https://doi.org/10.48047/AFJBS.6.12.2024.2329-2351

JACKFRUIT SEED: A FUNCTIONAL FOOD COMPANION

Mohammed Shafi Shajahan[1], Susmita Das[2*], Arti Sharma[3], Ab Waheed Wani[2], Neha Rawat[1], Sanjeev Kumar[2], Meraj Ahmad[4]

[1]Department of Food Science and Technology, School of Agriculture, Lovely Professional University, Phagwara, Punjab.

[2]Department of Horticulture, School of Agriculture, Lovely Professional University, Phagwara, Punjab.

[3]Division of Fruit Science, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Jammu and Kashmir.

[4]Department of Soil science, School of agriculture, Lovely professional university, Phagwara, Punjab.

*Corresponding Author – susmita.29546@lpu.co.in

Article History

Volume 6, Issue 12, 2024

Received: 16 May 2024

Accepted : 20 June 2024

Doi:10.48047/AFJBS.6.12.2024.

2329-2351

Abstract

The jackfruit (*Artocarpus heterophyllus*) is a tropical fruit known for its large size, sweet taste, and versatile culinary applicationsand is the largest fruit that grows on trees worldwide. While fleshy, yellow pods of the jackfruit have gained popularity, its seeds often go unnoticed despite being a nutritional powerhouse. Additionally, we explore the emerging trend of incorporating jackfruit seeds into various consumable products, such as cakes, noodles, pasta, biscuits, and cookies, to enhance both flavor and nutritional value. Seeds of jackfruit are abundant in macronutrients such as carbohydrates, proteins, and dietary fiber. They also contain essential micronutrients including vitamins (B-complex vitamins, vitamin A, and vitamin C) and minerals (potassium, magnesium, and zinc). The high protein content in the seeds makes them a valuable plant-based protein source, contributing to muscle development and overall health. Consuming jackfruit seed offers various health advantages.The seeds have been found to possess antioxidant properties, aiding in the neutralization of free radicals and reducing oxidative stress. Additionally, they comprise componentswith potential anti-inflammatory as well as anti-cancer elements, contributing to overall well-being. The versatility of jackfruit seeds extends beyond their nutritional benefits, as innovative food products are emerging in the market. Jackfruit seed flour is being used to create health-conscious alternatives to traditional wheat-based products. Jackfruit seed cakes, noodles, pasta, biscuits, and cookies are gaining popularity for their unique flavors and enhanced nutritional profiles. These products not only cater to individuals with gluten sensitivities but also appeal to those seeking diverse and sustainable food options.

KEYWORDS:

Jackfruit seed, Starch, Value added products, Food properties, Health benefits

INTRODUCTION

Southeast Asian native Jackfruit (*Artocarpus heterophyllus*)is a part of the*Moraceae* botanical family of fruits.The *Artocarpus* genus encompasses 50 different types of evergreen trees, varying in size from largetosmall. (Tang *et al*., 2013)Its widely grownmany tropical countries, including Brazil, Queensland, Africa, Australia, and America, as well as Philippines, Malaysia, India, Pakistan, Bangladesh, Thailand, Sri Lanka, and Burma. In other words, jackfruit is a tropical fruit that is widely grown in warm, humid climates throughout the world (Ajiboye *et al.*, 2018). Because its fruit, tree, and branches are all useful, jackfruit is a fruit tree with many advantages. Before consumption, it's essential to peel and discard the skin of unripe jackfruit. Once this step is completed, the entire fruit can be cut into bite-sized pieces for consumption and prepared for cooking. It's important to note that the raw young fruit is not suitable for consumption. Young jackfruit possesses a mild flavor and a unique texture reminiscent of poultry(Islam *et al*., (2015). The fruit itself has a wealth of nutrients and can be eaten when ripe or while it's still green for a

vegetable. Ripe jackfruit bulbs are frequently eaten fresh or transformed into various processed goodsthat may be bottled; roughly 10–15% of the fruit weight consists of seeds. Since jackfruit has been shown to have antibacterial, anti-inflammatory, antioxidant, and anti-diabetic qualities, people in Asia also utilize different sections of the plant medicinally. It is a non-seasonal fruit that was crucial in keeping humans and animals fed when there were few important grains crops available (Sim *et al.*, 2003). While cutting a jackfruit might initially appear daunting, once it's opened, the process becomes easy and enjoyable. Jackfruit typically becomes available in spring and remains in season through summer. It is hence frequently described as "poor man's food" (Singh *et al.,* 1963)., these fruits are instances of compound fruits with dicotyledonous traits. They possess an elongated cylindrical form, varying in length from 22 to 90 cm with the diameter 13 to 50 cm (Sharma *et al.*, 1964). The weight of each fruit can vary between two and twenty kg, and larger fruits weighing around fifty kg that have been documented (Reddy*etal*.,2004).Health advantages of jack fruit including helps to prevent cancer, prevent ulcer, prevent hypertensive, and prevent aging properties, have been associated with phytonutrients found in jackfruit, such as lignans, flavones, and saponins (Swami *et al.,* 2018). Its seeds are especially rich in nutrients including manganese, magnesium, potassium, calcium, iron, and lectins, making them an important source of nourishment for individuals living in rural areas (Khan et al., 2021). It is also a good source of carbs,fiber, vitamins, and minerals. Furthermore, jackfruit seeds are a cheap way to get major nutrientsincluding protein, carbs, and dietary fiber. Glycoproteins, such as lectinare also present in the seeds (Palamthodi*et al.*, 2021).

The jackfruit seed are approximately two to three cent meter long and one to one-point five cent meter in diameter, a light brown color and rounded shape (Prakash *et al.*,2009).Approximately ten percentage to fifteen percentage of the total weight of a jackfruit consists of seeds. These seeds are enveloped by the fruit's flesh and are situated within a white aril. This aril surrounds a delicate brown seed coat, which in turn encases the fleshy, white cotyledon.The seeds are edible after being cooked, or fried or roasted. Additionally, their flour is utilized for the preparation of different food products like cake, bread, cookies, biscuits, noodlesetc.These seeds are abundant in carbohydrates and proteins. Seedsare packed with nutrients, including carbohydrates, fat, potassium, minerals such as Mn and Mg, which are also present in the jack fruit seed powder (Barua *et al.*,2006). The seed contains two types of lectins, one is jacalin, it helps to prevent the herpes simplex virus type two and it boost the immune condition of individuals with human immunodeficiency virus-1 (HIV-I). Jacalin is also employed for isolating human plasma glycoproteins, investigating IgA nephropathy, analyzing O-linked glycoproteins and detecting tumors (Haq *et al.,* 2006).Several scientists have identified jackfruit seed as a promising functional ingredient due to its rich phytonutrient composition

