INTERNATIONAL JOURNAL OF PHARMACEUTICAL SCIENCES
[ISSN: 0975-4725; CODEN(USA): IJPS00]
Journal Homepage: https://www.ijpsjournal.com

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Review Article

A Review on Jack Fruit Seeds and Their Uses

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ARTICLE INFO

Published: 29 Sept 2025
Keywords:
Jackfruit, Bulbs, Health Promoting Attributes, Jack fruit seed powder
DOI:
10.5281/zenodo.17223020

ABSTRACT

Jackfruit (Artocarpus heterophyllus) is a widely cultivated tropical fruit, prominent in India and Southeast Asia. Although primarily consumed for its sweet bulbs, jackfruit seeds represent an underutilized by-product, rich in nutrients, bioactive compounds, and functional properties. This review consolidates current research on the composition, processing, health-promoting attributes, modification techniques, antinutritional factors, and diverse applications of jackfruit seeds across food, pharmaceutical, and industrial sectors. Processing and value-addition strategies are highlighted, emphasizing the seeds' promise as sustainable, healthful, and eco-friendly ingredients. Opportunities and future directions for maximizing jackfruit seed utility are also discussed.

INTRODUCTION

Starches are widely used in pharmaceutical preparations as excipients but they have limitations (e.g., low solubility, poor stability). Modern applications are required to modify the low solubility, poor stability of naturally occurring starches by using modification techniques like Acid–alcohol hydrolysis, [3] Cross-linking (improves thermal and shear stability), Carboxymethylation (enhances solubility, viscosity, Heat-treatment, Hydroxypropylation (improves freeze-thaw stability), Pregelatinization (instant solubility), Annealing, oxidation, microwave modification. Modified starches exhibit improved thickening, binding, emulsifying, and film-. forming properties for use in foods, pharmaceuticals, and biodegradable plastics.

Natural polymers are needed to replace problematic synthetic polymers which offer biocompatible and biodegradable alternatives in applications like drug delivery and food packaging, and fulfil essential roles in biological systems. Their biodegradability, natural origins, and ability to integrate with biological environments without toxicity make them crucial for developing sustainable materials, advanced

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Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

medical treatments, In this review we have explored the wide applications of Jack fruit seeds as a pharmaceutical excipient, Jackfruit (*Artocarpus heterophyllus*), a member of the Moraceae family, has its origins in the rainforests of India's Western Ghats and is cultivated across tropical Asia and Brazil. Foremost producer is India including some significant from West Bengal , Kerala, Assam and Odisha[1]. Each jackfruit tree typically yields 150–250 fruits annually, each containing up to 500 seeds. Jackfruit seeds, accounting for 12–14% of fruit mass, are an abundant, underexploited by-product. Historically, seeds have been consumed as snacks after roasting or boiling, but their true potential as nutrient-rich food and functional ingredient is increasingly recognized, especially amidst growing interest in sustainable waste-to-wealth solutions.[2]

Table no: 1 Botanical Classification of Jackfruit [4]

Category	Information
Kingdom	Plantae (plants)
Subkingdom	Tracheobiophyta (vascular plants)
Class	Magnoliopsida
Order	Urticales
Family	Moraceae (mulberries)
Genus	*Artocarpus* (breadfruit)
Species	*Artocarpus heterophyllus* Lam. (jackfruit)

Table no 2: CHEMICALCOMPOSITION OF JACK FRUIT [6]

Components	Amount per 100 grams	Notable details
Calories	94	low-calorie fruit
Potassium	303mg	High in potassium lower blood pressure
Vitamins		Vitamin A, vitamin C, thiamine, riboflavin, niacin
Minerals		calcium, potassium, iron, sodium, zinc, phosphorus
Carbohydrates		Major sugars, fructose, glucose, sucrose
Protein		present in edible bulb
Fiber		contributes to dietary fiber in take
Fatty acids		palmitic, oleic, stearic, linoleic, lauric, arachidic
Phytonutrients		lignans, isoflavones, saponins phenolic acids
Other compounds		carotenoids, flavonoids, volatile acids, sterols, tannins

Table no :3 CHEMICAL COMPOSITION OF JACK FRUIT SEED[1]

