STM JOURNALS

Research & Reviews: Journal of
Dairy Science & Technology

https://journals.stmjournals.com/rrjodst

ISSN: 2319-3409 (Online)
ISSN: 2349-3704 (Print)
Volume 14, Issue 1, 2025
January–April
DOI (Journal): 10.37591/RRJoDST

Research RRJoDST

Jackfruit – A Protentional Fruit for Producing Functional Yogurt

Mohammed Tanvir Ahamed[1], Sayedul Alam[1], Arfanul Saif[2], Sumana Rashid[3,*], Minhajul Islam[4], Md. Shajjdul Kabir[5]

Abstract

Jackfruit (Artocarpus heterophyllus), the largest tree-borne fruit, is a rich source of nutrition and medicinal properties. Native to the rainforests of the Western Ghats in India, its diverse varieties are celebrated across Asia for their unique texture, flavor, and nutritional value. The jackfruit is high in protein, carbohydrates, vitamins, and minerals, with its flesh and seeds offering various health benefits, including improved digestion, enhanced bone health, and cardiovascular support. Rich in dietary fiber, jackfruit aids colon health and alleviates constipation while its high magnesium and vitamin C content bolster immunity. Its medicinal applications extend to treating skin conditions, anemia, and thyroid dysfunction. Yoghurt, a popular fermented dairy product, is known for its nutritional benefits and digestibility. Made by fermenting milk with lactic acid bacteria, like Lactobacillus bulgaricus and Streptococcus thermophilus, yoghurt is rich in essential nutrients, such as calcium, vitamins, and proteins. It supports gut health, strengthens bones, and enhances metabolic functions. The addition of jackfruit to probiotic yoghurt increases its nutritional profile and introduces beneficial bioactive compounds, creating a functional food that combines the health-promoting properties of both ingredients. Fermentation improves the digestibility of lactose, making yoghurt a preferred choice for individuals with lactose intolerance. This chapter explores the nutritional composition, therapeutic effects, and industrial applications of jackfruit and yoghurt. The combination of these two nutrient-rich foods offers promising potential for developing innovative, health-enhancing functional products catering to the evolving dietary preferences of health-conscious consumers.

***Author for Correspondence**
Sumana Rashid
E-mail: aishaikh@kamdhenuuni.edu.in

[1]Student, Department of Applied Chemistry & Chemical Technology, Faculty of Food Science & Technology, Chattogram Veterinary & Animal Sciences University, Chittagong, Bangladesh
[2]Student, Department of Physiology Biochemistry & Pharmacology, Faculty of Veterinary Medicine, Chattogram Veterinary & Animal Sciences University, Chittagong, Bangladesh
[3]Dietitian & Nutritionist, Department of Nutrition & Diet Management, Apollo Imperial Hospitals, Khulshi, Chittagong, Bangladesh.
[4]Student, Faculty of Food Science & Technology, Chattogram Veterinary & Animal Sciences University, Chittagong, Bangladesh.
[5]Student, Department of Computer Science & Engineering, International Islamic University Chittagong, Chittagong, Bangladesh

Received Date: February 01, 2025
Accepted Date: February 04, 2025
Published Date: February 13, 2025

Citation: Mohammed Tanvir Ahamed, Sayedul Alam, Arfanul Saif, Sumana Rashid, Minhajul Islam, Md. Shajjdul Kabir. Jackfruit – A Protentional Fruit for Producing Functional Yogurt. Research & Reviews: Journal of Dairy Science & Technology. 2025; 14(1): 20–27p.

Keywords: Jackfruit, Yogurt, Artocarpus heterophyllus, Lactobacillus bulgaricus, Streptococcus thermophilus

INTRODUCTION

Jackfruit, scientifically known as *Artocarpus heterophyllus* is the largest fruit that grows on trees globally, with a weight that can reach up to 50 kg and a length of 60–90 cm. This plant belongs to the Moraceae family, which also contains the mulberry, ficus, and maclurapomifera (Schneid) trees (Osage orange or hedge apple). The tree's main branches and its lateral branches are both capable of bearing fruit. A small, fibrous jackfruit with mushy, squishy, and sweet carpels-thinks raw oyster texture and a crisp, crunchy jackfruit with less sugar are the two main varieties. The large seeds of this nonleguminous plant are edible but difficult to digest. The pulpy white cotyledon is

enveloped by a thin brown spermoderm, which is encased in a white aril that surrounds a single seed. The cotyledons of jackfruit are rich in protein and carbohydrates [1].