(Conforti *et al*., 2009). The seeds consist of significant quantity of saponins, measuring 6.32 g/100 g in seeds. Through various antioxidant assays such as free radical scavenging and metal chelating, it was determined that seeds of jackfruit possess potent antioxidant properties, attributed to their moderate phytochemical content. Another study examining different jackfruit seed extracts highlighted their high levels of phenolic compounds and flavonoids, which correlate with strong antioxidant potential. These findings suggest the prospective application of jackfruit seed extract as a valuable plant-based product in functional medicine and pharmaceuticals due to its abundance of flavonoids (ranging from 0.86 to 4.05) and notable reducing potential (ranging from 9.56 to 13.12) (Shanmugapriya *et al.,* 2011). Jackfruit seeds exhibit functional properties that include weight management, protecting against cancer, help to prevent constipation, and reduce the level of cholesterol. Notably, seeds of jack fruit are abundant in mg 1.12mg/kilogram (Oclooet *al.*,2010), alsoconsist of iron that assists in maintaining healthy blood circulation (Abedin *et al.*,2012). Anti-nutritional factors such as oxalate are six-point three seven mg/hundred gram andphytate are forty-eight-point five six mg/100gm present in seeds of jack fruit (Okpala *et al.*,2013). However, techniques such as boiling, roasting, and fermentation can effectively reduce these anti-nutritional factors (Abiola *et al.,* 2018).

Jackfruit seeds serve as valuable sources of both protein and starch, containing phytonutrients like lignans, isoflavones, and saponins. These contribute to various health benefits, including antioxidant effects, anti-aging properties, and potential anti-cancer advantages. Starch, a crucial stored carbohydrate in plants, plays a vital role in global production, amounting to 66.5 million tons annually. Due to high demand in various industries such as textile, paper, food, adhesives, and pharmaceuticals, there is growing interest in alternative sources like seeds, leaves, fruits, and legumes (Ancona *et al.*,2004).Starch exhibits attributes like thickening, gelling, and the ability to form films (Alabi*et al.*, 2005).

Since the seeds are perishable, they are usually thrown away as garbage. They can be used for approximately a month if kept in a cold, damp place. To improve a range of products and increase their shelf life, these seeds are easily roasted and processed into powders. This powdered version of roasted seeds is used in place of regular flour in baked goods and confections. It is combined with cheap flours such as wheat flour (Hossain, 2014). The seeds are added to potatoes or boiled and roasted in several parts of India(Banerjee *et al*., 2015).

Figure:1. Jackfruit and its components

NUTRITIONAL COMPOSITION OF SEED OFJACK FRUIT

Seed of jack fruit contain excessive amount of fiber, starch, and protein, constituting approximately 55% moisture and serving as valuable sources of starch and protein. The seeds contain lectins named jacalin, making up about 50% of the fruit's protein, which can have adverse effects on the digestive tract. Additionally, jackfruit is a significant reservoir of various minerals, including zinc, phosphorus, copper, calcium, sulfur, nitrogen, magnesium,and potassium(Maurya *et al., 2016*). Concerning proteins, amines, amides, amino acids, and in the case of carbohydrates, polysaccharides and lipids are present in the seeds. The presence of aromatic compounds indicates the occurrence of flavonoids, while the antimicrobial characters of seedsare attributed to the existence of sulfur and its derivatives. Seed of jack fruit has soft part and hard part contain 92.8% and 94.5% starch and 2.49% crude fiberrespectively (Madruga *et al.,* 2014).Notably, jackfruit seeds contain substantial amounts of thiamine and riboflavin, two B vitamins that play essential roles in energy production and overall bodily functions. Moreover, these contain good source of fiber and resistant starch, which remain undigested as they moveacross the body, providing nutriment for beneficial gut-flora (Cheri *et al.,* 2019).

Nutrient	**Jack fruit**
Energy	95 kcal
Fat	0.64g
Water	73.5g
Carbohydrates (CHO)	23g
Dietary fiber	1.5g
Sugar	19.08g
Magnesium (Mg)	29mg
Phosphorous (P)	21mg
Calcium (Ca)	24mg
Manganese (Mn)	0.043mg
Sodium (Na)	2mg
Iron (Fe)	0.23mg
Zinc (Zn)	0.13mg
Potassium (K)	448mg
Protein	1.72g
Pyridoxine (Vit-B_6)	0.329mg
Pantothenic acid (Vit-B5)	0.235mg
Riboflavin (Vit-B2)	0.055mg
Folate (Vit-B9)	24mg
Niacin (Vit-B3)	0.92mg
Thiamine (Vit-B1)	0.105mg
Vitamin C	13.8mg

Table: 1. Nutritional composition- Jackfruit.**Source:** USDA- (2016)

The seeds are rich in carbohydrates, approximately 76.1%(Kumar *et al.,*1988) and protein levels can range between 5.3% to 6.8% (Chrips*et al.,*2008).Researchers made efforts to isolate a compound from jackfruit seeds to explore a fresh and valuable protein source possessing emulsifying capabilities (Zhang *et al.,*2019). The seed contain significant number of readily soluble protein, known for its potential in alleviating mental stress and anxiety. Protein isolates from jackfruit seeds exhibit preservative qualities.Vitamins are abundant in jackfruit, particularly vitamin C. Additionally, it stands out as a unique fruit with a substantial presence of B-complex vitamins, including notable quantities of riboflavin, folic acid, niacin and pyridoxine (Swami *et al.*,2012). Minerals like sulfur, potassium, copper, magnesium, phosphorus, zinc, calcium,and nitrogen are present.Theseed is known for containing a significant amount of dietary fiber(Babu *et al.*, 2017). Due to high amount of

dietary fiber, it helps to prevent cardiovascular disease and decreased mortality risk (Barber *et al*., in 2020).It contains fiber content of about 3.19%.The fatty acids found incl+ude linoleic and linolenic acids(Oclooet *al*., 2010).

