



Nutritional Composition and Health Benefits of Superfoods: Potential Roles in Chronic Disease Prevention and Dietary Applications

Vishal Kumar^{1*} , Akanksha² , Anu Kumari¹ , Nimisha Tehri¹ 

¹College of Post harvest Technology and Food Processing, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh- 250 110

² Centre of Food Technology, Institute of Professional Studies, University of Allahabad, Prayagraj, Uttar Pradesh- 211 002

*Correspondence: vishalkumar@bhu.ac.in

This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0/>).

Summary

Recent progress in food science and nutrition has led to the emergence of a specialized class of food products referred to as superfoods, recognized for their potential to confer a range of health benefits. These foods are characterized by high concentrations of essential nutrients—such as vitamins, minerals, dietary fiber, and essential fatty acids—as well as bioactive phytochemicals, including polyphenols, flavonoids, carotenoids, and anthocyanins. Superfoods have garnered substantial attention due to their purported roles in enhancing immune function, mitigating oxidative stress, and reducing the risk of chronic diseases, including cardiovascular disorders, diabetes mellitus, obesity, and certain types of cancer. Despite the historical use of many superfoods in traditional dietary and medicinal practices, the scientific understanding of their mechanisms of action remains relatively limited. Their increasing popularity is largely driven by consumer interest in health and wellness, alongside marketing influences. This review aims to systematically examine the nutritional composition and functional attributes of selected superfoods, while exploring current evidence regarding their potential health-promoting effects. The findings aim to support informed

dietary choices and inform the integration of superfoods into evidence-based nutritional strategies for disease prevention and health promotion.

Keywords

Bioactive, Health Promoting, flavonoids, Superfood, Therapeutic

Introduction

In recent years, accumulating scientific evidence has emphasized the profound influence of diet and its components on human health, prompting a marked shift in consumer behavior and dietary preferences [31]. Beyond satisfying fundamental physiological needs such as hunger and nutrient provision, a growing segment of consumers now perceives food as a vehicle for enhancing overall well-being, preventing diet-related disorders, and supporting both mental and physical health. This evolving perspective is deeply rooted in historical ideologies—particularly the Hippocratic principle, “Let food be thy medicine and medicine be thy food”—which has gained renewed relevance in contemporary nutritional science [52].



Foods that positively influence physiological functions, assist in the prevention of various diseases, and may serve therapeutic purposes are categorized under the term "functional foods." The concept of functional food was first established in Japan nearly three decades ago and has since garnered global recognition across scientific, regulatory, and commercial domains [53]. In addition to their role in promoting health, functional foods are increasingly acknowledged for their potential to reduce healthcare expenditures, particularly in aging populations, and are considered economically significant within the food industry.

More recently, the term "superfoods" has gained prominence, often used to describe a subset of functional foods that are distinguished by their high nutrient density and purported health benefits [39]. Interest in superfoods has grown considerably, especially in Western societies, due to their rich concentrations of essential macro- and micronutrients, which contribute to their perceived role in disease prevention and overall health maintenance. According to the Oxford English Dictionary, a superfood is defined as a food product considered especially beneficial to human health and well-being due to its high nutritional content [28].

The scope of the term "superfood" has expanded to include certain traditional food items that have undergone enhancement through non-genetic processing techniques aimed at improving their functional attributes [17]. While superfoods share functional attributes with functional foods, they differ in several key respects. Typically, superfoods are characterized as minimally processed, naturally occurring food items with a longstanding history of traditional use. These foods often originate from remote or indigenous regions and are associated with both culinary and medicinal applications. Their increasing popularity is attributed not only to their potent

health benefits but also to their perceived authenticity and cultural distinctiveness [43].

Furthermore, superfoods particularly those classified as superfruits—are often regarded as dual-purpose entities, functioning both as dietary and medicinal agents. This classification is attributed to their complex composition of synergistic bioactive compounds that contribute collectively to health promotion [48]. Superfoods are frequently represented in the produce sections of supermarkets, primarily among fruits and vegetables rich in phytochemicals. These include antioxidants, micronutrients, and other biologically active compounds, which, when consumed, may enhance health outcomes by increasing the intake of protective dietary constituents.

