



ISSN (E): 2277-7695

ISSN (P): 2349-8242

NAAS Rating: 5.23

TPI 2023; 12(6): 879-888

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www.thepharmajournal.com

Received: 09-03-2023

Accepted: 14-04-2023

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Health benefits of jackfruit (*Artocarpus heterophyllus* Lam.) seeds: A review

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Abstract

This abstract provides an overview of the underutilized jackfruit seeds, which are often neglected despite their high nutrient content. Jackfruit trees are monoecious and widely grown throughout Asia, Africa, and parts of South America. The article highlights the structure of the jackfruit seed, its nutritional composition, and the presence of anti-nutritional factors. The anti-nutrients present in jackfruit seeds, such as trypsin inhibitor, phytate, and tannin, can negatively affect nutrient absorption, but can be reduced through roasting and germination. The health benefits of jackfruit seeds are also discussed, including their high fiber content, which aids digestion and prevents constipation. Jackfruit seeds are also rich in iron, which helps in preventing anemia and ensuring proper blood circulation. The lectins present in the seeds support the immune system, while prebiotic activity can promote probiotic bacterial growth. The seeds can be used in the preparation of ice cream and as a source of pectin with high antioxidant activity. Additionally, a combination of jackfruit seed-sourced resistant starch and *Bifidobacterium pseudolongum* subsp. *globosum* has been found to lower body weight and blood cholesterol levels, making it a potential treatment for hyperlipidemia. Overall, this abstract provides comprehensive information on the nutritional benefits and potential applications of the often-overlooked jackfruit seeds.

Keywords: Jackfruit seed, health benefits, anti-nutritional factors

1. Introduction

Jackfruit (*Artocarpus heterophyllus*) belongs to the family *Moraceae*. The word jackfruit is derived from the Portuguese word *jaca*, which is further derived from the Malayalam (Caminiti *et al.*, 2012) ^[50] word *chakka* (Pradeepkumar *et al.*, 2008) ^[51]. Jackfruit trees produce both female and male flowers, hence making them monoecious. In several Asian nations, the jackfruit is a well-known fruit. Although jackfruit seeds are underutilized and less well known, they have significant nutritional advantages and could be used as a functional food ingredient. Jackfruit major producers are India, Bangladesh, Indonesia, Philippines, Thailand, Vietnam and Brazil. India was the top producer of jackfruit in 2017, with an output of 1.4 million tonnes, followed by Bangladesh, Thailand, and Indonesia (Sawe, 2018). Jackfruit is thought to be native to the rainforests of the Western Ghats (Julia, 2016). As of 2021-22, India produced 1.8 million tonnes of jackfruit, while Bangladesh, Thailand, and Indonesia followed suit. (Julia, 2018). In India's production 16.63% share is contributed by Orissa- 312000 tons of jackfruit, 14.01% contributed by Kerala- 263000 tons of jackfruit, 11.31% share is contributed by Assam and West Bengal – 212000 tons jackfruit by each state and followed by Chhattisgarh, Jharkhand and Tripura etc. A good output in India is 150 large fruits per tree per year, while some plants bear as many as 250, and a completely mature tree may produce 500, most of which are middle or tiny in size (Julia (2016). The monoecious jack fruit tree has both male and female inflorescences on the same tree (M.S. Baliga *et al.*, 2011) ^[24]. The entire fruit growth process takes three to seven months from the moment of successful pollination. Various countries have different fruiting times. The fruit axis, the persisting perianth, and the actual fruit make up most of the fruit. Due to the presence of laticiferous cells, the fruit's axis, or core, which keeps the fruits together, is inedible and rich in latex (Prakash *et al.*, 2009) ^[52]. The by-products of jackfruit are seeds, perianth, rags, peel, and skin. Consumption and processing of fresh jackfruit leads to significant production of non-edible waste including the central axis and peel, as well as edible by-products such as seeds and perianth. Jackfruit peel, which comprises the outer layer of the fruit, accounts for 40-50% of the fruit weight. Despite the potential value of edible by-products such as jackfruit seeds, they are generally overlooked on a global scale. During the processing of raw agricultural products into finished products, a significant amount of food waste is produced. While some of these waste materials are

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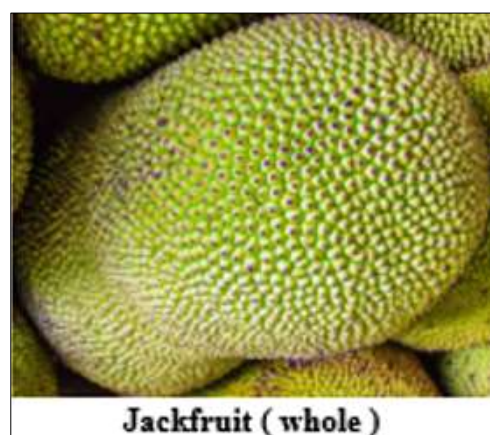
repurposed as animal feed or used to enrich the soil as a nutrient, a variety of industries within the agricultural sector generate significant amounts of waste, such as peels, seeds, whey, waste liquid, molasses, bagasse, and more (Balasundram, 2006) ^[53].