Nutrient	Jack fruit seed	Reference
Fat%	0.70	Madrigal *et al.*,2011
Carbohydrates%	76.1%	Kumar *et al.*,1998
Proteins%	5.3 to 6.8%	Chrips*et al.*,2008
Moisture%	50%	Maurya *et al.*,2016
Crude fiber%	2.49%	Madruga *et al.*,2014
Ash %	3.14	Madrigal *et al.*,2011
Fiber%	3.19%	Oclooet *al.*,2010

Table:2. Nutritional composition- Jackfruit seed

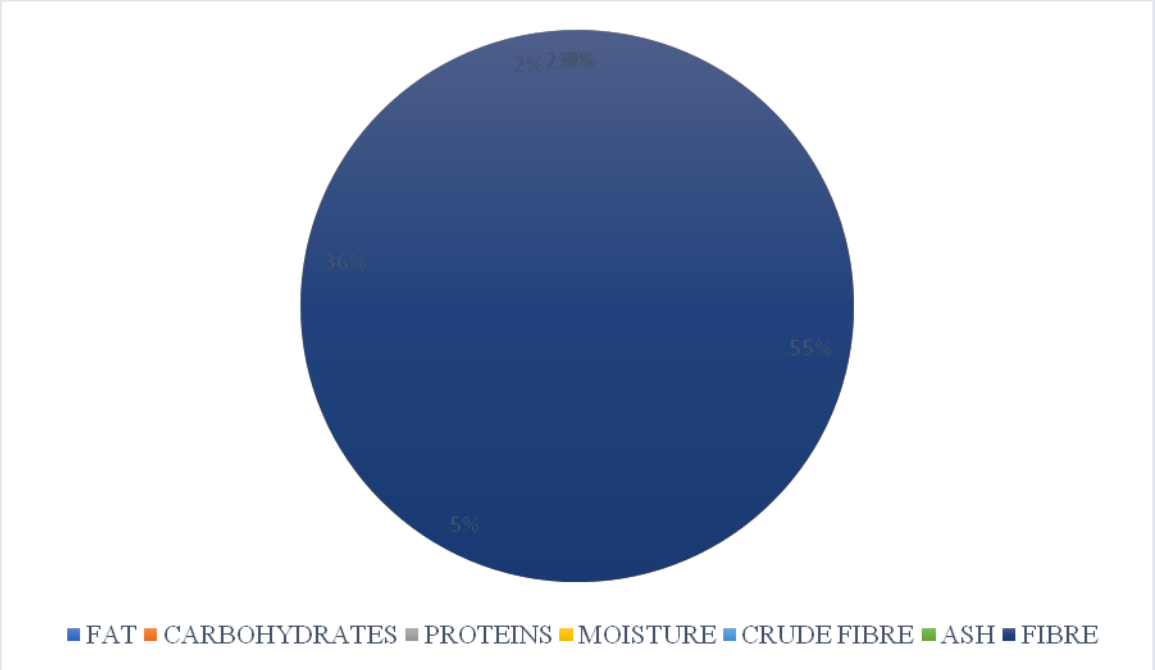

Figure :2 Main constituents of jackfruit seed

HEALTH BENEFITS OF JACK FRUIT SEED

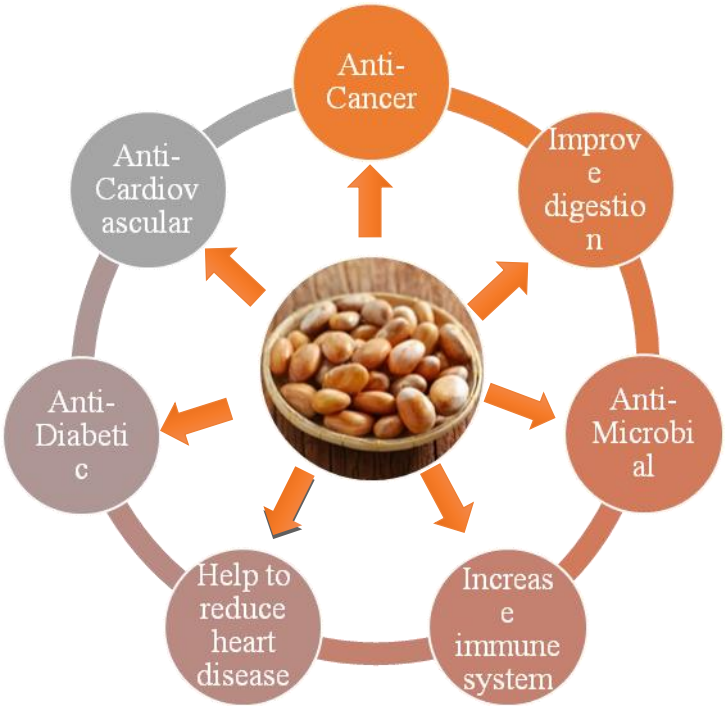

Figure:3. Health benefits of jackfruit seed

The seeds of jackfruitcontain phytonutrients like lignans, saponins, and isoflavones, which contribute positively to human well-being (Noor*et a*l., 2014). Also, jackfruit seed flour helpsin reduction of fat absorption, within certain limits (Butool*et al.*, 2013). Abundant in dietary fiber and B-complex vitamins, these seeds aid in mitigating heart disease risk, preventing constipation, and promoting weight loss due to their substantial fiber content.The presence of resistant starch in seeds contributes the blood sugarregulation levels and the promotion of gut health (Akmeemana*et al.*, 2022).These seeds have antimicrobial properties, guarding against foodborne illnesses (Maurya *et al.*, 2016). Among their attributes, jackfruit seeds contain an important lectin named jacalin, employed to assess the immune status of individuals with HIV infection. In China, these seeds are recognized for their potential in counteracting alcohol toxicity, while in India, they constitute a vital element in an antidote formulated for heavy drinkers (Butool*et al.*, 2013).Magnesium helps in reducing blood pressure and supporting bone well-being. This is achieved through its facilitation of calcium absorption, contributing to enhanced bone strength. And these seeds possess a notable quantity of easily soluble protein, contributing to the mitigation and management of mental stress and anxiety. Their capacity for minimal water and fat absorption further aids in preventing obesity (Maurya *et al*., 2016). It gives immunomodulatory effect due to the seeds contain high amount of protein.Jacalin, a prominent protein extracted fromseeds of jackfruit, exists as a tetramer composed of two chains. The heavy chain consisting of one thirty-three amino acids, is partnered with a light β chain containing twenty to twenty-one amino acids. Its specific affinity lies in recognizing the O-

glycoside of the Thomsen-Friedenreich antigen (Galβ1–3GalNAc). Those characteristics has led to the utilization of jacalin for researching diverseO-linked glycoproteins, especially human IgA1. The remarkable feature of jacalin is its strong stimulation of human CD4+T lymphocytes, making it valuable for assessing the immune condition of individuals affected by human immunodeficiency virus (HIV-I). Jacalin is practicality arises from its abundant source material, easy purification, high yield, and stability. Applications are wide range, including the separation of human plasma glycoproteins (Kabir 1998).The phenolic substance found in seed of jack fruit(Soong *et al.,* 2004). It possesses about six point zero three mg/g of non-reducing sugar extracted (Nualla-ong*et al.,* 2009) which serves as prebiotic substance. Prebiotics are indigestible components present in food. They form a subset of oligosaccharides and Nonreducing sugars promote the proliferation and function of beneficial bacteria in the digestive system, thereby enhancing the balance of intestinal microbes in the host. Prebiotics consist primarily of carbohydrates. The utilization of seed starch is prescribed for the alleviation of biliousness. Roasted seeds are commonly considered to possess aphrodisiac qualities. A higher intake of ripened part of jackfruit assists in mitigating deficiency of retinol (Vit-A). Extract derived from fresh seeds provides a remedy for dysentery and diarrhea. Extract sourced from seeds (or bark) aids in the process of digestion. Both the pulpand seeds of jackfruit are regarded as both cooling and nourishing tonic (Swami *et al.,* 2012).