Component	Value	Details
Starch	22%	Major carbohydrate components
Dietary fiber	3.19%	Beneficial for digestion
Protein	13.50%	Varies by sample
Carbohydrates	79.34%	High-carb seed
Ash (seed flour)	2.70%	
Fat (seed flour)	1.27%	
Calcium	3,087mg/kg	High mineral content
Iron	130.74mg/kg	
Potassium	14,781mg/kg	Very rich in potassium
Sodium	60.66mg/kg	
Copper	10.4mg/kg	
Manganese	1.12mg/kg	
Ph	5.78	Slightly acidic
Lactic acid	1.12%	
Titrable acidity	-	-

PREPARATION AND PROCESSING METHODS:

Raw Material Collection and Preparation:

Fresh semi-ripe or just ripe jackfruits were collected and to avoid dirt and impurities of fruit washed by using tap water. Fruits were kept for 1-2 days to attain the correct stage of ripening. Fruits were cut diametrically into pieces using a manual slicer device. Fresh bulbs were manually extracted from the slices and separated from seeds and unwanted materials. Dirt and slimy substance of extraction seeds washed by using water. The slimy seed coat was peeled off manually. Seeds were soaked in 3% sodium hydroxide (NaOH) solution for 4–5 minutes to remove the thin brown testa covering the cotyledons. Seeds were then rubbed manually between hands to assist peeling. Seeds were washed thoroughly under running water to remove residual lye.

Lye-peeled seeds were sliced into thin chips. To achieve a constant moisture content for chips were dried at cabinate drier at 60–70°C, Dried chips were powdered using a hammer mill. The powder was sieved through ISS 35 mesh to obtain fine jackfruit seed flour. [5]

MODIFICATION OF JACK FRUIT SEED STARCH:

Purpose of Starch Modification:

After extraction, native starches often exhibit limitations such as poor solubility, instability under heat, shear, or acidic conditions, and undesirable texture or viscosity. Modifying starch improves its functional properties to enhance performance in various industrial applications such as food, pharmaceuticals, textiles, and adhesives[7].

Common Techniques Used to Modify Jackfruit Seed Starch (JFS):

1. Acid–Alcohol Modification:

- Treatment with acid followed by alcohol helps in partial depolymerization of starch molecules.
- Improves paste clarity, reduces retrogradation, and increases freeze-thaw stability.[8]

2. Acid-Thinned Method:

- Controlled hydrolysis with dilute acids reduces molecular weight.
- Results in starches with lower viscosity and better film-forming properties.[8]

3. Cross-Linking:

- Chemical agents (e.g., phosphorus oxychloride, sodium trimetaphosphate) create covalent bonds between starch chains.
- To reduce swelling and resistance to shear by enhances thermal stability[9]

4. Carboxymethyl Modification (Carboxymethylation):

- Introduction of carboxymethyl groups makes starch water-soluble and increases viscosity.
- Useful to improve thickening, binding, and emulsification properties.[10]

5. Heat-Moisture Treatment (HMT):

- Starch is treated by heating at limited moisture content (10-30%) and high thermal exposure.
- Enhances gelatinization temperature, reduces swelling power and paste viscosity.[11]

6. Hydroxypropylation:

- Substitution of hydroxyl groups with hydroxypropyl groups by reacting with propylene oxide.
- Increases freeze-thaw stability, clarity, and reduces retrogradation.[12]

7. Pregelatinizing:

- Starch is cooked and then dried, to soluable in cold water spontaneously
- Used in instant food products for quick thickening.[10]

8. Annealing:

- Starch is treated with excess water at temperatures below gelatinization.
- To achieve granular integrity, raises gelatinization temperature, and narrows gelatinization range.[13]

9. Oxidation:

- Treatment with oxidizing agents (e.g., sodium hypochlorite) introduces carbonyl and carboxyl groups.
- Produces starch with lower viscosity, higher clarity, and improved film-forming ability.[14]

10. Microwave Modification:

- Use of microwave radiation for rapid energy transfer leads to changes in starch structure.
- Results in modified gelatinization properties and enhanced functional behavior.[15]

11. Conventional Heating Modification:

- Heating starch suspensions under controlled conditions modifies viscosity and gelatinization.[7]

HEALTH BENEFITS OF JACKFRUIT SEEDS:

1. ANTI OXIDANT ACTIVITY:

Jackfruit seeds are rich in phenolics and flavonoids with powerful free radical scavenging capacity Germination accentuates antioxidant content. Applications include:

1. Food antioxidant supplementation

2. Pharmaceuticals for oxidative stress management

Rich Source of Antioxidants:

Multiple parts of the jackfruit plant—seeds, peels, and even the slimy seed sheath—contain a variety of antioxidant molecules, notably phenolic compounds and flavonoids.