Seed is an important by-product that consists around 12-14% of a whole jackfruit (Akther, 2019) ^[54]. The seeds have a thin, whitish membrane covering them and are light brown, spherical, and are 2-3 cm (0.8-1.2 in) long by 1-1.5 cm (0.4-0.6 in) wide. Each jackfruit holds up to 500 seeds (Prakash *et al.*, 2009) ^[52]. The waste produced is both biodegradable and contains valuable nutrients including carbohydrates, proteins, and vitamins. Jackfruit seeds, which are often overlooked, can be consumed as a snack and prepared through cooking or roasting. While dried or powdered seeds can be stored for extended periods, fresh seeds have a shorter shelf life.

The nutritive value of jackfruit seed per 100 g is, calorie - 429.5, carbs- 38.4, moisture- 3.215 g, protein - 9.78 g, fat - 0.56 g, fibre- 25.43 g, ash - 2.75 g, starch- 55.90 g (Bakri *et al.*, 2021) ^[28], calcium-77.3 mg, iron- 0.59 mg, phosphorus - 43.7 g, potassium - 14.7 mg, copper - 1.04 mg, manganese - 0.12 mg (Akther, 2019) ^[54]. Anti-nutritional factors like tannin (0.5547%) and phytic acid (0.0713%) are present in jackfruit seeds (Lasekan *et al.*, 2015) ^[55]. But through germination, roasting, drying or boiling these can be reduced to a significant level.

Jackfruit seeds offer significant nutritional benefits but are neglected and underappreciated by people while making up 10% to 15% of the weight of the fruit (Hossain, 2014) ^[56]. In local communities, jackfruit seeds have been traditionally used for making dishes like sabji and curry. To preserve them for future use during the rainy season, they are taken out of ripe fruit, dried under the sun, and stored properly. However, preparing and storing seeds can be difficult, resulting in a significant amount of annual wastage. (Waghmare, R. *et al.*, 2019). The seeds are typically thrown away as waste due to their perishable nature, but they can last for about a month if they are kept in a cold, moist environment. The ground and roasted jackfruit seeds can be mixed with other flours, such as wheat flour, to increase their value and shelf life. This seed powder is used as a substitute flour in baking and confectionery items in order to make it more cost-effective (Hossain, 2014) ^[56]. The presence of substantial amounts of amylose and protein in jackfruit seed flour or starch makes it a promising candidate for food production (Mukprasirt and Sajjaanantakul, 2004) ^[57]. Now a days usage and studies regarding jackfruit seed are increasing as it is having high nutritional benefits. Jackfruit seed flour is used in different bakery products such as biscuits, cookies, bread, cake, muffins etc have been developed by adding varied amounts of jackfruit seed flour. Jackfruit seeds can also be used to make ice cream (Shinde *et al.*, 2021) ^[6]. Due to insufficient protein consumption, malnutrition is one of India's biggest issues. To combat malnutrition, jackfruit seeds could be used as a cost-effective substitute protein source, as it has been referred to as cheap non-conventional source of protein (Roy Chowdhury *et al.*, 2012). Health benefits of jackfruit seed includes, have antioxidants activity which prevents cells from free radicles, decreases LDL, lowers risk of high cholesterol, lowers risk of heart disease. Improves blood sugar control as it contains resistant starch and potassium content maintains proper blood pressure levels. Contains good amount of thiamine and riboflavin it is good for healthy hair, skin, eyes and stimulates

hair growth, it also contains copper which helps to promote thyroid metabolism. Contains insoluble fiber which prevents constipation and indigestion. seeds include saponins, which by preventing cell development and promoting death in cancer cell lines, have demonstrated effective anticancer potential. the phytonutrients found in seeds, including lignans, saponins, and isoflavones, are helpful to human health. The seeds of jackfruit are rich in fiber which can lower the risk of heart diseases, promote bowel movement, and aid in weight loss. Furthermore, they are a good source of B-complex vitamins. Jackfruit seeds also contain resistant starch that regulates blood sugar levels and promotes gut health. In addition, they have antimicrobial properties that protect against foodborne illnesses. Other properties of jackfruit seed are thickening and binding agent, reducing potential, least gelation, bulk density, foaming capacity and stability and emulsification (Waghmare, 2019).