The seeds of jackfruitcontain flavanones, saponins and lignans, which have been identified possess various beneficial effects such as antioxidants, anticancer properties, antiulcer effects, antihypertensive effects also it has antiaging benefits (Shedge*et al.,*2022).A cluster of secondary metabolites called lignans is generated through the oxidative dimerization of two or more phenylpropanoid units. Among these, two antiviral lignans, podophyllotoxin, and bicyclol, have demonstrated strong efficacy adverse to persistent hepatitis B and venereal diseases (Cui *et al.,* 2020).An essential class of bioactive substances included in food sources, flavones, have anti-inflammatory qualities(Wang *et al.,* 2021). Because they may rupture cell membranes, saponins are amphiphilic chemicals that are significant in pharmacology for their numerous biological activities, including cytotoxicity, hemolysis, and fungicidal properties. The jackfruit seed possess significant number of flavonoids and has antioxidant properties. These attributes make them suitable for utilization as a functional remedy and a plant-derived ingredient in pharmaceutical applications (Shanmugapriya *et al.,* 2011).

TECHNIQUE FORPROCESSING JACKFRUIT SEEDS

After the fruit ripened, the seeds undergo processing in areas where jackfruit is grown. The fruit is openedusing a knife and the seeds are separated from the bulb within the fruit. Each fruit typically have between 100-500 seeds, with no correlation between fruit size and seed quantity. On average, there are about 50-90 seeds per kilogram of fruit. The slimy thin coating surrounding the seed needs to be removed by thoroughly rinsing in water to eliminate any remaining pulp juice or sugary residue.To handle the slimy layer, seeds are shade-dried for an hour, but over-drying in open places should be avoided to prevent nutrient loss (Craig*et al*., 2006). Jackfruit seeds are increasingly being processed more extensively than the peel. Utilizing jackfruit seeds for various purposes is becoming a new trend. Approximately 75% of seeds are converted into flour (Cheok *et al*., 2016).

To process the seeds into flour, the initial steps involved are sorting and cleaning them. Following cleaning, the seeds undergo roasting, which is conducted at ansuitable temperature, typically around 160°C. This temperature ensures the retention of nutrients such as protein and minerals by reducing moisture content. After roasting, the seeds are dried either in a tray drier or a cabinet drier before being milled into flour using a flour mill. The resulting flour can be used directly after drying (Eke-Ejiofor *et al*., 2014). The flour finds applications in various sectors including bakery, extruded products, confectionery, chapati making, and even as a weaning food.Jackfruit seeds are additionally processed to extract starch, which serves as a binding agent. The starch extraction process involves soaking the seeds and subjecting them to enzymatic treatment, while maintaining a pH of 6.0. The resulting mixture is then filtered using a 212mesh sieve, and the remaining filter cake is washed with distilled water. The filtrate is left to precipitate overnight at 40°C, after which the supernatant is discarded and the crude starch is cleaned using distilled water, repeating this step three times. The starch cake is then dried in an oven dryer at 40°C for 24 hrs before being ground. The ground starch is packed into plastic bags and stored at room temperature for future use (Noor *et al*., 2014).

Fully ripened jackfruit exhibits improved qualities such as color, texture, aroma, sweetness, and taste, resulting in high-quality juice with nutritional benefits. Processing for juice extraction is therefore conducted (Sim *et al*., 2003). Jackfruit seeds are also utilized in the making of raw meal from jackfruit by grinding them with coffee meal. In Mexico, boiled jackfruit seed meal is prepared by boiling seeds in coffee meal (Jose *et al*., 2017). Presently, processing is carried out to produce seed flour using various methods such as boiling, roasting, and drying the seeds before milling (Eke-Ejiofor *et al*., 2014).

APPLICATION OF JACK FRUIT SEED POWDER IN FOOD INDUSTRY

The seeds of jackfruit are increasingly being utilized in bakery products like bread, where 10 to 20% of jackfruit seed flour is blended with wheat flour. This combination serves to lower gluten content and aids in digestion (Butool*et al.*, 2013). In cake making, incorporating 5 to 15% jackfruit seed flour results in higher protein content and reduced fat content (Arpit *et al*., 2015). Additionally, extruded products such as noodles benefit from the incorporation of jackfruit seed flour, with up to 20% inclusion resulting in increased protein and dietary fibers (Nandkule*et al.*, 2015). For chapatti preparation, flour of jackfruit seedscan be utilized up to 25%, and the addition of preservatives increase their shelf life to 3-4 days at surroundingtemperature and up to 30 days under refrigeration (Sultana *et al*., 2014). Furthermore, the seeds are also used for starch extraction due to their high amylose content, with starch isolation showing good paste stability during heating (Tulyathan*et al.*, 2002). Presently, jackfruit seed is utilised as a nut by roasting. Roasting jackfruit seeds at 160°C for an hour leads to decrease in moisture, resulting in enhancing protein, carbohydrates, and minerals, as well as a reduction in fat content and fat absorption capacity. Consequently, roasted jackfruit seeds have become popular in regions where jackfruit is grown. Given their gluten-free nature, jackfruit seed flour can serve as an alternative for wheat flour, particularly for individuals with specific food allergies.Theseeds are versatile ingredients used in the creation of numerous value-added products. In South Indian cuisine, jackfruit seed flour is commonly incorporated into recipes such as dosa, dhokla, and idli, typically mixed with rice flour. Additionally, the seeds can be enjoyed as nuts after being salted or used in brine (Chakraborty *et al*., 2013).

