strength (Babitha *et al.* 2004).

The antioxidant 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 (Fernando *et al.* 1991; Jackfruit nutrition facts). 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 (Fernando *et al.* 1991). Jackfruit is enriched with magnesium (27 mg/100 g in young fruit and 54 mg/100 g in seed) which helps to absorb calcium and may strengthen the bone, thus prevents bone-related disorders such as osteoporosis (Fernando *et al.* 1991; Singh *et al.* 1991). It also prevents anaemia and also supports proper blood circulation because of the presence of iron (0.5 mg/100 g) (Singh *et al.* 1991). Jackfruit contains micromineral copper (10.45 mg/kg), which plays an important role in maintaining thyroid gland metabolism, especially in hormone production and absorption (Gunaseena *et al.* 1996).

The presence of high fibre content (3.6 g/100 g) in the jackfruit prevents constipation and produces smooth bowel movements and offers protection to the colon mucous membrane by removing carcinogenic chemicals from the large intestine (Siddappa 1957). This smooth bowel movements also shows anti-ulcer properties which has the potential to cure ulcers and digestive disorders and improves the digestion. Martin (2016) has reported about a study conducted by Sydney University's Glycemic Index Research Service that the true potential of unripe jackfruit after cooking can bring down diabetes. Leaf extract is given to diabetics as a control measure which decrease the risk for diabetes and can be easily brought under control without the consumption of tablets or insulin injection (Swami *et al.* 2012; Haq 2006). Jackfruit leaves may improve glucose tolerance in normal and type 2 diabetes patients. According to the study, 30 grams of dehydrated unripe jackfruit replaced a cup of cooked rice or two wheat chapattis and also offered much higher level of being satiated or the feeling of being full, eliminating the need for snacks. The study showed that glycaemic load (glucose level) in unripe jackfruit is almost half that of rice or wheat. This is the reason why unripe jackfruit helps reverse the diabetic condition (James 2014). Jack-

fruit could be therefore play a vital role in health and nutrition of local populations in Fiji and other Pacific nations where diabetes prevalence among the adults is among the highest in the world (WHO 2010).

Various plant parts are widely used in folk medicine because of the presence of bioactive compounds in the roots, leaves bark, fruits and seeds. The folk medicinal uses should not be used for self-medication. Some of the jackfruit plant part which are in putative use as local medicine (Table 2). In regard to human safety, it is relevant that the fresh jackfruit has been consumed by local people and animals regularly during the fruit season. The findings of a multiple study about the jackfruit's chemical, physical and functional properties indicated no adverse effects or toxicity, and no published reports of adverse effects or toxicity in this underutilized crop.

## 5.0 VALUE-ADDED PRODUCTS FROM JACKFRUIT

Jackfruit seeds can be roasted like chestnuts. The fruit pulp is sweet and tasty and is used as a dessert or preserved in syrup. The fruits and seeds are also processed in a variety of ways for food and other products (Sidhu 2012). Jackfruit seed flour has great potential in the food industry (Table 3), especially as a thickener and binding agent in various food systems (Ocloo *et al.* 2010).

The flour is prepared from seeds without removing the thin brown spermoderm with the crude fibre content. This flour has a good ability for water and oil absorption, thus is used in the biscuit industry (Tulyathan *et al.* 2002; Ejiofor *et al.* 2014). Jackfruit seed flour is of high demand for making various bakery products such as cookies (Chowdhury *et al.* 2012). The various products developed from jackfruit are candy, finger chips, fruit bars, fruit leather, halvah, papad, ready-to-serve beverages, toffee, and milk-based srikhand, ice cream, and kulfi. 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 (Tulyathan *et al.* 2002; Chowdhury *et al.* 2012).

In culinary use, the pulp of the fruit is made into various local delicious dishes. The jackfruit pulp can be used to make jam (Figure 4). Many other fruit jams in supermarkets are mixed with a generous amount of sugar, which increases the risk of contracting diabetes. On the contrary, jackfruit jam is full of natural sugars and is low in calories making it an ideal food source to reduce body weight (FAO 2004; Swami *et al.* 2012).