Jackfruit (whole)

Fig 1: Jackfruit



Jackfruit seeds

Fig 2: Jackfruit seeds

2. History and utilization during early days

The jackfruit, or *Artocarpus heterophyllus* Lam., is a tropical climacteric fruit that is a member of the Moraceae family. It is indigenous to India's Western Ghats and is widely grown throughout Asia, Africa, and some parts of South America (Bhattacharyya *et al.*, 2012) ^[1]. India is considered as the motherland of jackfruit (Maurya and Mogra, 2016) ^[4]. Yet, other writers think that Malaysia could be the centre of genesis (Ranasinghe *et al.*, 2019) ^[3]. It is well known that it is the world's largest edible fruit. It is one of the most important tropical evergreen trees and is widely cultivated in Asia,

particularly India (Bhattacharyya *et al*, 2012) ^[1]. Jackfruit farming began between 3,000 and 6,000 years ago in India. According to reports, practically every component of the jackfruit tree is used in the creation of a variety of Ayurvedic and Yunani medications (Maurya and Mogra, 2016) ^[4].

Jackfruit were used in local medicine for the following, For the treatment of diarrhoea, asthma, and skin conditions, roots are extracted. Asthma is cured, ringworm is prevented, and cracked feet are healed with a latex and leaf extract (Swami, *et al*, 2012) ^[2]. Diabetics receive leaf extract as a management tool. Heated leaves are said to ease pain and treat wounds, abscesses, and ear disorders. Gallstones are treated with a bark and mature leaf infusion. Asthma is treated by drinking a tea made from dried and powdered leaves. To treat ulcers, use coconut oil alone or combined with the ash from jackfruit leaves burned with maize and coconut shells. Inflorescences that have been crushed are used to halt bleeding in open wounds. Fruits that are ripe have laxative properties (Thakor, *et al*, 2012) ^[2]. The pulp and seeds of the jackfruit are a nourishing tonic that can be used to counteract the negative effects of alcohol on the body. Dysentery can be treated with an extract made from roots, bark, and rags (the inedible section of ripe fruits). Bark is used to make poultices (Swami, *et al*, 2012) ^[2]. Burning bark can provide ash that can treat ear issues and abscesses. The latex, when combined with vinegar,

aids in the healing of glandular swellings, abscesses, and snakebites (Thakor, *et al*, 2012) ^[2]. Giving the seed starch will help with biliousness. Aphrodisiac properties are attributed to roasted seeds. Diarrhea and dysentery can be treated with fresh seed extract. Extract from jackfruit seed supports digestion (Swami, *et al*, 2012) ^[2].

3. Structure of jackfruit seed

There may be about 100–500 seeds per fruit (N Haq, 2006) ^[7]. Jackfruit seeds measure 2-3 cm in length by 1-1.5 cm in diameter, and they are light brown and rounded with coriaceous Testa (Ranasinghe *et al.*, 2019) ^[3]. The Testa is thin and leathery, and when dried, it becomes thick, rigid, and parchment-like. The inner seed coat is a thin, membrane with a brownish tint. The hilum, which is located with the micropyle in the distilled endor close to the reticular end of the seed, thickens the seed (N Haq, 2006) ^[6]. A single seed is enclosed in a white aril encircling a thin brown spermoderm, which covers the fleshy white cotyledon (Swami *et al.*, 2012) ^[2]. The fleshy cotyledons are very equal in size, with just a third to a half difference in size between each cotyledon. The endosperm is quite tiny. The embryo has a radicle on the surface. (N Haq, 2006) ^[7]. The seeds moisture content is about 55% (Ranasinghe *et al*, 2019) ^[3].

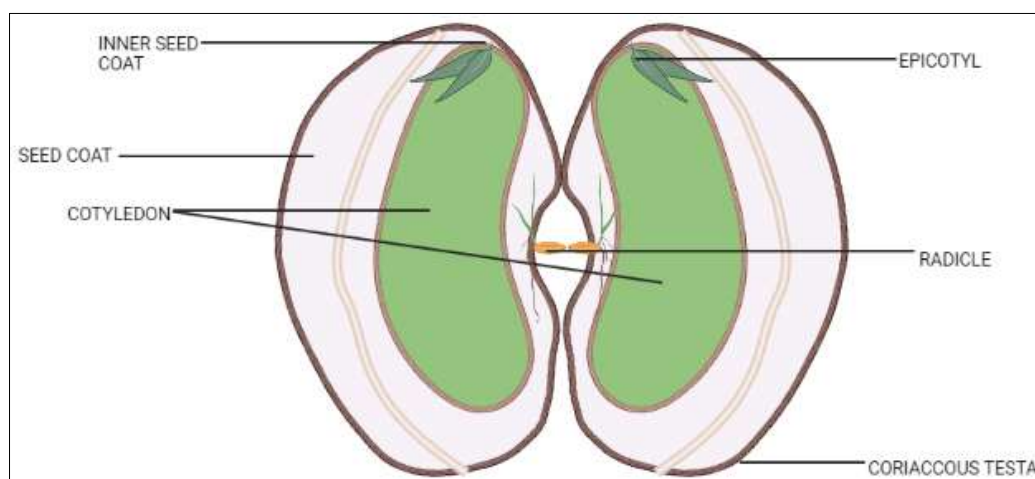


Fig 3: structure of Jackfruit seed



Fig 4: Jackfruit seed with and without slimy sheath

4. Nutritional composition

The nutritive value of jackfruit seed per 100 g is, calorie - 429.5, carbs- 38.4, moisture- 3.215 g, protein - 9.78 g, fat - 0.56 g, fibre- 25.43 g, ash - 2.75 g, starch- 55.90 g (Bakri *et al*, 2021) ^[28]. calcium-77.3 mg, iron- 0.59mg, phosphorus - 43.7 g, potassium - 14.7 mg, copper - 1.04 mg, manganese -