Product	**Outcome**	**Reference**
Biscuit	Different ratios of jackfruit seed flour were used to obtain a suitable degree of inclusion for biscuit making. The jackfruit seed flour used to make the final biscuits turned a deep brown. The biscuit samples were made by following the conventional process for the preparation of biscuit. Ingredients were well blended and added necessary amount of milk along with hydrogenated fat. After that, in an oven 150°C for the baking temperature of biscuit.	(Islam *et al*., 2015)

	The jackfruit seed flours slightly raised the amount of ash and crude fiber in the biscuit batter. It contributes to the seed flour's increased mineral and fiber content. Biscuit with 25% jackfruit seed flour exhibited superior nutritional qualities compared to whole wheat bread due to its elevated levels of carbohydrates, fats, proteins, and crude fiber. The levels of moisture, fat, crude fiber, and ash content have risen.	
Noodles	Noodles also making by use of jackfruit seed flour incorporated up to 20% seed flour into the noodle formulation, Incorporation of jackfruit seed flour in noodle production leads to an augmentation in protein and dietary fiber content, elevating the complete nutritional value of the noodles. Noodle samples that had some of their ingredients changed with jack fruit seed flour showed increased moisture and fat content than the regular control noodles. Substituting 30% ofseed of jack fruit flour to the noodles follow in an increase in fiber and ash, as compared with control sample.	(Akter *et al.*,2018), (Alsedik*et al*., 2021)

	Increased yield ratio, better organoleptic properties and reduced cooking duration.	
Cookies	A sweet baked delicacy, it's a fat, small, typically round or square in shape. Cookies were created by combining jackfruit seed flour with both all-purpose wheat flour (maida) and whole wheat flour. The cookies with 20% and 30% jackfruit seed flour were well-received for their taste. However, if the proportion of seed of jack fruit flour is boost to 50%, the cookies became excessively firm in texture. Cookies incorporating those flour demonstrated increased levels of ash, protein, fiber, and fat content compared to those using only wheat flour. Additionally, amount of phytate and oxalate in the cookies remained within acceptable ranges. Moreover, using jackfruit seed flour also resulted in a reduction in cooking time compared to other methods.	(Akter *et al.*,2018), (Xian *et al*., 2024)
Cake	Cake is an important bakery product and is widely enjoyed by people around the globe. Due to its high caloric content, excessive consumption can contribute to obesity. As a result, there is a growing consumer demand	(David 2016)

	for cakes with reduced calories and higher fiber content, which would provide essential nutrients. Fortifying cakes with jackfruit seed flour provide healthier options. Integrated jackfruit seed flour in cake recipes, ranging from 5% to 15%. Jackfruit seed flour contributes to an elevation in protein levels and a reduction in fat content in the cake samples In chocolate cake it enhances dietary fiber content and increase antioxidant potential. Best baking temperature at 190℃ at 15-20 minutes and cool at room temperature. It helps to reduce cooking time and improved crumb structure, texture, and nutritional profile.	
Pasta	Seed of jack fruit flour and wheat flour (ranging from 100:0 to 80:20) are used for making pasta. Using this composite flour not only boosted the nutritional content but also enhanced the pasta's texture. The incorporation 10% jackfruit seedflour, though, led to the creation of a well-structured starch and gluten	(Kumari *et al.,* 2017)

	It helps to Increased yield efficiency with reduced cooking duration	
Muffin	Jackfruit seed flour can have a mildly nutty flavor, which can add a unique taste to your muffins. Using of nutrients such as protein, fiber, and minerals, muffins can enhance nutritional profile compared to muffins made with refined flour alone. Viscosity decreased and specific gravity increased	(Faridah *et al*., 2012)
Bread	Adding 25%flour led to bread that was positively received overall and had superior nutritional qualities compared to whole wheat bread, boasting higher levels of carbohydrates, fats, proteins, and crude fiber. Increased water absorption and oil absorption capacity As the substitution level increased, there was a notable reduction in the color, flavor, texture, taste, and overall likability of the breads.	(Tulyathan*et al*., 2002),(Pathak *et al.,* 2022)
Snack bar	Offers a mild, nutty flavor that can be enhanced with other ingredients. It can give a slightly grainy texture, depending on the grind, and may absorb moisture. Offers a nutritious option packed with carbs,	(Meethal*et al.,* 2017)

	fiber, andprotein, as well as vitamins and minerals. Expect a slightly grainy texture that may vary depending on the grind, along with a mild, nutty flavor that can be enhanced with other ingredients. Can be customized with additional nuts, seeds, fruits, or spices to tailor both flavor and texture according to personal preference.	
Waffle ice cream	A waffle ice cream made with jackfruit seed flouroffers a unique twist on a classic dessert. The flour provides a gluten-free and nutritiousalternative, rich in carbs, fiber, and protein, along with vitamins and minerals. Expect a slightly different texture compared to traditional waffles due to the nature of the flour, possibly with a slightly grainy consistency. The mild, nutty flavor of flour can add depth to the waffle, complementing the sweetness of the ice cream.	(Kushwaha *et al*., 2023)

Table: 3. Value-added products made by enhancing with jackfruit seeds in various formats.