A recent study demonstrated that a Google search for the term "superfoods" yielded approximately 57 relevant entries within the first 15 pages of search results, indicating widespread usage in consumer-facing domains [45]. Notably, the term "superfoods" is predominantly encountered in marketing materials, food packaging, media discourse, and discussions surrounding innovative or alternative ingredients aimed at improving consumer health, rather than in rigorous scientific literature [47]. As of August 2018, a database search revealed that "superfoods" returned 191 entries including research articles, book chapters, and reviews while "superfruits" produced 85 results on the ScienceDirect platform. In contrast, "functional foods" generated 210,226 entries on Wiley and 382,852 results on ScienceDirect for the period between 1998 and 2017, highlighting the more established scientific foundation of functional foods compared to superfoods [44].

Superfoods especially exotic superfruits are frequently characterized by high levels of bioactive compounds such as anthocyanins, flavonoids, and phenolic acids. These



compounds are recognized for their potent antioxidant capacities and have been linked to protective effects against chronic diseases, including cardiovascular disorders and type 2 diabetes mellitus. The mechanisms underlying these effects often involve modulation of critical clinical biomarkers, such as blood pressure, body mass index, waist circumference, fasting blood glucose, and plasma triacylglycerol concentrations [46].

Brazil Nuts

Brazil nuts are among the most commonly consumed tree nuts in South America and are derived from the Brazil nut tree (*Bertholletia excelsa*), a large species native to the Amazon rainforest. This tree thrives in well-drained, compact soils typically found along the Amazon River and is predominantly located in countries such as Brazil, Venezuela, Colombia, Ecuador, and Peru. The fruit of *Bertholletia excelsa* is generally round or pear-shaped, with a woody, thick outer shell approximately 0.5 cm in thickness and a diameter of about 6 cm. Each fruit contains between 12 and 24 angular, three-sided seeds (commonly referred to as nuts). These seeds are irregularly cylindrical in shape, nutritionally light cream in color, and enclosed within a hard, woody capsule. The seed capsule itself resembles a large grapefruit in size and can weigh up to 2 kilograms [51].

Brazil nuts hold significant economic value, particularly for local and indigenous communities in South America. Harvesting typically occurs during the rainy season, after which the nuts are transported to processing facilities. The processing sequence includes several key stages: initial sorting and grading, drying, shell removal, and size classification.

The first stage—manual or visual sorting—is critical for the removal of nuts that are mold-contaminated or discolored. Following this, the nuts are grouped based on size. After undergoing

controlled drying and cooling, the final product is sealed using heat and vacuum packaging techniques to ensure quality preservation and extend shelf life [32]. Brazil nut kernels are of significant interest in food science research due to their rich content of proteins, lipids, and minerals, particularly selenium, which exhibits strong antioxidant properties. As a result, the food industry has increasingly focused on extracting oil from these nuts using hydraulic pressing methods. However, several by-products generated during this process—such as press cake, defatted meal, oilcake flour, nut shell powder, and skin residues—remain largely underutilized. These by-products are typically rich in plant proteins, dietary fiber, essential amino acids, polyphenols, and residual lipids, making them promising candidates for various value-added applications. Potential uses include incorporation into functional foods, protein-enriched flours, dietary fiber supplements, and nutraceutical formulations, as well as animal feed, organic fertilizers, and biodegradable packaging materials. Comprehensive characterization and valorization of these by-products could support sustainable resource utilization and promote circular economy practices within the nut processing industry.

The global recognition of Brazil nuts stems from their high caloric density and substantial nutritional value, prompting numerous studies aimed at isolating and characterizing their key functional and nutritional components. Among these, the lipid fraction is of particular industrial interest due to its economic viability and high yield potential. Brazil nuts are regarded as promising candidates for future commercial applications, offering favorable cost-benefit ratios and significant potential for advancement in experimental research and product development [38].