Wide-ranging Biological Effects:

The antioxidant components are linked not only to antioxidant activity but also to antidiabetic, antibacterial, prebiotic, and anticancer effects.

Phytochemical Insights:

Studies demonstrate that jackfruit seed flour and extracts possess significant amounts of total phenolics and flavonoids, with the seed slimy sheath newly recognized as a pectin source with potent antioxidant capability.

Comparative Antioxidant Assessment:

Using the Phosphomolybdate method, total antioxidant capacity has been specifically measured:

- Germinated seeds: 41mg/g
- Ungerminated seeds: 14mg/g

Potential Applications

- Food Industry
- Pharmaceutical

Due to their strong radical scavenging properties, jackfruit plant extracts could serve as natural

agents in health-promoting supplements or as ingredients in therapeutics targeting oxidative stress-related diseases.[16]

2. ANTIDIABETIC ACTIVITY:

Resistant starch and dietary fiber from seeds help regulate blood glucose by slowing carbohydrate absorption. Research (in vitro and animal studies) demonstrates:

- Reduced blood sugar and body weight gain
- Improved glucose tolerance
- Tegmen crystals and certain phytochemicals (e.g., beta-carotene epoxide) promote insulin secretion
- Jackfruit seed powder is a rich source of dietary fibre and bioactive compounds, making it a promising functional food for preventing and managing metabolic diseases, including diabetes.

Key Findings:

- High-Sugar Diets and Metabolic Health: Diets high in sugar are directly linked to conditions like diabetes and obesity, while fiber-rich diets offer protective health benefits.

Effects of Jackfruit Seed Powder (JSP):

Supplementing high-sugar diets with JSP in animal studies resulted in significant reductions in body weight gain, food intake (hyperphagia), and LDL cholesterol, alongside improved glucose tolerance.

In Vitro Antidiabetic Assays:

Extracts of jackfruit seeds enhance glucose uptake in yeast cells (Saccharomyces cerevisiae), with methanolic extracts often outperforming others. The glucose transport mechanism observed is facilitated diffusion.

Among different seed components, tegmen crystals exhibited the highest anti-diabetic action (55%), compared to husk crystals (18%). The effectiveness increased with higher concentrations of the tegmen sample.

For reference, pharmaceutical antidiabetic agent Vildagliptin demonstrated 60% activity under similar test conditions, making jackfruit seed tegmen crystals comparable in efficacy at high concentrations.

Animal Studies and In Silico Evidence:

Gestational Diabetes Model: Administration of 70% ethanol extract of jackfruit seeds in streptozotocin-induced gestational diabetic rats resulted in notable blood glucose reduction, with the highest tested dose (400mg/kg body weight) causing a 61.73% decrease—comparable to the antidiabetic drug glibenclamide.

Molecular Docking: In silico studies identified that beta-carotene epoxide in the seeds may induce insulin secretion, supporting glucose-lowering activity.

Practical Implications:

Dietary Supplement Potential: Jackfruit seed powder supplementation can play a key role in controlling blood sugar, lipid profile, and body weight, especially in the context of high-sugar diets.

Mechanism:

Multiple mechanisms contribute, including increased glucose uptake, improved insulin secretion, and the action of unique phytochemicals present in the seed tegmen.

Jackfruit seed, therefore, supports anti-diabetic management through both metabolic regulation

and direct glucose-lowering activity mediated by its bioactive constitue[17]

3. ANTICANCER ACTIVITY:

- Anticancer Activity and Safety Profile of Jackfruit Seed Extracts
- Key Findings from Animal Studies

Toxicity Assessment:

- Low doses: Safe in rat models.
- High doses: Toxic effects observed, mainly liver damage.
- In vitro results: Seed extract demonstrated hemolytic and cytotoxic effects, potentially harmful to red blood cells and various cell types.

Anticancer Potential:

- Outcomes: Significantly reduced the number of lung tumors.
- Additional benefits: Improved antioxidant status in treated rats.
- Implication: Indicates potential as an anticancer agent.

Implications and Cautions

- Potential Health Benefits: Evidence suggests that jackfruit seed extract may help reduce tumor burden and improve antioxidant defenses in animal models.
- Safety Concerns: High doses can cause liver toxicity and may damage blood cells, highlighting the importance of dose regulation.