GRAPHICAL ABSTRACT

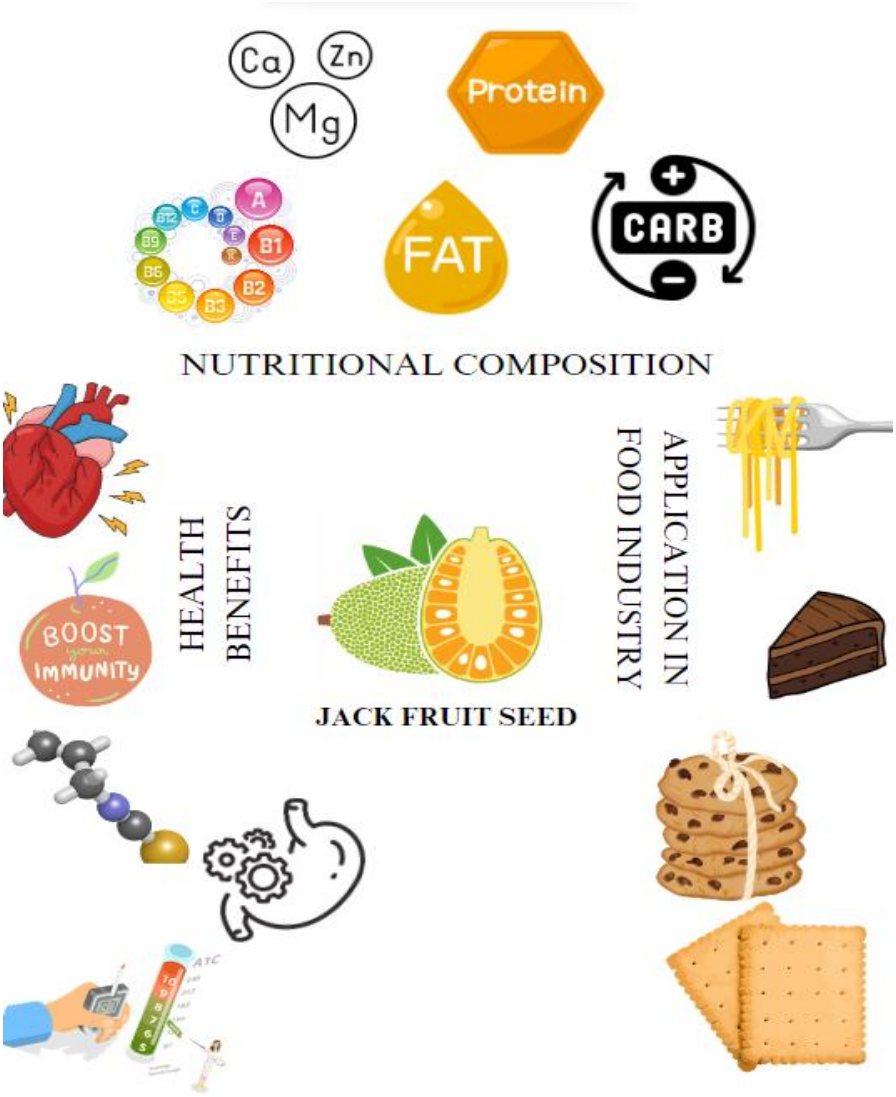

Figure: 4. Functional properties and health benefits of jackfruit seed

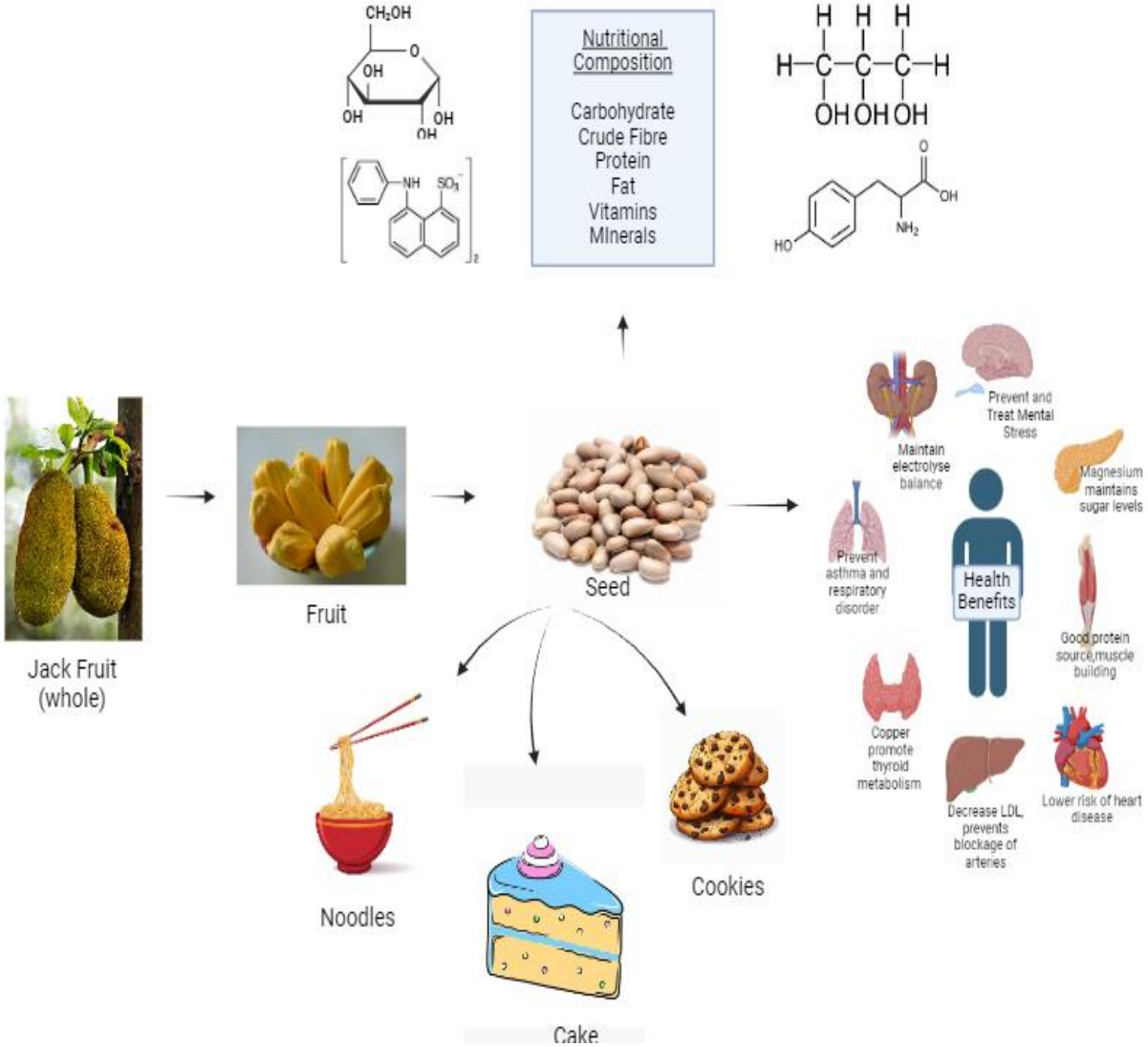

Figure: 5. Health benefits, functional properties and its application of jackfruit seed

CONCLUSION

Jackfruit seeds are a nutritionally rich and versatile ingredient that can positively impact health and food product development. Their high protein and fiber content, along with essential vitamins and minerals, make them a valuable addition to a balanced diet. Additionally, their potential to reduce food waste aligns with sustainable food practices. Incorporating jackfruit seeds into various recipes can be a tasty and nutritious way to reap their benefits.Utilizing seeds as an additive in food can serve as a more effective method for increasing both the protein and starch levels. Moreover, nutritional value can be improved through the process of roasting, which not only reduces antinutrient content but also boosts the accessibility of protein. Using jack fruit seed powder can

make different food product like noodles, cake, cookies, biscuit etc and it also contains high nutrients comparing to other powder like wheat powder. And due to its high nutrient content, consumption of jack fruit seed food product helps in digestive system, increase in immune system, decrease in heart disease and it also have anti-microbial, anti-cancer activity, it is good for especially low immunity peoples. So, this review helps in generating innovative concepts for the utilization of waste from jackfruit, along with the utilization of its seeds, their superior nutritional, health benefits and functional attributes.