0.12 mg (Akther, 2019) ^[54]. Jackfruit seed is also rich in minerals like Sodium, Phosphorus, Potassium, Calcium, Magnesium, Sulphur, Zinc, Copper, etc (Maurya & Mogra, 2016) ^[4]. The jackfruit seeds include sulphur and its derived compounds, which are responsible for the anti-microbial effect, and the aromatic chemicals suggest the presence of flavonoids (Waghmare *et al*, 2019). Jacalin and artocarpin are two significant lectins that are beneficial for the health of the human immune system. Due to their high fibre content, the seeds are also abundant in B-complex vitamins and dietary fibre (Bakri *et al*, 2021) ^[28]. The jackfruit seed's substantial nonreducing sugar content also makes it a valuable source for prebiotics. (Fadilah MB *et al*, 2021) ^[13] did a comparative study in nutritional composition in raw, germinated, and roasted jackfruit seed. In this study he found that both treatments (roasting and germination) improved major nutrients like protein and starch and decreased the fat content. Roasting only increased the moisture content and energy value.

Table 1: Nutritional composition of jackfruit seed1

Nutrients	Amount/ 100G	Reference
Calorie	429.5 kcal	(Bakri <i>et al.</i> , 2021) [28]
Carbohydrate	38.4 g	(Bakri <i>et al.</i> , 2021) [28]
Protein	13.68 g	(Bakri <i>et al.</i> , 2021) [28]
Fat	0.56 g	(Bakri <i>et al.</i> , 2021) [28]
Ash	2.75 g	(Bakri <i>et al.</i> , 2021) [28]
Moisture	3.12 g	(Bakri <i>et al.</i> , 2021) [28]
Starch	55.90 g	(Bakri <i>et al.</i> , 2021) [28]
Fibre	25.43 g	(Bakri <i>et al.</i> , 2021) [28]
Phosphorus	14.7 mg	(Akther <i>et al.</i> , 2019)
Copper	1.04 mg	(Akther <i>et al.</i> , 2019) [54]
Magnesium	0.12-1.30 mg	(Sreelatha <i>et al.</i> , 2017) [39], (Akther <i>et al.</i> , 2019) [54]
Vitamin C	31.98 mg	(Zuwariah <i>et al.</i> , 2018) [27]
manganese	0.12 mg	(Akther <i>et al.</i> , 2019) [54]
Calcium	77.3 mg	(Akther <i>et al.</i> , 2019) [54]
Sodium	0.18 mg/g	(Sreelatha <i>et al.</i> , 2017) [39]
Potassium	9.72 mg	(Sreelatha <i>et al.</i> , 2017) [39]
Zinc	0.05173 mg	(Sreelatha <i>et al.</i> , 2017) [39]

Table 2: Comparative study in nutritional composition in raw, germinated, and roasted jackfruit seed

SI no	Nutrients	Raw seeds	Germinated seeds	Roasted seed	Reference
1	Energy, kcal/100 g	429.5	429.5	434	(Fadilah MB <i>et al.</i> , 2021) [13]
2	Carbohydrate, g/100 g	83.68	83.63	76.03	
3	Protein, g/100 g	9.78	10.41	24.98	
4	Fat, g/100 g	0.56	0.48	0.22	
5	Starch, g/100 g	55.90	64.98	50.97	
6	Fibre, g/100 g	25.433	24.48	14.33	
7	Moisture, g/100 g	3.215	2.925	5.985	
8	Ash, g/100 g	2.75	2.56	2.43	

4.1 Antinutritional factors

Anti-nutrients are chemical compounds that are present in plants that prevent the body from using nutrients. The maximum amount of trypsin inhibitor present in jackfruit seed was (1.14 to 1.41), and tannin (0.01 - 0.04%) and phytate (0.05 - 0.30 g), they are present in very small amounts (Lasekan *et al.*, 2015) [55]. These crucial components can be negatively impacted by the distinctive structure of this chemical, which can strongly chelate with cations including calcium, magnesium, zinc, and iron to produce insoluble salts (Bakri *et al.*, 2021) [28]. Anti-nutritional factors like tannin (0.5547%) and phytic acid (0.0713%) are present in jackfruit

seeds. Fresh samples and samples that had undergone roasting treatment had significantly different tannin levels. Roasted treatment samples showed the lowest level of tannin (0.1039%) and phytic acid (0.0159%). Phytic acid level in the germinated sample was lower (33%) than in the raw sample. Even though anti-nutritional factors are present in the jackfruit seed through the roasting and germination process peoples can safely consume them (Fadilah MB *et al.*, 2021) [13]. Tannins, saponins, and alkaloids quantitative phytochemicals estimates in seed powder were 1.45±0.29, 2.67±0.17, and 3.05±0.19, respectively in 100 g - 1 DW (Sreeja Devi *et al.*, 2021) [29].