Yogurt is a dairy product that may be eaten as a snack, a thirst relieving beverage, or a dessert. It is a semisolid custard-like substance. It is the result of pasteurized or boiled milk being soured by a harmless lactic acid or other bacterial culture, either naturally or artificially. Yoghurt may include extra cane sugar. Sugar was added at a rate ranging from 8% to 10% during preparation. The fat and SNF percentages should match those of the processed milk. Milk is highly nutritious and essential for human consumption. During this era of industrialization, the dietary habits of the general population are evolving. They are preferred for being healthful and flavorful compared to fresh raw foods. Milk is processed into several products, such as yoghurt, fermented milk, cheese, butter, and milk ice cream. Yoghurt is a commonly found dairy product on the Indian subcontinent. Yoghurt is highly nutritious, containing iodine, calcium, phosphorus, zinc, riboflavin, vitamin B_5, and vitamin B_{12}, like milk. The food is high in protein, molybdenum, and pantothenic acid [2].

LITERATURE REVIEW

Milk is a nutrient-dense liquid produced by mammals' mammary glands to nurture newborns, consisting of water, fat, and solids that are not fat. It is the main source of nourishment for young mammals, such as breastfed human infants, before they can consume solid food. Milk is a valuable source of high-quality protein, lactose, vitamins (except vitamin C), calcium, and phosphorus. It is the only food that naturally contains lactose

Composition of Milk and Health Benefits

Billions of people worldwide consume cow's milk daily and is acknowledged as a comprehensive food source. Cow's milk contains vital macronutrients and micronutrients necessary for human body growth and development. The protein is of significant biological significance as it contains all essential amino acids and is highly digestible.

Milk has a high nutritional value because of the balanced composition of its nutrients. Composition differs between animal species and breeds within the same species, as well as between different dairies, based on lactation period and food. Cow milk consists of 87.2% water and 12.3% solids, including 3.7% fat, 3.4% protein, 4.1% lactose, 0.8% ash, 8.9% SNF, and 8.13% fat solids. The composition also includes calcium (0.11%), phosphate (0.08%), and magnesium (0.21%).

Milk contains multiple categories of nutrients. Organic chemicals are evenly distributed and categorized into elemental builders, proteins, energy components, carbohydrates, and lipids. The water also includes essential components including vitamins, enzymes, and dissolved gases, as well as dissolved salts, particularly phosphates, nitrates, and chlorides of calcium, magnesium, potassium, and sodium. The water also includes dissolved gases, comprising 5% by volume, primarily carbon dioxide, nitrogen, and oxygen [3].

Nutrition Values and Health Benefits of Milk Protein

The twenty key proteinogenic amino acids are categorized into two groups: essential, which the body cannot produce and must be obtained from the diet, and nonessential, which the body can synthesize in sufficient quantities. Under certain circumstances, such as physiological or pathological conditions, if the body is unable to produce certain amino acids in sufficient quantities, those amino acids may be deemed conditionally necessary. Protein in the diet provides nitrogen for all nitrogen-containing molecules in the human body. Milk's protein content fluctuates according on factors, such as breed, genetics, milking stage, season, and nutrition. There are two primary proteins: caseins and whey proteins, such as β-lactoglobulin and α- lactalbumin can have their antigenicity reduced through specific treatments.

Milk Carbohydrates

Carbohydrates are substances that can be categorized based on their polymerization level, including monosaccharides (e.g., glucose, fructose, and galactose), disaccharides (e.g., lactose, sucrose, maltose, polyols), oligosaccharides (e.g., maltodextrins, raffinose), and polysaccharides (e.g., starch), depending on the number of monomeric units present and how they are linked together. Carbohydrates in our diet are crucial for human health and nutrition as they are the primary energy sources for the body. They also have additional functions in the human body, including involvement in lipid metabolism and intestinal function via fermentation. Lactose aids in the absorption of calcium, magnesium, and phosphorus in the intestines, as well as the utilization of vitamins. Nevertheless, oligosaccharides, glycoproteins, glycopeptides, and nucleotides are present in limited amounts [4].