REFERENCE

1. Abioye, V. F., Olatunde, S. J. & Elias, G. (2018). Quality attributes of cookies produced from composite flours of wheat, germinated finger millet flour and African yam bean. *International Journal of Research*, **6**(11):172-183.
2. Akmeemana, C., Wickramasinghe, I., Wanniarachchi, P. C., & Vithanage, T. (2022). Effect of drying and frying pre-treatments on nutrient profile, antioxidant capacity, cooking time, and sensory acceptability of easy to cook jackfruit seeds. *Applied Food Research*, 2(**2**), 100234.
3. Akter, B., & Haque, M. A. (2018). Utilization of Jackfruit (*Artocarpus heterophyllus*) seed's flour in food processing: A review. *The Agriculturists*, **16**(2):131-42.
4. Akter, F., & Haque, M. A. (2019). Jackfruit waste: a promising source of food and feed. *Annals of Bangladesh Agriculture*, **23**(1): 91-102.
5. Alabi, D.A., Akinsulire, O.R. and Sanyanyalolu, M.A. (2005). Quantitative determination of chemical and nutritional composition of jack fruit seed. *African Journal of Biotechnology*, **4**(8): 812-815.
6. Alsedik, A. S., Shalaby, M. T., Elgammal, R. E., &Motawei, A. M. (2021). Utilization of Whole Oat Grains in Cookies Processing for Secondary School Girls in El Mansoura City, El-Dakahliea Egypt. *Journal of Food and Dairy Sciences*, 12(**11**): 289-293.
7. Arpit, S. and John, D. (2015). Effects of different levels of Jackfruit Seed Flour on the Quality Characteristics of Chocolate cake. *Research Journal of Agriculture and Forestry Sciences*, **3**(11): 6-9.
8. B. M. C. Reddy, P. Patil, S. Shashikumar, and L. R. Govindaraju, (2004). "Studies on physic-chemical characteristics of jackfruit clones of south Karnataka, Karnataka," *Journal of Agricultural Science*, **4** (17): 279–282.

9. Babu, N. G., Kumar, S., & Sundar, S. (2017). Extraction and comparison of properties of jackfruit seed oil and sunflower seed oil. *International Journal of Scientific and Engineering Research*, **8**(11): 635–639.
10. Banerjee, S., & Datta, S. (2015). Effect of dry heat-treated jackfruit seed powder on growth of experimental animals. *Journal of Pharmacy and Biological Sciences*, **10**: 42-46.
11. Barber, T. M., Kabisch, S., Pfeifer, A. F., & Weickert, M. O. (2020). The health benefits of dietary fiber. *Nutrients* **12**(10): 3209.
12. Betancur-Ancona, D., Gallegos-Tintore, S. and ChelGuerrero, L. (2004). Wet-fractionation of Phaseolus lunatus seeds: partial characterization of starch and protein. *Science of Food and Agriculture*, **84**: 1193–1201.
13. Butool, S. and Butool, M. (2013). Nutritional quality on value addition of jackfruit seed flour. *International Journal of Science and Research*, **4**:2406- 2411
14. Chakraborty, P., Bhattacharyya, D.K., Bandyopadhyay, N.R. and Ghosh, M. (2013). Study on utilization of jackfruit seed flour and defatted soy flour mix in preparation of breakfast cereal by twin-screw extrusion technology. *Discovery*, **4**:32- 37
15. Chrips, N. R., Balasingh, R. G. S., & Kingston, C. (2008). Nutrient constituents of neglected varieties of *Artocarpus heterophyllus Lam.* from Kanyakumari district, South India. *Journal of basic and applied biology*, **2**(1): 36-47.
16. Conforti, F. D., &Cachaper, K. F. (2009). Effects of selected antioxidants on physical and sensory characteristics of yeast bread containing flaxseed meal. *International Journal of Consumer Studies*, **33**(1): 89-93.
17. Craig, R. E., & Harley, I. M. (2006). *Artocarpus heterophyllus* (jackfruit). *Species Profiles for Pacific Island Agroforestry*, **4**: 1-16.
18. Cui, Q., Du, R., Liu, M., & Rong, L. (2020). Lignans and their derivatives from plants as antivirals. *Molecules*, **25**(1): 183.
19. David J. (2016) Antioxidant properties of fiber rich dietetic chocolate cake developed by jackfruit (*Artocarpus heterophyllus L.*). Seed Flour. **2**:132-135.
20. Hasan, S.M.K., Hossain, M.A., M.J., Roy, J., and Sarker, M.S.H. (2010). Preparation of Biscuit from Jackfruit (*Artocarpus heterophyllus*) Seed Flour Blended with Wheat Flour. *The Agriculturists***8**(1): 10-18.
21. Hossain, M. T. (2014). Development and quality evaluation of bread supplemented with jackfruit seed flour. *International Journal of Nutrition and Food Sciences*, **3**(5): 484-487.

22. Khan, A. U., Ema, I. J., Faruk, M. R., Tarapder, S. A., Khan, A. U., Noreen, S., & Adnan, M. (2021). A review on importance of *Artocarpus heterophyllus L.*(Jackfruit). *Journal of Multidisciplinary Applied Natural Science*.
23. Kumar, S., A. B. Singh, A. B. Abidi, R. G. Upadhyay and A. Singh. 1988. Proximate composition of jack fruit seeds. *Journal of Food Science and Technology*. 25: 308-309.
24. Kumari VS, Divakar S. (2017). Quality analysis of raw jackfruit-based noodles. *Asian Journal of Dairy and Food Research*, **36**(1):45-51.
25. Kushwaha, R., Gupta, A., Singh, V., Kaur, S., Puranik, V., & Kaur, D. (2023). Jackfruit seed flour-based waffle ice cream cone: Optimization of ingredient levels using response surface methodology. *Heliyon*, **9**(2).
26. Madruga, M.S., de Albuquerque, F.S., Silva, I.R., doAmaral, D.S., Magnani, M. and Queiroga Neto, V. (2014). Chemical, morphological and functional properties of Brazilian jackfruit (*Artocarpus heterophyllus L.*) seed starch. *Food Chemistry*, **143**:440-445.
27. Maskey, B., Subedi, S., & Shrestha, N. K. (2020). Effect of incorporation of jackfruit (*Artocarpus heterophyllus*) seed flour on the quality of cookies. Dristikon: *A Multidisciplinary Journal*, **10**(1): 60-72.
28. Maurya, P., & Mogra, R. (2016). Assessment of consumption practices of jackfruit (*Artocarpus heterophyllus lam*.) seeds in villages of Jalalpur block district Ambedarnagar (U.P.) India.*Seeds*, **2**: 73-75.
29. Meethal, S. M., Kaur, N., Singh, J., & Gat, Y. (2017). Effect of addition of jackfruit seed flour on nutrimental, phytochemical and sensory properties of snack bar. *Current Research in Nutrition and Food Science*, **5**(2): 154-158.
30. Nandkule, Vinod, D. Masih, Dorcus, Sonkar, Chitra and Patil, Devendrasing D. (2015). Development and quality evaluation of jackfruit seed and soy flour noodles. *International Journal of Engineering, Science and Technology*., **3** (3): 802-806.
31. Noor, F., Rahman, M. J., Mahomud, M. S., Akter, M. S., Talukder, M. A. I., & Ahmed, M. (2014). Physicochemical properties of flour and extraction of starch from jackfruit seed. *International Journal of Nutrition and Food Sciences*, **3**(4): 347-354.
32. Nualla-ong, S., Chetpattananondh, P., Prasertsit, K., & Yamsaengsung, R. (2009). Extraction of prebiotics from jackfruit seeds. *Engineering and Applied Science Research*, **36**(3):213-220.
33. Ocloo, F. C. K., Bansa, D., Boatin, R., Adom, T., &Agbemavor, W. S. (2010). Physico-chemical, functional and pasting characteristics of four produced from Jackfruits (*Artocarpus heterophyllus*) seeds. *Agriculture and Biology Journal of North America*,**1**(5): 903–908.