Table 3: Anti-nutritional factors in jackfruit seed

SI no	Anti-nutritional factors	Seed type	Amount (%)	Reference
1	Tannin	Fresh seed	0.554%	(Fadilah MB <i>et al.</i> , 2021) [13].
		Roasted seed	0.1039%	
		Germinated seed	0.1162%	
2	Phytic acid	Fresh seed	0.0713%	
		Roasted seed	0.0159%	
		Germinated seed	0.0476%	

5. Health benefits of jackfruit seed

Malnutrition is a common problem in India because of a lack of protein consumption. Due to this, an effort was undertaken to find and assess underutilized, unconventional, inexpensive protein sources like jackfruit seed as a substitute (Chowdhury, *et al.*, 2012) [1]. The jackfruit has valuable components in many areas of the fruit that exhibit functional and therapeutic properties, making it possible to classify it as a functional

food. The powdered jackfruit seed carries magnesium and manganese. The effectiveness of jackfruit seed as an antibacterial agent was demonstrated by their antibacterial action on *E. coli* and *B. megaterium* microorganisms. According to studies on the specific surface area of jackfruit seed particles, they can have an antibacterial impact on host material. Thus, jackfruit seeds have the potential to be turned into medicinal substances capable of treating infectious

diseases as well as protecting food from illnesses spread through food. Jackfruit seeds may be transformed into dual-purpose dietary components with antibacterial properties. The investigation of the SSA of two distinct bacteria came to the similar conclusion that the SSA of the bacteria plays a significant impact in how they react with antimicrobial drugs. According to the study, jackfruit seed powder, particularly when used as a thickening and binding agent, has a lot of potential in the pharmaceutical industries.

Table 4: Reported health benefits of Jackfruit seeds

Reported activity or benefits	Reference
Anti-diabetic activity	Goswami <i>et al.</i> , 2021 [42], Saha <i>et al.</i> , 2016 [44].
Anticancer activity	Burci <i>et al.</i> , 2018 [48], Thiruselvi & Dhurairaj., 2018 [43]
Antiradical activity	Zubaydah <i>et al.</i> , 2020 [58]
Antibacterial activity	Eve <i>et al.</i> , 2020
Antioxidant activity	Kumar <i>et al.</i> , 2021 [47], Sivaranjini <i>et al.</i> , 2020 [59]
Prebiotic activity	Rodríguez <i>et al.</i> , 2021 [46]
Anti-hyperlipidemia activity	Zang <i>et al.</i> , 2021
Enhance digestion	Ranasinghe <i>et al.</i> , 2019 [3]
Preventing anemia	Swami <i>et al.</i> , 2012 [2]
Support immune system	Chandrasekar <i>et al.</i> 2021

5.1 Anti diabetic activity

High-sugar diets (HSD) have a direct link to the emergence of metabolic illnesses including diabetes, obesity, and others. Diets high in dietary fibre have been linked to several health advantages (Kazal *et al.*, 2021) [42]. The powdered seeds of jackfruit are a rich source of dietary fibre and may be able to prevent metabolic disorders. Jackfruit seed powder supplementation shown a substantial decrease in both body weight gain and hyperphagia. JSP substantially lowered LDL cholesterol and enhanced glucose tolerance (Goswami *et al.*, 2021) [42]. Functional molecules isolated from the seeds were evaluated *in vitro* using biochemical methods (glucose uptake in yeast cells) the seed of Jackfruit were examined for their antidiabetic properties. According to report glucose transport in yeast cells (*Saccharomyces cerevisiae*) is exceedingly complicated and occurs by a facilitated diffusion mechanism. Therefore, tegmen crystals from Jackfruit seeds had the highest anti-diabetic action (55%) compared to husk crystals from the same seeds (18%). The anti-diabetic property of the crystal of the tegmen of seed increased when the sample concentration was increased. In comparison to the reference sample, Vildagliptin, which demonstrated 60% anti-diabetic activity at maximum concentration, the anti-diabetic activity of the crystal of tegmen of jackfruit seed was only 5% (Saha *et al.*, 2016) [44]. Virtual screening in silico research using molecular docking revealed that a 70% ethanol extract of jackfruit seeds is efficient at decreasing the level of glucose in the blood in gestational diabetic rats induced by streptozotocin (Dwitiyanti *et al.*, 2019) [14].