Nutritional Composition of Brazil Nuts



Macro-Nutrients

The macronutrient composition of Brazil nuts includes approximately 3.5% water, 66.4% total lipids, 14.3% protein, and 12.3% carbohydrates. In terms of lipid composition, Brazil nuts (*Bertholletia excelsa*) contain approximately 66.4% total lipids by dry weight, making them one of the richest natural sources of dietary fat among tree nuts. The fatty acid profile of these lipids is predominantly composed of unsaturated fatty acids, including approximately 25% monounsaturated fatty acids (MUFAs) and 21% polyunsaturated fatty acids (PUFAs), along with about 15% saturated fatty acids (SFAs) [56]. It is important to note that these percentages refer specifically to the relative composition of fatty acids within the total lipid fraction, not to the overall nut weight. The remaining portion of the lipid content may include minor fatty acids and non-triglyceride lipid components such as phytosterols, phospholipids, and fat-soluble vitamins (e.g., vitamin E). Nuts, in general, are among the most concentrated dietary sources of unsaturated fatty acids, and Brazil nuts are particularly valued for their favorable ratio of MUFAs and PUFAs, which are known to confer cardioprotective and anti-inflammatory health benefits.

Among tree nuts, Brazil nuts exhibit one of the highest saturated fat contents—second only to coconuts—and surpass macadamia nuts in this regard. They also contain a notable proportion of omega-3 fatty acids, primarily α -linolenic acid, which constitutes approximately 7% of total fat content. The predominant lipid in Brazil nuts is monounsaturated fat, mainly oleic acid, followed by saturated fats such as palmitic and stearic acids, and polyunsaturated fats including linoleic acid (omega-6) [25, 37].

Micro-Nutrients

Brazil nuts are recognized for their high concentrations of trace elements, which play a

crucial role in human nutrition. Elements such as chromium (Cr), copper (Cu), and iron (Fe) function as essential cofactors in numerous metabolic and physiological processes. Typically, the elemental concentration in Brazil nuts follows the general descending order: magnesium (Mg) > calcium (Ca) > iron (Fe) > copper (Cu) > chromium (Cr) > arsenic (As) > selenium (Se). Notably, Brazil nuts are one of the richest dietary sources of selenium; however, their selenium content varies significantly due to differences in soil selenium levels, tree uptake, and geographic origin—ranging from very high in selenium-rich soils (e.g., eastern Amazon) to much lower in deficient regions. This variability has important implications for dietary recommendations, as both deficiency and excess intake may pose health risks [30]. Among various tree nuts, Brazil nuts demonstrate significantly higher selenium concentrations compared to cashew nuts, walnuts, and pecans [21]. Brazil nuts are regarded as one of the most concentrated dietary sources of selenium, supplying approximately 160% of the United States Recommended Dietary Allowance (US RDA) for this essential trace element per serving [50]. Brazil nuts are rich in sulfur-containing amino acids, which can enhance the absorption of selenium and other essential minerals [40]. Nuts contain a substantial quantity of bound phenolic compounds, measured at approximately (123.1 ± 18.4) mg per 100 grams [50]. Brazil nuts contain appreciable levels of tocopherols, with concentrations of α -tocopherol, β -tocopherol, and δ -tocopherol reported as (5.73 ± 1.54) mg, (7.87 ± 2.15) mg, and (0.77 ± 0.66) mg per 100 grams, respectively (Maguire et al., 2004 [38]). Phytosterols such as β -sitosterol, stigmasterol, and campesterol constitute approximately 95% of the total phytosterol content considered beneficial in the human diet. Brazil nuts are a notable source of these compounds, containing significant amounts of campesterol (26.9 ± 4.4 μ g/g oil), β -sitosterol (1325.4 ± 68.1 μ g/g oil), and



stigmasterol ($577.5 \pm 34.3 \mu\text{g/g oil}$). Additionally, Brazil nuts have been reported to possess the highest levels of squalene, with a concentration of (1377.8 ± 8.4) $\mu\text{g/g oil}$ [50].