Milk Fat

Fats and oils encompass many lipid molecules, such as fatty acids, mono-, di-, and triacylglycerols, phospholipids, and sterols. Fatty acids serve as the foundational components of triacylglycerol's and phospholipids, as well as being involved in the production of signaling molecules known as eicosanoids. Triglycerides exceeding 98%, together with monoacylglycerols, phospholipids, sterols, hydrocarbons, and cholesterol esters, are the predominant fats found in milk. Milk contains a significant amount of conjugated linoleic acid that enhances the body's immune system by activating immunoglobulins, cytokines, and prostaglandins, which are mediators of immunity. It also has anticarcinogenic, antiatherogenic, antidiabetic, immunomodulatory, and antiadipogenic properties

Milk Vitamins

Vitamins are vital nutrients found in food in minimal quantities. Due to the human body's low synthesis capacity, essential nutrients must be obtained through diet. They perform several roles in the human body, and inadequate or excessive consumption can result in health problems, which become more serious as the degree of deficiency or toxicity rises. Vitamins can be categorized based on their solubility into fat-soluble vitamins (A, D, E, and K) and water-soluble vitamins (C and B complex). Fat-soluble vitamins have various crucial roles in the human body, such as supporting eyesight (Vitamin A), maintaining bone health (Vitamin D), providing antioxidant activity (Vitamin E), and aiding in blood clotting (Vitamin K). Insufficient intake of these vitamins can hinder several physiological functions due to their significant roles in human physiology. A fat-free diet can negatively impact human health by causing malabsorption of vitamins, perhaps leading to vitamin shortage. This is because fat-soluble vitamins are absorbed and transported with fat and stored in the liver and adipose tissue. Water-soluble vitamins are crucial for various functions in the human body, including collagen synthesis (vitamin C), energy-yielding reactions (vitamin B1), redox metabolism (vitamin B2), and formation of NAD and NADP (vitamin B3). Amino acid and lipid metabolism are supported by vitamin B5, also known as pantothenic acid. Enzymes require co-factors, such as vitamin B6 (pyridoxine) and vitamin B7 (biotin). Vitamin B9, known as folate, is essential for RNA and DNA synthesis, while vitamin B12 (cobalamin) acts as a co-enzyme [5].

Milk Minerals

Milk contains potassium, calcium, chloride, phosphorus, selenium, zinc, and copper. Potassium plays a crucial role in maintaining acid-based balance, muscular function, neuron function, and kidney health. Chloride is beneficial for liver function and helps regulate fluid balance, blood pH, and osmotic pressure. Calcium is essential for maintaining strong bones and promoting blood clotting. Selenium is beneficial for protecting cells from free radicals. Zinc is abundant in milk and is essential for maintaining good skin, promoting wound healing, and providing antioxidative characteristics. It serves as a cofactor for antioxidant enzymes, aids in protein formation, and plays a role in regulating insulin for glucose breakdown (Jackfruit).

Jackfruit has been a staple meal in Sri Lanka since ancient times. It is a perennial fruit that significantly supported the food supply for people and cattle during shortages of staple food grains. Hence, it is commonly known as nourishment for people with limited financial resources. Jackfruit is

believed to have originated in the rainforests of the Western Ghats in the Southwestern region of India, while some writers suggest that Malaysia may also be a potential place of origin. It is distributed over several regions in Asia, Africa, and South America. Jack tree thrives in warm and humid areas.

The jackfruit, the largest cultivated fruit, is oblong to cylindrical, usually 30–40 cm long, but occasionally reaching 90 cm. Jackfruits typically range in weight from 4.5 to 30 kilograms, most generally falling between 9 and 18 kg, with a highest recorded weight of 50 kg. The weighty fruits are mainly carried on the trunk and inner sections of the main branches. Jackfruit is a numerous aggregation fruit generated by the fusion of several blooms in an inflorescence. The external rind is green to yellow green. The tough outer layer originates from the larger female flowers. The pale fibrous flesh inside the fruit contains numerous seeds, up to 500 per fruit. Each seed is surrounded by flesh (aril) with a flavor ranging from acidic to sweetish when ripe, reminiscent to bananas. The dense fruit is supported by a central fibrous core. In the Northern Hemisphere, the fruiting season occurs primarily from late spring to early autumn, namely from March to September, with a focus on summer. Some fruits ripen during the winter or early spring [6].

In Bangladesh, the jackfruit typically ripens from early May to late July, with the peak season usually occurring in June.