5.2 Anticancer activity

Two studies have investigated the toxicity and potential anticancer effects of *Artocarpus heterophyllus* seed extracts. The first study by (Burci *et al.*, 2018) [48] evaluated the toxicity of *Artocarpus heterophyllus* seed extracts in rats. The results showed that the extracts were safe at low doses, but

higher doses resulted in toxicity, with liver damage being the main target organ. The extracts also showed hemolytic and cytotoxic effects *in vitro*, suggesting potential harm to red blood cells and other cells in the body. The second study by (Thiruselvi & Dhurairaj., 2018) [43] investigated the potential anticancer effects of *Artocarpus heterophyllus* seed extract in a rat model of lung cancer. The rats were treated with benzopyrene to induce lung cancer, and then treated with *Artocarpus heterophyllus* seed extract. The results showed that the extract was able to reduce the number of lung tumors and improve antioxidant status, suggesting that it may have potential as an anticancer agent. Taken together, these two studies provide valuable insights into the potential health benefits and risks of *Artocarpus heterophyllus* seed extracts. While the extracts may have potential anticancer effects, they also have the potential to cause toxicity at high doses. Therefore, further studies are needed to determine the optimal dosage and long-term safety of *Artocarpus heterophyllus* seed extracts for use in human medicine. It is also important to note that the studies were conducted on rats, and further studies are needed to determine whether the same effects would be seen in humans. Additionally, the studies focused only on the seed extracts of *Artocarpus heterophyllus*, and further research is needed to investigate the potential health benefits of other parts of the plant. In conclusion, *Artocarpus heterophyllus* seed extracts have shown both potential health benefits and risks in animal studies. Further research is needed to determine the optimal dosage and long-term safety of the extracts for use in human medicine, as well as to investigate the potential health benefits of other parts of the plant

5.3 Anti-radicle activity

(Zubaydah *et al.*, 2020) [58] investigates the potential antioxidant activity of jackfruit seed extracts and their phenolic and flavonoid contents. The study found that the extracts and fractions of jackfruit seeds exhibited significant antiradical activity and high total phenolic and flavonoid contents. The results suggest that jackfruit seeds may be a potential source of natural antioxidants, which could have various health benefits. However, further research is needed to determine the bioavailability and efficacy of these antioxidants *in vivo*, as well as to investigate their potential applications in various industries, such as food and cosmetics. Overall, this study provides valuable insights into the potential health benefits of jackfruit seeds and highlights the importance of exploring natural sources of antioxidants for promoting health and preventing disease. Flavonoid content was found to be 70.1990 g/100 g and phenolic content was found to be 49.5971 g GAE /100 g. The highest antiradical activity was demonstrated by the ethyl acetate fraction, with a value of 5.4350.064 g/ml.

5.4 Anti-bacterial activity

(Eve *et al.*, 2020) [31] investigates the potential antibacterial activity of crude extracts of *Artocarpus heterophyllus* (jackfruit) seeds against selected diarrhoea-causing superbug bacteria. The study found that the crude extracts exhibited significant antibacterial activity against all tested bacteria, including multidrug-resistant strains such as *E. coli* and *Salmonella typhi*. The results suggest that jackfruit seed extracts could be a potential source of natural antibacterial agents, which could be used to treat and prevent diarrhoeal

diseases caused by superbug bacteria. The study also identified the potential bioactive compounds responsible for the antibacterial activity of jackfruit seed extracts, such as alkaloids, flavonoids, and tannins. This information could be useful for further research and the development of new antibacterial agents from natural sources. Overall, this study provides valuable insights into the potential health benefits of jackfruit seeds and highlights the importance of exploring natural sources of antibacterial agents for combating antibiotic-resistant superbug bacteria. However, further research is needed to determine the safety and efficacy of jackfruit seed extracts *in vivo*, as well as to investigate their potential applications in the pharmaceutical industry.

5.5 Antioxidant activity

The *Artocarpus heterophyllus* (Jackfruit) plant species has been extensively studied for its antioxidant properties across different parts. The phytochemical profiling of the plant revealed the presence of phenolic compounds, flavonoids, and other antioxidant molecules. The different parts of the plant,

including the seeds and peels, were shown to possess antidiabetic, antibacterial, prebiotic, and anticancer properties. Several studies have also determined the antioxidant activity, total phenolic compounds, and flavonoids in the jackfruit seed flour. The seed slimy sheath was identified as a novel source of pectin with promising antioxidant activity. In addition, the seed extracts showed potent radical scavenging activity and antioxidant properties. Overall, the studies suggest that jackfruit plant parts possess strong antioxidant activities and may have potential applications in the food and pharmaceutical industries (Burci *et al.*, 2018) ^[45], (Sivaranjini *et al.*, 2020) ^[59], (Rodríguez *et al.*, 2021) ^[46], (Devi *et al.*, 2021) ^[29], (M. Kumar, J. Potkule, M. Tomar *et al.* 2021) ^[47]. In one study the Phosphomolybdate method was used to determine the total antioxidant capacity. Jack fruit seeds that had germinated and those that hadn't had their antioxidant capacity measured at 41 mg/g and 14 mg/g, respectively. Overall, during germination, the Jack fruit seed's antioxidant capacity increased (Sivaranjini *et al.*, 2020) ^[59].