Needs for Further Research:

- Optimal and safe dosage levels for human use remain unknown.
- The effects observed in rats haven't been confirmed in humans; human trials are necessary.
- Only seed extracts were studied—future research should explore other plant parts for potential health effects.[18]

4 ANTIBACTERIAL AND PREBIOTIC ACTIVITIES:

Crude seed extracts display:

Antibacterial effects against multidrug-resistant pathogens (e.g., E. coli, S. typhi)

- Prebiotic action: Increased growth of beneficial gut flora (Lactobacillus, Bifidobacterium) demonstrated in culture studies Effective Against Superbug Bacteria:
- Crude extracts of jackfruit seeds demonstrated strong antibacterial effects againstq a range of diarrhea -causing bacteria, notably including multidrug-resistant strains such as Escherichia coli and Salmonella typhi.

Bioactive Compounds Identified:

- The antibacterial efficacy is primarily attributed to natural compounds present in the seeds, specifically alkaloids, flavonoids, and tannins.

Potential for Disease Treatment:

- The study suggests that jackfruit seed extracts may serve as a promising natural source for developing new antibacterial agents to help treat and prevent diarrheal diseases caused by antibiotic-resistant ("superbug") bacteria.

High Dietary Fibre & Antioxidant Capacity

- Jackfruit seed flour is rich in fibre and exhibits notable antioxidant properties.

- Promotes Beneficial Gut Bacteria

When used as a substrate, jackfruit seed flour:

- Increased the growth of Lactobacillus acidophilus by 112.5%
- Increased the growth of Bifidobacterium bifidum by 100%
- This demonstrates its significant prebiotic effect in fostering the proliferation of key probiotic strains.

Comparative Prebiotic Effectiveness

- In experimental comparisons, the prebiotic activity of jackfruit seed flour and extracts matched or exceeded that of established prebiotic substances, supporting the growth of probiotic bacteria at similar or superior levels.

Health Implication

- By stimulating probiotic organisms, jackfruit seed flour has the potential to support and improve gut microbiota health.
- This prebiotic property is a crucial mechanism for promoting intestinal health and potentially enhancing immune and metabolic functions.[19]

5. ANTIHYPERLIPIDEMIC AND DIGESTIVE BENEFITS:

Lipid profile improvement: Combination treatments (seed components + probiotics) reduce total cholesterol, triglycerides.

Digestive Health: High fiber content prevents constipation, aids detoxification, supports bowel regularity, and protects colon mucosa.

Synergistic Lipid-lowering Effects:

- The combination of jackfruit seeds resistant starch and the probiotic led to greater reductions in serum total cholesterol and triglyceride levels than either component alone.[20]

Gut Microbiota Modulation:

- The treatment increased the proportion of beneficial bacteria, notably Bifidobacterium species.
- There was a decrease in Firmicutes species, which are often associated with negative metabolic profiles.[21]

Therapeutic Implications:

- These findings support the potential of using natural dietary starches together with probiotics to prevent or treat hyperlipidemia and possibly other metabolic disorders.
- Practical Implications.[22]

Nutraceutical/Food Application:

- Combining natural resistant starches from jackfruit with specific probiotics may offer a dietary strategy for managing cholesterol and triglyceride levels.[23]

Dietary Fiber Content:

- Jackfruit seeds contain a high fiber amount of 25.43 g per 100 g.
- Digestive Health
- The fiber helps prevent constipation by promoting easy and regular bowel movements
- Acts as an effective laxative by increasing stool bulk, which facilitates smooth passage through the intestines.[24]

Colon Protection:

- The fiber aids in removing carcinogenic substances from the large intestine.
- This cleansing action protects the colon mucous membrane from harmful agents, helping to reduce the risk of colon-related diseases.
- By shortening the time these cancer-causing substances remain in the colon, fibre minimizes their damaging effects.

Regularity and Detoxification:

- Consistent intake of dietary fiber maintains regular bowel motions.
- Prevents constipation and enhances the body's natural detoxification process by binding to harmful.[25]

6. ANTI RADICLE ACTIVITY:

Study Highlights

Significant Antioxidant Activity:

- Extracts and fractions from jackfruit seeds showed notable antiradical (antioxidant) action in laboratory assays.
- High Phenolic and Flavonoid Contents:
- Flavonoids: 70.20g per 100g
- Total Phenolics: 49.60g GAE* per 100g
- (*GAE = Gallic Acid Equivalents, a common standard for measuring phenolic compounds)

Fraction Efficacy:

- The ethyl acetate fraction of the extract had the highest antiradical (antioxidant) activity, demonstrated by a maximum value of 5.44g/ml.