VARIETIES OF JACKFRUIT

Various studies have documented the diversity in jackfruit, focusing on morphological, phenotypic, and organoleptic traits, such as tree size, leaf structure, fruit shape, fruit-bearing age, fruit flesh quality, size, shape, spine density, color, texture, odor, quality, and maturity period that there are a minimum of 30 varieties of jackfruit on the Indian subcontinent and an additional 30 variants in Malaysia. Various jackfruit cultivars including “Vela”, “Varaka (Waraka)”, “Peniwaraka”, “Kuruwaraka”, Singapore, or the Ceylon Jack are found in Sri Lanka.

There are two primary types of jackfruits: firm and soft. In the firm variety, the perianth remains hard even when fully ripe, whereas in the soft variety, the perianths become mushy and fleshy upon ripening the soft version of the fruit contains small, fibrous, soft, and spongy flakes with highly sweet carpels, whereas the firm type is crunchy with crisp carpels and lacks the sweetness of the soft variety. The firm variety is regarded as high grade. Studies have shown differences in starch, total sugar, and decreasing sugar levels between soft and firm varieties.

Chemical Composition and Nutritional Value of Jackfruit

The chemical composition of jackfruit varies based on the variety. Jackfruit flesh and seeds have higher levels of protein, calcium, iron, and Thiamine compared to other tropical fruits.

A study has found that mature jackfruit contains higher levels of certain minerals and vitamins compared to apples, apricots, avocado, and banana. Jackfruit has a low caloric content, with 100 g containing only 94 calories. Table 1 shows the makeup of jackfruit based on various investigations conducted [7].

Medicinal and Functional Properties of Jackfruit

Jackfruit’s high fiber content of 3.6 g/100 g helps avoid constipation and promotes regular bowel motions. It provides protection to the colon mucous membrane by eliminating carcinogenic substances from the large intestine (colon). Jackfruit contains high levels of magnesium, with 27 mg/100 g in young fruit and 54 mg/100 g in the seed. It is a vital nutrient that plays a crucial role in calcium absorption and collaborates with calcium to enhance bone strength and prevent bone illnesses like osteoporosis. Jackfruit contains iron (0.5 mg/100 g), which aids in preventing anemia and promoting healthy blood circulation. Copper at a concentration of 10.45 mg/kg is crucial for thyroid

gland function, particularly in hormone synthesis and absorption. Jackfruit is rich in these essential trace minerals. Jackfruit is beneficial since it is a rich source of vitamin C. The human body does not synthesize vitamin C endogenously; therefore, it must be obtained through dietary sources containing vitamin C to obtain its health benefits. Jackfruit is devoid of gluten and casein, providing systemic anti-inflammatory advantages for the skin. Jackfruit is rich in antioxidants and contains vitamin C, flavonoids, potassium, magnesium, and fiber. Vitamin C is essential for collagen formation, which is a protein that gives skin structure, firmness, and strength. Potassium in jackfruit aids in reducing blood pressure and counteracting the impact of salt, which leads to elevated blood pressure and damages the cardiovascular system. This aids in the prevention of cardiovascular disease and stroke. Potassium aids in the prevention of bone loss and enhances muscle and nerve function. The jackfruit contains vitamin B6, which can reduce homocysteine levels in the blood, hence decreasing the risk of heart disease. Jackfruit seed powder includes manganese and magnesium ions. Seeds also include two lectins: jacalin and artocarpin. Jacalin has been demonstrated to be beneficial in assessing the immunological state of patients infected with human immunodeficiency virus 1.

Table 1. Composition of jackfruit (100 g edible portion).

Composition	Young Fruit	Ripe Fruit
Water (g)	76.2–85.2	72.0–94.0
Protein (g)	2.0–2.6	1.2–1.9
Fat (g)	0.1–0.6	0.1–0.4
Carbohydrate (g)	9.4–11.5	16.0–25.4
Fibre (g)	2.6–3.6	1.0–1.5
Total sugars (g)	–	20.6
Total minerals (g)	0.9	0.87–0.9
Calcium (mg)	30.0–73.2	20.0–37.0
Magnesium (mg)	–	27.0
Phosphorus (mg)	20.0–57.2	38.0–41.0
Potassium (mg)	287–323	191–407
Sodium (mg)	3.0–35.0	2.0–41.0
Iron (mg)	0.4–1.9	0.5–1.1
Vitamin A (IU)	30	175–540
Thiamine (mg)	0.05–0.15	0.03–0.09
Riboflavin (mg)	0.05–0.2	0.05–0.4
Vitamin C (mg)	12.0–14.0	7.0–10.0
Energy (KJ)	50–210	88–410