The ripe jackfruit contains an agreeable amount of fermentable sugar, which may be exploited for the commercial production of vinegar and wine (Figure 5) (Amit and Ambarish 2010). The maximum alcohol content in jackfruit wine (jackwine) was 10% (v/v), and this makes the jackfruit famous for commercial wine production. The jackwine is considered to be commercially valuable by-product for the jackfruit growers (Amit and Ambarish 2010; Umesh *et al.* 2010).

Dehydrated jackfruit (Figure 6) is made from ripe jackfruit pulp, and it is a nutritious snack item. It is golden-yellow to orange and has a chewy texture with a sweet and sour taste. Unlike other dehydrated products it is free from sulphite preservatives thus it will not trigger allergic reaction in humans (Diamante 2009). Seeds are removed from clean jackfruit bulbs which are then chopped into fine pieces and fried in oil making fine chips (Figure 7) (Jagadeesh *et al.* 2006). The nutrients in jackfruit will remain same and also it retains its own original color, flavor, and texture after frying.

The jackfruit chips are rich in vitamin E,  $\gamma$ -oryzanol and phytosterols which provide health benefits (Molla *et al.* 2008). Jackfruit leather (Figure 8) is made from dried sheets of fruit pulp. It has a soft, rubbery texture, and a sweet taste. It can be eaten as a snack food by adding other fruits, sugar, chopped nuts, or spices to vary the flavor. It can also be used as an ingredient in cookies, cakes, and ice cream (Gunaseena *et al.* 1996; Swami *et al.* 2012). The crisp bulbs of the ripe Jackfruit are used for canning in sugar syrup. After cutting the fruit in several pieces, the bulbs are removed and are then canned either as whole or as halves or quarters, with or without seeds. The canned jackfruit (Figure 9) has an exotic flavour and is relished by all sections (Jackfruit product Manual 2003).

The ripened jackfruit bulbs are deseeded and passed through a pulping/ fruit mill. After pulping, it is mixed with about 10% hot water and passed through a pulpier for preparing nectar (Figure 10)



Figure 8. Jackfruit leather



Figure 9. Canned/ Packed Jackfruit



Figure 10. Jackfruit Nectar



Figure 11. Jackfruit pickle

Courtesy Source: Google Images (Link given in reference)

(Jackfruit product Manual 2003). Young green jackfruit are peeled and cut into 1.2 to 1.8 cm thick slices. The slices are placed in a container and covered in an 8% common salt solution for 8-10 days. To this vinegar and spices are added in appropriate measures to make the pickle (Figure 11) prior to packing (Lal *et al.* 1986).

## 6.0 MARKET POTENTIAL AND CHALLENGES TO VALUE ADDITION IN FIJI

Fruits and vegetable processing in Fiji is yet to be fully exploited. The commercial fruit farming development in the smaller Pacific Island countries is constrained by their isolation, a limited and restricted environment, lack of capital, natural disasters, the effect of other agricultural activities and the conflict between export-oriented policy and the need to strengthen smallholder farms for the local markets (Sommers 1990; Malolo *et al.* 2001). There is a prospective market for these products not only in Fiji but also outside the country. It is also learnt that there is a good export market potential for these items especially in Australia, New Zealand, US, Canada, and EU markets (Brown 2009). In view of the above, it is envisaged that there is a good scope for setting up jackfruit processing units in jackfruit growing areas in Fiji. This will not only help the farmers to utilize the perishable raw material but also generate more employment opportunities in the country.

Due to limited information on production and trade of value added products from jackfruit, farmers are unaware about the potential of this fruit. The market potential of jackfruit can be better exploited if fruits are made available to the consumers in a ready to eat or ready to cook form throughout the year. Technologies for post-harvest handling, preservation of fresh fruits and preparation of primary processed products that can be used for production of other products need to be promoted and commercialized for ensuring availability of the fruit throughout the year. Emphasis should be given in imparting trainings to more and more farmers of Fiji on value addition in jackfruit. At the same time, capacity building of marginal farmers in processing such native fruits of Fiji should also be focused upon. Establishment of strong forward and backward linkages, facilitating proper packaging,

labelling and marketing, including certification should also be ensured for avoiding the wastage of this wonderful fruit.