Health Implications:

- These results indicate that jackfruit seeds are a promising natural source of antioxidants, which may benefit health by protecting the body against oxidative damage.[26]

7. SUPPORT IMMUNE SYSTEM:

There are two types of lectins present in seeds of Jack fruit. They are jacalin and atrocarpin, Lectins are nonimmune proteins that are found in large quantities in both plants and animals. They were initially noted for them capacity to precipitate certain serum components before agglutinating a variety of cell types, including tumor cells, bacteria, viruses, leucocytes, and erythrocytes. These diverse agglutinin activities all have the common trait of being inhibited by certain monosaccharides or oligosaccharide [27]

FUNCTIONAL AND INDUSTRIAL APPLICATIONS:

1. FUNCTIONAL FOODS AND INGREDIENTS:

Ice Cream:

- Incorporating jackfruit seed powder with skim milk powder in different ratios resulted in ice cream with improved chemical composition, superior sensory qualities, and lower microbial counts after five weeks of storage.[28]

Protein-Enriched Cake:

- Replacing 6% of wheat flour with jackfruit seed protein isolate produced cakes with excellent taste, texture, color, flavor, and overall acceptability, also exhibiting good storage stability.[24]

Chocolate Cake (Low-Calorie):

- Cakes prepared using jackfruit seed flour offered a nutritious, sustainable alternative

with reduced calories, providing a healthier dessert option.[29]

Chips/Crackers:

- Jackfruit seed crackers contain high carbohydrates (84.24%), modest protein (1.12%), low fat (0.97%), water (9.36%), and ash (4.31%), favorably compared to durian seed crackers.

Energy Drink:

- A novel, nutrient-rich beverage was developed using jackfruit seed powder, date powder, and coffee powder, found to surpass existing market options in nutritional value.[30]

2. FOOD ADDITIVES & FUNCTIONAL COMPONENTS:

Pectin (JSSP):

- Pectin from the jackfruit seed's slimy sheath exhibited higher antioxidant activity than commercial apple/citrus pectin's, showing comparable structural features. This pectin has strong potential for use in food, cosmetics, and pharmaceuticals.[31]

Edible Antioxidant Film:

- Combining jackfruit seed starch with rosella flower extract produced an edible film with antioxidant properties, offering an eco-friendly, sustainable packaging alternative.[32]

Vinegar:

- vinegar fermented from jackfruit seed in summary: Jackfruit seeds exhibit remarkable versatility, serving as core ingredients in innovative foods (ice cream, cakes, beverages, chips), functional additives (pectin, edible films), industrial products (bioplastics, xanthan gum).[33]

3. INDUSTRIAL PHARMACEUTICAL INNOVATIONS:

Bioplastic:

- Jackfruit seed starch serves as a raw material for biodegradable bioplastics, presenting a renewable and sustainable alternative to petroleum-based plastics by utilizing agricultural waste.[34], .[44]

Xanthan Gum Production:

- Using jackfruit seed powder along with peptone, citric acid, and phosphate salts yielded high xanthan gum quantities (up to 51.62g/L), providing a cost-effective production route.[35],[43]

4. ANTI NUTRITIONAL FACTORS:

Jackfruit seeds host some antinutrients (tannins, trypsin inhibitors, phytates) but at low, non-concerning level. Tannin and phytate are reduce by roasting and germination of seeds.

Antinutrients can modestly reduce mineral bioavailability but are manageable with proper processing.[36]

Food:

- Nutrient-rich ingredient: Jackfruit seeds are high in carbohydrates, protein, dietary fibre, and contain essential minerals like calcium, magnesium, iron, and zinc.

Functional foods:

- Used as flour or powder to enrich baked goods (cakes, crackers, bread), noodles, and snacks.

- Incorporated in innovative products such as protein-enriched cakes, low-calorie chocolate cakes, nutrient-rich energy drinks, and traditional foods like ice cream and chips for added nutrition and texture.[37]

Food additives:

- Source of pectin (especially from the slimy sheath), which displays strong antioxidant activity and can be used as a natural gelling or thickening agent in jams, jellies, desserts, and yogurt.
- The starch from seeds provides a base for biodegradable edible films, which can be used for sustainable packaging.[38]

5. PHARMACEUTICAL APPLICATIONS:

- **Super disintegrants:** Modified seed starch in tablet formulations (e.g., irbesartan FDTs) [39]
- Binders, diluents, release-modifying excipients[40]
- **Drug delivery:** Lamivudine sustained-release matrix[41]
- Biodegradable excipients preferable over synthetic alternatives