The Uses of Jackfruit in Local Market

a. *Roots:* Root extract is utilized in the treatment of skin diseases, asthma, and diarrhea.
b. *Leaves:* Extracts from leaves and latex can treat asthma, prevent ringworm infestation, and heal cracked feet. Diabetics are administered leaf extract as a control method. It is said that warmed leaves can treat wounds, abscesses, ear disorders, and alleviate pain. A concoction made from fully grown leaves and bark is utilized for the treatment of gallstones. A tea brewed from dried and powdered leaves is consumed to alleviate asthma symptoms. Jackfruit leaf ash, when burned with maize and coconut shells, can be applied alone or combined with coconut oil to treat ulcers.
c. *Flowers:* Crushed flower clusters are utilized to halt bleeding in exposed injuries.
d. *Pulp:* Jackfruit pulp and seeds are a nourishing tonic that can help counteract the effects of alcohol on the body.
e. *Seed:* Seed starch is administered to alleviate biliousness. Roasted seeds are considered to have aphrodisiac properties. Enhanced intake of ripe jackfruit seeds helps to reduce vitamin A deficiency. Utilizing fresh seeds can remedy diarrhea and dysentery. Extract from seeds or bark aids with digestion.

f. *Bark:* Extracts from bark, rags, or roots can be used to treat dysentery. Bark is utilized to create poultices. Ash derived from burning bark possesses medicinal properties that help treat abscesses and ear issues.
g. *Latex:* When mixed with vinegar, latex can help heal abscesses, snakebites, and glandular swellings.

FOOD FERMENTATION

Fermentation is the metabolic activity of microorganisms that undergo complicated transformations of organic material to support their growth and reproduction. Food fermentation is among the first applications of biotechnology. Fermented food and drinks have been a significant component of the human diet for thousands of years, contributing around 20–40% of the global food supply. Biochemical changes in milk through fermentation.

Microbial fermentation in food processing breaks down sugar and protein to produce various organic chemicals that enhance the flavor, preservation, and appearance of food products. Lactobacilli and streptococci bacteria start the process of milk fermentation by utilizing the nutrients in milk for their growth, leading to changes in the nutritional content and physical characteristics of the milk.

Lactic acid bacteria (LAB) utilize lactose as their primary carbon source for growth and energy. The compound is first broken down by lactase into galactose and glucose. This is then followed by the conversion of glucose into D- or L-lactic acid through the glycolytic Embden-Meyerhof-Parnas's pathway. Lactic acid fermentation involves two main pathways: homolactic fermentation, which creates lactic acid, and heterolactic fermentation, which produces equal amounts of lactic acid, carbon dioxide, and ethanol. Fermentation produces volatile fatty acids, ethanol, acetaldehyde, acetone, and butanone. The lactic acid produced by the decrease in pH of milk led to a nice sour flavor [8, 9]. Protein is broken down through proteolysis, leading to an increase in peptide and free amino acid levels in fermented milk products. LAB has a restricted ability to produce amino acids from inorganic nitrogen sources, hence relying on preexisting amino acids. Lipids are broken down by LAB lipases, which are more effective on triglycerides with lower molecular weights rather than greater ones. LAB need minerals and vitamins for growth, as minerals work as catalysts and vitamins act as mediators in enzymatic reactions. However, their need is minimal and would not greatly change the overall content of fermented milk products. Fermentation can alter the bioavailability of certain minerals by affecting pH levels.

Fermented Dairy Products

Fermented dairy products are dairy foods that have undergone fermentation with LAB like Lactobacillus and Lactococcus. Fermentation extends the product's shelf life, enhances its flavor, and improves the digestibility of its milk. Fermented milk products have been manufactured from circa 10,000 BC. The products have been reported to be more nutritious than the milk they are derived.

Fermented milk products are dairy products manufactured from skim, whole, or slightly condensed milk that use specialized LAB to create their unique flavor and texture. The goods consist of cultured buttermilk, sour cream, yoghurt, acidophilus milk, kefir, and concentrated fermented milk products.

Fermented milk products are considered highly beneficial for human nutrition due to their rich vitamin content, ability to regulate cholesterol metabolism, enhance protein and fat utilization, and contain important cations. The primary variables influencing the distinct identity of fermented milk products are the flavoring components.

Cultured milk products rely on starter culture bacteria for acid production and the accumulation of desired compounds including volatile acids, acetone, and diacetyl, which contribute to their flavor.