Jackfruit do not have any separate farm in Fiji and improved cultivation practices are not being followed by most of the farmers, therefore the commercial scale cultivation is still quite low. It has been hailed as a miracle food, able to withstand heat and is a potential replacement for wheat and other staple crops under threat from climate change (Padre 2014). So the perishable fruits produce are all too frequently wasted due to inadequate post-harvest storage facilities and lack of effective preservation techniques.

The potential for developing a new industry in processing and exporting jackfruit in Fiji is relevant for the development of social and economic status of farmers in Fiji. Like other food crops, jackfruit should also considered as a future staple food for Fiji. It is deliberately significant for exports, although international markets are less exploited for jackfruit. To maximize value chains, large scale production, agro-processing and marketing of jackfruit in Fiji is very important. Jackfruit farming, production, processing and export must be promoted in Fiji. In order to sustain this fruit and its value, it is important to create an awareness about this poor man's fruit among the farmers.

## 7.0 FUTURE PROSPECTS

In view of the increased population growth worldwide coupled with limitations on resources, the steady supply of food and adequate nutrition in many developing countries assumes greater significance. Therefore the quality and quantity of food have become important issues at the global level. Jackfruit is grown mainly on homestead farms and produces multiple products for food, feed, and industry as well as contributing towards soil management for sustainable environments. Due to limited development of downstream products, jackfruit has remained mainly as a minor fresh fruit in domestic markets. Although the importance of jackfruit for these purposes has been moderately recognized, no tree improvement research program has been done on this important underutilized fruit species. Carbohydrates, proteins and fat are in general supplied from cereals, pulses and oilseeds, respectively but there are notable vitamin and mineral deficiencies

in many developing countries. In this above context, there are high levels of vitamins and minerals have been recorded in jackfruit and it is nutritionally rich and is a good candidate to meet the nutritional deficiency in developing countries.

The basic understanding of the existing clones in and around the island countries is an essential prerequisite for the further improvement in jackfruit. The research on better selection, vegetative propagation and breeding for improvement of qualitative traits are also to be considered. Any attempt to produce improved jackfruit cultivars needs to be targeted both for commercial production to increase the value of fruit and, thus increase the farmers income generation and food. Irrespective of commercial business, the local farmer should also get knowledge about the appropriate technologies for post-harvest handling, processing and product development for local and regional markets should be developed. There is a great need to establish appropriate market linkages so that the jackfruit farmers/growers can channelize the sale of their produce in an efficient and cost-effective manner.

## 8.0 CONCLUSION

This paper reviewed the potentials of jackfruit as a sustainable resource and to realize the business feasibility and benefits of processing jackfruits including nutritive value of jackfruits and briefly narrated its importance as a staple food in population growth worldwide. This fruit is s God's gift to nature, which has high carbohydrate content. The consumption of jackfruit has increased in recent years due to its reported health benefits. The rich bioactive profile of jackfruit makes it a highly nutritious and desirable fruit crop (Swami *et al.* 2012).

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 (Siddappa 1957; Martin 2015). Jackfruit is grown mainly on homestead farms in Pacific and considered as a minor fruit crop. The commercial scale cultivation of this precious fruit is very low and improved cul-

tivation practices are not being followed by most of the farmers. The jackfruit cultivators are facing many problems in cultivation such as rainfall, selection of seed and financial assistance and lack of preservation bases. The cultivation requires linking operations more closely and systematically, modernizing marketing infrastructure and technologies, capacity building of the cultivators, and strengthening the policy for better marketing. The production of value added products from jackfruit can be converted to an important agricultural products in the country, which plays an important role in the economic development. Jackfruit has not yet received the attention and have rarely discussed about its immense possibilities in the context of food security, climate change and global warming. The researchers has already warned that climate change will create food shortage, and they say that jackfruit will be useful alternative to other staple crops, during such shortage (Nissanka and Marambe 1996), The fruit survives pests, diseases and high temperatures and those qualities fulfill what farmers need in food production when facing a lot of challenges under climate change.

Although the importance of jackfruit has been well recognized, very little research work has been done on this important fruit species. The research and development (R&D) should concentrate more on germplasm collection, characterization, conservation and utilization; varietal improvement; package of cultivation practices; diversified uses and value added products, economics and marketing (Gunasena *et al.* 1996). Technologies to ensure availability of the fruit throughout the year and avoiding wastage should be promoted for this wonderful fruit.

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