34. Pathak, N., Singh, S., Singh, P., Singh, P. K., Singh, R., Bala, S., ... & Tripathi, M. (2022). Valorisation of jackfruit waste into value added products and their potential applications. *Frontiers in Nutrition*, 9, 1061098.
35. Prakash, O., Kumar, R., Mishra, A., & Gupta, R. (2009). *Artocarpus heterophyllus* (Jackfruit): an overview. *Pharmacognosy Reviews*, **3**(6): 353.
36. Rahman, A. M., Huq, E., Mian, A. J., & Chesson, A. (1995). Microscopic and chemical changes occurring during the ripening of two forms of jackfruit (*Artocarpus heterophyllus L.*). *Food Chemistry*, **52**(4): 405-410.
37. S. Kabir. Jacalin, (1998) a jackfruit (*Artocarpus heterophyllus*) seed-derived lectin of versatile applications in Immunobiological research. *Journal of Immunological Method***212**(2): 193-211.
38. S. Palamthodi, S. Shimpi, and K. Tungare. (2021). "A study on nutritional composition and functional properties of wheat, ragi and jackfruit seed composite flour". *Food Science and Applied Biotechnology,* **4** (1): 63.
39. Shaiful, M.I., Rokeya, B., Morshada, K. and Kamalesh, C.D. (2015). A study on nutritional and functional properties analysis of jackfruit seed flour and value addition to biscuits. *International Journal of Engineering Research and Technology*, **4**(12): 139-147.
40. Shanmugapriya, K., Saravana, P. S., Payal, H., Peer Mohammed, S., & Binnie, W. (2011). Antioxidant activity, total phenolic and flavonoid contents of *Artocarpus heterophyllus* and *Manilkara zapota* seeds and its reduction potential. *International Journal of Pharmacy and Pharmaceutical Sciences*, 3, 256-260.
41. Sharma, M. R. (1964, December). Morphological and anatomical investigations on *Artocarpus forst*: IV. The fruit. In Proceedings/*Indian Academy of Sciences*. *New Delhi: Springer India***60**(6): 380-393.
42. Shedge, M. S., Haldankar, P. M., Ahammed Shabeer, T. P., Pawar, C. D., Kasture, V. V., Khandekar, R. G., &Khapare, L. S. (2022). Jackfruit: functional component related with human health and its application in food industry. *Pharma Innovation Journal,***11**(6): 824-830.
43. Sim, M. Y. M., Ahmad, M. N., Shakaff, A. Y. M., Ju, C. P., &Cheen, C. C. (2003). A disposable sensor for assessing *Artocarpus heterophyllus L.*(jackfruit) maturity. *Sensors*, **3**(12): 555-564.
44. Siti Faridah, M. A., & Noor Aziah, A. A. (2012). Development of reduced calorie chocolate cake with jackfruit seed (*Artocarpus heterophyllus Lam*.) flour and polydextrose using Response Surface Methodology (RSM). *International Food Research Journal*, **19**: 515-519.

45. Soong YY, Philip Barlow J. (2004). Antioxidant activity and phenolic content of selected fruit seeds. *Journal ofAgricultural Food Science Chemistry*,**88**: 411–7.
46. Sultana, A., Islam, M., Ramim, Md. and Rahman, T. (2014). Evaluation of quality of chapaties enriched with jackfruit seed flour and bengal gram flour. *Journal of Environmental Science, Toxicology & Food Technology*, **8**:73-78.
47. Swami, S. B., Thakor, N. J., Haldankar, P. M., &Kalse, S. B. (2012). Jackfruit and its many functional components as related to human health: a review. *Food Science and Food Safety,***11**(6): 565-576.
48. Tang, Y.P., Linda, B.L.L. and Franz, L.W. (2013). Proximate analysis of *Artocarpus odoratissimus* (Tarap) in Brunei Darussalam. *International Food Research Journal.*,**20**: 409-415.
49. Tulyathan, V., Tananuwong, K. and Songjinda, P. (2002). Some physicochemical properties of jackfruit seed flour and starch.*ScienceAsia*, **28**: 37-41.
50. Tulyathan, V., Tananuwong, K., Songjinda, P., &Jaiboon, N. (2002). Some physicochemical properties of jackfruit (*Artocarpus heterophyllus Lam*) seed flour and starch. *ScienceAsia*, **28**(1): 37-41.
51. Wang, X., Cao, Y., Chen, S., Lin, J., Bian, J., & Huang, D. (2021). Anti-Inflammation Activity of Flavones and Their Structure-Activity Relationship. *Journal of Agricultural and Food Chemistry*, **69**(26): 7285–7302.
52. Xian, G. S., Mamat, H., & Aziz, A. H. A. (2024). Valorisation of agriculture by-product: Development of gluten-free biscuit made from blends of okara and jackfruit seed flour. *Waste Management Bulletin*.
53. Zhang Y., Zhang, Y., Li, B., Wang, X., Xu, F., Zhu, K., ... & Li, S. (2019). Invitro hydrolysis and estimated glycemic index of jackfruit seed starch prepared by improved extrusion cooking technology. *International Journal of Biological Macromolecules*, **121**: 1109-1117.