Health Benefits of Brazil Nuts

Scientific studies have demonstrated that the regular consumption of Brazil nuts offers various health benefits, largely attributed to their rich content of both macro- and micronutrients, which serve as sources of functional and nutritional compounds. In this context, the substantial presence of amino acids, proteins, and selenium facilitates the formation of affinity interactions among these components, resulting in the development of an organic complex with enhanced bioavailability. Consumption of Brazil nuts significantly increases plasma selenium levels; however, this has minimal direct effects on HDL functionality, lipid profiles, or apolipoproteins in humans [41]. Nonetheless, the nuts' rich content of unsaturated fatty acids, antioxidants, and fiber may support cardiovascular health through alternative mechanisms such as reducing oxidative stress and inflammation. A single consumption of Brazil nuts by healthy individuals was associated with a sustained reduction in inflammatory markers [23]. Selenium, a trace mineral abundantly present in Brazil nuts, plays a critical role in maintaining human health. It is essential for optimal thyroid gland function and the proper operation of the immune system. Selenium serves as a key component of antioxidant enzymes, contributing to the body's defense against oxidative stress. Due to its potent natural anti-carcinogenic properties, selenium has garnered significant research interest. Experimental studies in animal models have demonstrated that elevated selenium levels may exert protective effects against cancer development, potentially through mechanisms involving its role in antioxidant defense via

selenoproteins like glutathione peroxidase, as well as in DNA repair and apoptosis regulation [9].

Various studies investigating the anti-proliferative effects of different nut extracts on cell cultures have demonstrated dose-dependent inhibition and cytotoxicity against Caco-2 human colon carcinoma and HepG2 human liver carcinoma cell lines. Nuts exhibited a more pronounced inhibitory effect on the proliferation of Caco-2 cells compared to HepG2 cells. The total phenolic content present in Brazil nuts is thought to contribute partially to the observed reduction in cancer cell proliferation, indicating that the antiproliferative effects may be attributed to specific phenolic compounds or groups of phenolics within the nut extracts [50].

Amla

Amla (*Emblica officinalis* Gaertn.), commonly referred to as Indian gooseberry, is a well-known medicinal plant belonging to the family Euphorbiaceae and is extensively utilized in Ayurvedic medicine due to its broad spectrum of therapeutic properties. It is well-regarded for its rich bioactive compound profile and is a source of various bioactive constituents. The fruit contains a diverse range of phytochemicals, including tannins, amino acids, mucic acid, flavone glycosides, alkaloids, sesquiterpenoids, phenolic glycosides, flavonol glycosides, phenolic acids, carbohydrates, and norsesquiterpenoids. These compounds contribute to its pharmacological efficacy and nutritional value [46]. *Emblica officinalis* is indigenous to the Indian subcontinent and is predominantly distributed across tropical and subtropical regions. Its natural habitat extends throughout South and Southeast Asia, including countries such as Sri Lanka, Pakistan, Uzbekistan, Malaysia, and China [33]. All parts of *Emblica officinalis* are employed in the prevention and treatment of various ailments; however, the fruit, characterized by its globular shape, yellowish-green coloration, and



smooth, fleshy texture, holds particular importance in traditional and folk medicine. In addition to its medicinal applications, the fruit is widely used in culinary practices, including the

Superfood	Key Components	Health Benefits
Brazil Nuts	Selenium, Phenolic compounds	Antioxidant activity, thyroid support, anti-cancer
Blueberries	Anthocyanins, Vitamin C	Anti-inflammatory, cognitive function, heart health
Kale	Vitamins A, C, K; Fiber	Bone health, immune support, detoxification
Quinoa	Complete protein, Fiber, Magnesium	Muscle repair, digestion, cardiovascular health
Salmon	Omega-3 fatty acids, Vitamin D	Heart health, brain function, anti-inflammatory
Turmeric	Curcumin	Anti-inflammatory, antioxidant, joint health
Chia Seeds	Omega-3 fatty acids, Fiber	Digestive health, cardiovascular support
Spinach	Iron, Folate, Vitamin K	Blood health, energy metabolism, bone health

Table 1-Superfoods: Components and Health Benefits Source-World Health Organization. <https://www.who.int/>