The Therapeutic Effect of Fermented Dairy Products

Individuals with lactase deficiency can ingest cultured milk, where bacterial enzymes partially break down lactose into simple sugars (Alpha Laval Dairy guide). In Russia, certain pediatricians and nutritionists favor yoghurt over fresh milk as a weaning diet for newborns. Fermented dairy products are commonly utilized in the Balkan region for medicinal reasons to combat illnesses including pneumonia, diarrhea, as well as minor ailments, such as sore throat and laryngitis.

YOGHURT

Yoghurt is the most widely recognized fermented milk product and is highly popular globally. Consistency, flavor, and scent differ amongst districts. The aromatic compounds contain trace amounts of acetic acid and acetaldehyde. Yoghurt is a fermented milk product produced with Streptococcus thermophilus and Lactobacillus bulgaricus bacteria. Goat's milk yoghurt is consistently more cost-effective than yoghurt manufactured from cow's or buffalo's milk.

According to FAO/WHO, yoghurt is a milk product formed by lactic acid fermentation with the help of Lactobacillus bulgaricus and Streptococcus thermophilus. The finished product should contain abundant and beneficial microorganisms. Jackfruit probiotic yoghurt is a nutritious food with increased protein content and several health advantages.

Yoghurt, often spelt as "yoghurt" or "yoghourt," is a fermented milk product that contains digested lactose and certain bacterial strains, usually Streptococcus thermophilus and Lactobacillus bulgaricus, as recognized by regulatory organizations globally. The item provides many vital elements, such as protein, calcium, potassium, phosphorus, and vitamins B2 and B12, and is used to enhance nutritional content.

Starter Culture in Yogurt

The primary bacterial cultures in yoghurt are Lactobacillus bulgaricus and Streptococcus thermophilus. Starter cultures ferment lactose to produce lactic acid. Lactic acid accumulation leads to a fall in pH, resulting in the coagulation of milk and the formation of the distinctive soft gel found in yoghurt. Lactobacillus bulgaricus is identified as the primary source of taste in yoghurt. Acetaldehyde's presence significantly influenced the flavor.

Nutritional Value of Yoghurt

Yogurt's nutritional content closely resembles that of the milk it is made from, with variations due to fortifications, additions, and fermentation. Some yoghurt may contain minor amounts of permissible food additives such preservatives, stabilizers, starch, colors, or flavors, although more fruit yoghurt is now being produced with solely natural additions. It is a highly healthy diet suitable for all individuals. Infants transitioning from a liquid to a solid diet can be given plain yoghurt as it contains essential nutrients found in milk but in a more solid form. Yoghurt is recommended for convalescents and the elderly due to its simple digestibility. Individuals aiming for weight loss may benefit from consuming low-fat plain yoghurt or reduced-calorie yoghurt as part of a controlled-calorie diet. Fermentation reduces the amount of lactose in the final yoghurt product.

Yogurt Prepared Using Jackfruit

The incorporation of jackfruit into probiotic yoghurt enhances its nutritional value and sensory appeal, creating a unique functional food. Jackfruit, rich in dietary fiber, vitamins, and minerals, complements the probiotic benefits of yoghurt, which is known for its gut-friendly bacteria. The fermentation process not only improves the digestibility of jackfruit's complex carbohydrates but also enhances its bioavailability of nutrients. Studies indicate that jackfruit-enriched yoghurt exhibits higher antioxidant activity, better probiotic stability, and improved texture compared to traditional yoghurt. The natural sweetness of jackfruit reduces the need for added sugars, making it a healthier alternative for consumers seeking both taste and nutrition. This combination aligns with the growing demand for functional dairy products that cater to both taste preferences and health benefits.

CONCLUSIONS

Jackfruit and yoghurt, individually recognized for their health benefits, create a synergistic effect when combined. Jackfruit contributes dietary fiber, vitamins, minerals, and bioactive compounds, while yoghurt provides essential probiotics, calcium, and proteins that promote gut health and overall well-being. The fusion of these nutrient-rich foods results in a functional dairy product with enhanced probiotic stability, antioxidant potential, and improved sensory properties. Jackfruit-enriched probiotic yoghurt presents an innovative approach to diversifying the functional food industry, catering to health-conscious consumers seeking natural and nutritious alternatives. Future research and product development in this area could further expand the potential applications of this combination in the food industry.

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