Table 5: Antioxidant activity in jackfruit seed

SI No	Antioxidant activity	Total phenolic compounds (GAE/g)	Total Flavonoids (mg QE/g)	Reference
1	68.24±0.60%	-	-	(M. Kumar, J. Potkule, M. Tomar <i>et al.</i> 2021) ^[47] ,
2	-	39.21±0.03	12.34±0.01	(Sivaranjini <i>et al.</i> , 2020) ^[59] .
3	-	46.01	-	(Saha, R.K <i>et al.</i> , 2016) ^[44]
4	-	31.2±0.07	-	(Rodríguez <i>et al.</i> , 2021) ^[46]
5	63.64 - 83.13%	97.40	7.47	(Burci <i>et al.</i> , 2018) ^[45]

5.6 Prebiotic activity

(Rodríguez *et al.*, 2021) ^[46] results indicated that jackfruit seed flour has a high fiber content and a significant antioxidant capacity. Moreover, the authors evaluated the prebiotic activity of jackfruit seed flour by analyzing its effects on the growth of beneficial gut bacteria such as *Lactobacillus acidophilus* (increased by 112.5%) and *Bifidobacterium bifidum* (Increased by 100%). The results showed that jackfruit seed flour significantly promoted the growth of these bacteria, indicating its potential as a prebiotic. The stimulation of probiotic microorganisms by prebiotics to enhance the health of the gut microbiota is one of their key properties. Because of this, the prebiotic activity of flour and jackfruit seed extract was assessed in this study by comparison to other prebiotic components. According to the findings in this paper, jackfruit seeds prebiotics promote probiotic bacterial growth as well as or better than other prebiotic sources.

5.7 Anti hyperlipidemic activity

(Zang *et al.*, 2021) provides a detailed analysis of the potential benefits of using jackfruit seed sourced resistant starch and *Bifidobacterium pseudolongum* subsp. *globosum* to suppress hyperlipidemia in mice. The authors conducted a series of experiments to evaluate the effects of these compounds on lipid metabolism and gut microbiota in mice with high-fat diet-induced hyperlipidemia. The results showed that the combination of jackfruit seed sourced resistant starch and *Bifidobacterium pseudolongum* subsp. *globosum* had a synergistic effect in reducing serum total cholesterol and triglyceride levels in mice. Furthermore, the combination treatment resulted in significant changes in gut microbiota composition, with an increase in beneficial bacteria such as *Bifidobacterium* spp. and a decrease in harmful bacteria such

as Firmicutes spp. Overall, the study suggests that the combination of jackfruit seed sourced resistant starch and *Bifidobacterium pseudolongum* subsp. *globosum* may have therapeutic potential in the prevention and treatment of hyperlipidemia and related metabolic disorders. The findings also highlight the importance of exploring natural sources of bioactive compounds and their potential synergy with gut microbiota in the development of new functional foods and nutraceuticals.

5.8 Digestion activity

The jackfruit seed's high fibre content (25.43 g/100 g) avoids constipation and results in easy bowel movements. By eliminating cancer-causing substances from the large intestine, it also provides protection for the colon mucous membrane (Swami *et al.*, 2012) ^[2]. The dietary fibre in jackfruit makes it an effective laxative for bulking up. This shortens the exposure period and binds to substances that cause cancer. High fibre consumption also keeps bowel motions regular and avoids constipation (Ranasinghe *et al.*, 2019) ^[3].

5.10 Support immune system

Jacalin and artocarpin are two lectins, are also present in seeds. Jacalin has been helpful in the health of people with human immunodeficiency virus type 1. Lectins are nonimmune proteins that are found in large quantities in both plants and animals. They were initially noted for their capacity to precipitate certain serum components before agglutinating a variety of cell types, including tumour cells, bacteria, viruses, leucocytes, and erythrocytes. These diverse agglutinin activities all have the common trait of being inhibited by certain monosaccharides or oligosaccharides,

indicating that membrane glycoproteins or glycolipids are involved in mediating them (Kabir and daar *et al*, 1994) ^[17].