Lamivudine Sustained-Release Tablet:

- Jackfruit seed extract acted as a release retardant, supporting controlled drug release and better patient compliance in lamivudine matrix tablets.
- Using starch derived from jackfruit seeds as a natural super disintegrant enhanced the breakdown and absorption of irbesartan fast-dissolving tablets, providing an eco-friendly substitute for artificial disintegrants. Fast-Dissolving Tablets (Irbesartan)[40]

Modified starches:

- Jackfruit seed starch is modified (e.g., pregelatinized, cross-linked, carboxymethylated) for use as pharmaceutical excipients, including:
- Disintegrants in immediate and sustained-release tablets.
- Binders, diluents, and film-forming agents.[42]

Drug delivery:

- Utilized as a natural super-disintegrant in fast-dissolving tablets, improving dissolution and drug absorption.
- Used as a release-retardant in sustained-release formulations for drugs like lamivudine.[43]

6. HEALTH AND FUNCTIONAL PROPERTIES:

Antioxidant, antibacterial, and prebiotic effects:

- Rich in bioactive compounds such as flavonoids, phenolics, alkaloids, and saponins, jackfruit seeds support health with antioxidant and antimicrobial activity, and they promote growth of beneficial gut bacteria [24].

Support for metabolic health:

- Consumption may help regulate blood sugar and lipid levels, aid digestion due to high fibre content, and offer protective effects for the colon and cardiovascular system.

Immune support:

- Contain lectins like jacalin and atrocarpin which exhibit immunomodulatory benefits.

Other Notable Uses [45]

Vinegar production:

- Fermentation of seeds yields vinegar rich in calcium, magnesium, antioxidants, and vitamin C.

Value-added products:

- Seeds are used in the formulation of edible films, natural thickeners, and novel food and beverage[46]

CONCLUSION:

Jackfruit and its seeds are among the most resourceful and multifunctional products derived from tropical agriculture. With India as the leading producer, jackfruit contributes prominently to food security and nutrition, particularly in Asian regions. The fruit, especially its seeds, are often overlooked despite offering a diverse nutritional profile rich in carbohydrates, proteins, fiber, essential minerals, and bioactive phytochemicals. Scientific studies highlight the seeds' antioxidant, anti-inflammatory, antidiabetic, anticancer, and prebiotic properties, underlining their considerable potential as functional food ingredients. Furthermore, innovative uses of jackfruit seed starch—including modified forms—support numerous applications in the food, pharmaceutical, and bioplastic industries, providing eco-friendly alternatives to conventional synthetic additives. The seeds' ability to lower blood sugar and cholesterol, promote digestive and immune health, and support wound healing and skin integrity makes them a valuable by-product with broad therapeutic promise. Advances in processing and isolation techniques further expand their viability in delivering value-added products, ranging from baked goods to sustainable packaging materials and even specialized pharmaceuticals. Despite the presence of minor antinutritional factors, these compounds are typically rendered innocuous through common preparation methods such as roasting or germination. Enhanced utilization, processing, and awareness of jackfruit seeds can significantly contribute to waste reduction, sustainable development, and improved health outcomes, making them a "hidden gem" for both nutrition and industry.

Jackfruit and its seeds are highly versatile, nutrient-rich, and underutilized resources with great potential. Beyond being a traditional fruit, jackfruit seeds provide valuable proteins, fibers, minerals, and bioactive compounds that offer health, nutritional, industrial, and pharmaceutical benefits. With advances in processing and application across food, pharmaceutical, and bioplastic industries, jackfruit seeds stand out as a sustainable solution for nutrition, health, and eco-friendly innovations. Expanding their use not only reduces waste but also adds remarkable value to nutrition and industry alike.

CONFLICT OF INTEREST:

The authors of this article declare no conflict of interest.

ACKNOWLEDGEMENT:

Authors of this article are grateful to the management of Koringa College of Pharmacy for providing Digital literary resources for completion of this review.

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HOW TO CITE: Vydani Krishnaveni, Karri Sandhya, Dandingi Teja Sri, Ganta Bhavana, Sadanala Satya Vanaja Durga, Nemala Naga Satish, A Review on Jack Fruit Seeds and Their Uses, Int. J. of Pharm. Sci., 2025, Vol 3, Issue 9, 3283-3298. https://doi.org/10.5281/zenodo.17223020