Superfood	Nutrient/Compound	Health Benefits	Reference
Moringa	Vitamin C, calcium, polyphenols	Antioxidant, anti-inflammatory, supports immunity and bone health	[24]
Chia Seeds	Omega-3, fiber, antioxidants	Supports heart health, digestion, and blood sugar control	[44]
Quinoa	Complete protein, fiber, iron	Supports muscle repair, digestion, and anemia prevention	[36]
Spirulina	Protein, B12, chlorophyll	Enhances energy, detoxification, and immune response	[7]
Blueberries	Anthocyanins, vitamin C, fiber	Boosts brain function, reduces oxidative stress, supports heart health	[20]
Turmeric	Curcumin	Anti-inflammatory, antioxidant, may reduce risk of chronic diseases	[1]
Flaxseeds	Lignans, omega-3, fiber	Supports hormonal balance, heart health, and digestive health	[8]
Goji Berries	Polysaccharides, vitamin A, antioxidants	Supports eye health, immune system, and healthy skin	[3]
Matcha Green Tea	Catechins, especially EGCG	Enhances metabolism, concentration, and protects against cell damage	[14]

Table 2 Superfood and its bioactive components



preparation of chutneys, pickles, and vegetable dishes. It is also traditionally processed into murabba, a sweet fruit preserve made by soaking ripe amla fruits in concentrated sugar syrup—a method that may contribute to the preservation and stability of key bioactive compounds, such as ascorbic acid and polyphenols, during storage and processing [57]. Furthermore, ripe amla fruits are used to produce fresh juice, which is often marketed as a concentrate for the convenient preparation of diluted beverages [4]. Amla fruit juice contains a significantly high concentration of vitamin C, measuring approximately (478.56) mg per 100 mL. This level is notably higher compared to the vitamin C content found in several other fruits, including apple, pomegranate, lime, Pusa Navrang grape, and Perlette grape.

Nutritional Composition of Amla

Macro-Nutrients

The macronutrient composition of *Emblica officinalis* primarily includes carbohydrates (82.91 g/100 g), protein (6.04 g/100 g), dietary fiber (2.78 g/100 g), and fat (0.51 g/100 g). The amino acid profile of the fruit reveals the presence of several key amino acids, with glutamic acid (29.6%) being the most abundant, followed by proline (14.6%), aspartic acid (8.1%), alanine (5.4%), and lysine (5.3%). In the dried pulp portion of the fruit—separated from the seed—additional constituents have been identified, including gallic acid (1.32%), albumin (13.08%), tannins (13.75%), gum (3.83%), moisture (17.08%), crude cellulose (4.12%), and various minerals [16].

Micro-Nutrients

Emblica officinalis is recognized as a rich source of bioactive constituents, particularly alkaloids, tannins, and phenolic compounds. Its fruit juice contains an exceptionally high concentration of vitamin C, approximately (478.56) mg per 100 mL. When incorporated into other fruit-based

products, amla significantly enhances their bioactive compound profile, particularly by increasing their vitamin C content [19]. The phytochemical analysis of *Emblica officinalis* fruit juice has revealed the presence of several bioactive compounds. Per 100 mL of juice, the concentrations of key phytoconstituents were reported as follows: chlorogenic acid (17.43 mg), gallic acid (37.95 mg), quercetin (2.01 mg), and ellagic acid (71.20 mg). These compounds contribute to the fruit's antioxidant and therapeutic properties [6]. A variety of phytochemical constituents have been isolated and identified in *Emblica officinalis*. These include ellagic acid, gallic acid, 3,6-di-O-galloyl-D-glucose, 1-O-galloyl- β -D-glucose, 3-ethylgallic acid, quercetin, chebulagic acid, 1,6-di-O-galloyl- β -D-glucose, corilagin, chebulinic acid, and isostrictinin. These compounds are known for their significant pharmacological and antioxidant activities, contributing to the therapeutic potential of the fruit [49]. The flavonoid profile of *Emblica officinalis* includes compounds such as kaempferol 3-O- α -L-(6'-O-methyl)-rhamnopyranoside, quercetin, and kaempferol 3-O- α -L-(6'-O-ethyl)-rhamnopyranoside. These flavonoids contribute to the fruit's antioxidant capacity and are associated with various health-promoting properties [15]. The mineral composition of *Emblica officinalis* fruit per 100 g fresh weight includes phosphorus (159 mg/100 g), calcium (129 mg/100 g), magnesium (46 mg/100 g), iron (11 mg/100 g), potassium (2.54 mg/100 g), chromium (0.82 mg/100 g), zinc (0.23 mg/100 g), copper (0.22 mg/100 g), and nicotinic acid (0.2 mg/100 g). These minerals contribute to the fruit's nutritional and therapeutic value [46].