6. Application and utilization of jackfruit seed

Application and utilization of jackfruit seed

Product	Result	Reference
Jackfruit seed ice cream	In terms of changes in chemical composition, sensory evaluation, and even microbial count during storage for five weeks, this treatment (in different ratios of skim milk powder, jackfruit seed powder) has produced the greatest outcomes.	Shinde <i>et al.</i> , 2021 ^[6]
Pectin	Comparing commercial pectin from apple and citrus to JSSP, it Jackfruit seed slimy sheath pectin have the highest antioxidant activity comparing to the commercially available pectin. The analysis of JSSP showed striking similarities to samples of commercial pectin. This has high capability of using in food, cosmetics, and pharmaceutical industries.	M. Kumar, J. Potkule, M. Tomar <i>et al.</i> , 2021 ^[47]
Edible film	The novelty of this product lies in the use of jackfruit seed starch and rosella flower extract to create an edible film with antioxidant properties. This sustainable approach to food packaging offers a unique alternative to traditional packaging materials, while also promoting the use of natural ingredients for preservation.	Ningsih, Purnama <i>et al.</i> , 2021 ^[8]
Jackfruit seed protein enriched cake.	After analyzing the physicochemical characteristics and storage stability of the JSP-enriched cakes, it can be said that adding 6% JSP isolation as a wheat flour substitute results in cakes with pleasing and acceptable colour, taste, texture, flavour, and overall acceptability.	Akter, Bonany <i>et al.</i> , 2021 ^[9]
Chips from jackfruit seed and durian seed	Based on the study's findings, it can be said that jackfruit seed crackers have a protein content of 1.1151%, a fat content of 0.9687%, a water content of 9.3626%, an ash content of 4.3118%, and a carbohydrate content of 84.2419%, whereas durian seed crackers have a protein content of 1.0786%, a fat content of 2.7932%, a water content of 8.8043%, an ash	Sofiyanita, Sofiyanita and Sri Nurhayati <i>et al</i> , 2018 ^[10]
Xanthan gum using jackfruit seed powder	The highest levels of JSP, pepton, citric acid, K ₂ HPO ₄ , and KH ₂ PO ₄ were found to produce the most Xanthan gum which is 51.62 g/L. According to the study's findings, JSP can be produced into XG at a reasonable price.	Felicia Katherine, R <i>et al</i> 2017 ^[11]
Lamivudine Tablet	The use of jackfruit seed extract as a release retardant in the formulation of sustained-release matrix tablets of lamivudine represents a novel approach in drug delivery systems. This innovation could potentially improve the efficacy of the drug by providing a more controlled release, leading to better patient compliance and overall treatment outcomes.	Reddy, M.S. (2017) ^[12] .
Irbesartan fast dissolving tablets	The use of jackfruit seed starch as a super disintegrant in the formulation of irbesartan fast dissolving tablets is a novel approach that offers a natural alternative to synthetic disintegrants, potentially reducing the environmental impact of pharmaceutical manufacturing while improving patient compliance and drug absorption.	(Suryadevara <i>et al.</i> , 2017) ^[16]
Energy drink	The preparation of an energy drink using jackfruit seed powder, date powder, and coffee powder was found an innovative product and the prepared energy drink was found as more nutrients than other energy drinks available on the market.	Farhan <i>et al.</i> , 2022 ^[19]
Cake	This product introduces a unique twist on traditional chocolate cake by utilizing jackfruit seed flour, which is a novel and sustainable ingredient. Additionally, the cake has reduced calories, making it a healthier option for those looking to indulge in a sweet treat without compromising their diet.	Faridah <i>et al.</i> , 2012 ^[20]
Bioplastic	The production of bioplastics from jackfruit seeds starch offers a novel and sustainable solution to the growing problem of plastic waste. Unlike traditional plastics, these bioplastics are biodegradable and renewable, making them an eco-friendly alternative. Additionally, the use of jackfruit seeds as a source of starch offers a new and innovative approach to utilizing agricultural waste.	Wisansakkul <i>et al.</i> , 2016 ^[60]
Vinegar	The characteristics of the vinegar fermented from jackfruit seeds and fibrous components were studied. It was discovered that the concentrations of calcium and magnesium were high. It also had antioxidant activity and vitamin C. Consequently, a beverage made of this vinegar was created.	Photphisutthiphong <i>et al.</i> , 2019 ^[22]

7. Conclusion

This review has shown that *Artocarpus heterophyllus* seed possesses various health benefits and bioactive from natural source which is a better advantage than conventional therapies. Reports also say that they are also good in supporting the immune system as they contain two lectins called Jacalin and Artocarpin. Jackfruit seed has been a traditional medicine for ages now so many researchers coming in forth fining the health benefits of it scientifically. In conclusion, jackfruit seeds have demonstrated a range of potential health benefits, including anti-diabetic, anticancer, antiradical, and antibacterial activity. The high fibre content of the seeds may help prevent metabolic disorders, while the antioxidant and flavonoid content could help protect against oxidative stress and related diseases. However, further research is needed to determine the optimal dosage and long-term safety of *Artocarpus heterophyllus* seed extracts for use in human medicine, as well as to investigate the potential

health benefits of other parts of the plant. The studies on jackfruit seeds provide valuable insights into the potential health benefits and risks of these seeds. Overall, jackfruit seeds have shown promising potential as a natural source of health-promoting compounds, but further research is needed to fully understand their health benefits and risks.

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