Health Benefits of Amla

The therapeutic significance of *Emblica officinalis* is attributed to its diverse pharmacological activities. The plant exhibits a broad spectrum of bioactive effects, including



anti-inflammatory, antioxidant, adaptogenic, anticancer, nootropic, antidiabetic, antimicrobial, and immunomodulatory properties [29]. In addition to its therapeutic efficacy against a range of diseases, *Emblica officinalis* has been shown to contribute to the prevention of osteoporosis, hyperlipidemia, and several other health conditions [34]. The potent antioxidant activity of *Emblica officinalis* is attributed to the presence of compounds structurally related to ascorbic acid, including pedunculagin, emblicanin A, emblicanin B, punigluconin, and gallic acid [46]. A clinical trial involving administration of *Emblica officinalis* powder over a 21-day period demonstrated significant reductions in fasting blood glucose and 2-hour postprandial glucose levels in diabetic subjects. Additionally, treatment with daily doses of (1, 2) or (3) g of *E. officinalis* powder resulted in decreased serum triglycerides (TG) and total cholesterol levels. Furthermore, an increase in high-density lipoprotein cholesterol (HDL-C) and a decrease in low-density lipoprotein cholesterol (LDL-C) were observed in both healthy and diabetic volunteers receiving (2) or (3) g of *E. officinalis* powder daily [2]. The antidiabetic effects of *Emblica officinalis* are primarily attributed to its key phytoconstituents, including corilagin, gallotannins, gallic acid, and ellagic acid. These compounds exert their therapeutic action largely through antioxidant-mediated free radical scavenging mechanisms [27]. Numerous preclinical studies in animal models have demonstrated that *Emblica officinalis* possesses cardioprotective and anticoagulant properties, suggesting its potential utility in the prevention and management of various cardiovascular disorders. This protective effect is primarily attributed to its tannin content, specifically ellagic acid, emblicanin A and B, and corilagin [11]. Various extracts of Triphala, an Ayurvedic formulation containing a high concentration of *Emblica officinalis*, have been evaluated for their antimutagenic potential using the Ames test with

Salmonella typhimurium strains TA100 and TA98. The assay tested against direct-acting mutagens such as sodium azide and NPD, as well as indirect-acting pro-mutagens like 2-aminofluorene, in the presence of the hepatic S9 microsomal fraction derived from phenobarbital-induced rat liver. The results indicated that *E. officinalis* effectively inhibited mutagenicity induced by both direct and indirect mutagens [22]. Multiple studies have investigated the hepatoprotective effects of *Emblica officinalis* against carbon tetrachloride (CCl_4)-induced acute liver injury. Results demonstrated that treatment with *E. officinalis* significantly reduced focal necrosis and inflammatory infiltration in hepatic tissue. Furthermore, histological analysis revealed restoration of normal liver architecture in treated subjects [46]. *Emblica officinalis* exerts anticancer effects by inhibiting activator protein-1 (AP-1) and targeting the translation of viral oncogenes involved in the progression of cervical cancer. This mechanism highlights its potential therapeutic application in the treatment of human papillomavirus (HPV)-induced cervical malignancies [26].

Jackfruit

Jackfruit (*Artocarpus heterophyllus* Lam.), a member of the Moraceae family, is primarily cultivated in India, followed by Bangladesh and various regions of Southeast Asia. It is considered one of the most prominent evergreen tree species found in tropical climates and is extensively grown across Asia, particularly in India. A medium-sized jackfruit tree typically attains a height ranging from 28 to 80 feet. The fruit commonly develops on both the main trunk and lateral branches. On average, the fruit weighs between 3.5 and 10 kilograms, although in some cases, it can reach up to 25 kilograms. Jackfruit is regarded as a non-seasonal fruit with considerable potential to contribute to food security, particularly in regions experiencing shortages of staple food grains, and is therefore



often referred to as the "poor man's food." Once the fruit reaches maturity, it must be consumed promptly to prevent the development of undesirable off-flavors. To ensure optimal quality and suitability for processing, it is generally recommended to harvest the fruit at a semi-ripe, firm stage before full ripening occurs on the tree. Post-harvest, the fruit should be stored under appropriate conditions until it softens and reaches a suitable state for consumption or processing [35]. Jackfruit seeds are recognized as a rich source of essential nutrients and are consumed either in their raw form or after undergoing various processing methods. They are commonly incorporated into a variety of culinary applications, including the preparation of traditional dishes, and their flour is frequently employed in baking formulations. The unripe jackfruit is typically utilized as a vegetable ingredient in savory preparations such as curries and salads, contributing both nutritional value and culinary versatility. In contrast, the ripe fruit is consumed in diverse forms, including raw, thermally processed (often prepared as a dessert with coconut milk), or as value-added products such as jackfruit-based confectioneries and edible fruit leathers [42]. In India, jackfruit seeds are traditionally consumed as a dessert, commonly prepared by boiling them in sugar syrup. Jackfruit is widely recognized for its high nutritional value and ranks third in terms of annual production among fruits in South India, following banana and mango. Both the seeds and pulp of jackfruit exhibit a superior bioactive compound profile particularly to calcium, protein, thiamine, and iron content, when compared to other tropical fruits such as papaya, pineapple, mango, orange, and banana [5].

Nutritional Composition of Jackfruit

Macro-Nutrients

Jackfruit (*Artocarpus heterophyllus* Lam.) is recognized for its nutritional value, particularly as a source of macronutrients. The edible portion of

unripe (young) jackfruit, on a per 100 g basis, comprises carbohydrates ranging from (9.4 to 11.5) g, fats between (0.1) and (0.6) g, proteins from (2.0) to (2.6) g, dietary fiber in the range of (2.6) to (3.6) g, and provides an energy value of approximately (50) to (210) kJ, with a moisture content of (76.2) to (85.2) g. In contrast, the ripe fruit exhibits higher carbohydrate levels, varying from (16.0) to (25.4) g per 100 g, while fat and protein contents are slightly lower, ranging from (0.1) to (0.4) g and (1.2) to (1.9) g, respectively. The fiber content in ripe jackfruit decreases to (1.0–1.5) g, energy content ranges from (88) to (410) kJ, and water content varies between (72.0) and (94.0) g per 100 g [13]. Jackfruit is characterized by a relatively low caloric density, providing approximately 94 kilocalories per 100 grams of edible portion [32]. Several studies have reported variability in the protein and carbohydrate composition of jackfruit seeds across different cultivars, even when cultivated under identical regional conditions [5]. The protein and carbohydrate content of jackfruit seeds varies among different species, ranging from (5.3%) to (6.8%) and (37.4%) to (42.5%), respectively. Histological and chemical analyses have confirmed a substantial presence of starch within both the seeds and perianth regions of the fruit. The edible pulp of ripe jackfruit contains approximately (1.9) g of protein per 100 g. Research indicates that as the fruit matures, there is a corresponding increase in dietary fiber and starch content in the flesh. Additionally, jackfruit is recognized as a valuable source of essential amino acids, including cysteine, arginine, leucine, histidine, methionine, lysine, tryptophan, and threonine [36]. Jackfruit is recognized as a notable source of various minerals, containing calcium (31.28 mg), magnesium (36.96 mg), copper (0.38 mg), iron (3.26 mg), manganese (0.56 mg), and lead (0.20 mg) per 100 grams of the fruit [36]. Jackfruit exhibits a notably high potassium content, measuring 303 mg per 100 grams of fruit. The fruit



also contains a diverse array of chemical compounds, primarily including morin, flavone pigments, cynomacurin, dihydromorin, isoartocarpin, artocarpin, cycloartocarpin, coxydihydroartocarpesin, artocarpesin, norartocarpetin, artocarpetin, artocarpanone, and cycloartinone [42]. Phytochemicals, particularly phenolic compounds, constitute a significant portion of jackfruit and play a crucial role in the development of value-added products. These compounds have potential applications in the food and nutraceutical industries aimed at promoting and sustaining human health.

Micro-Nutrients

Jackfruit is a rich source of various micronutrients, including significant levels of riboflavin, vitamin C, vitamin A, thiamine, potassium, calcium, sodium, iron, niacin, and zinc [32]. In addition to its bioactive compound profile, jackfruit is recognized as an abundant source of various bioactive compounds, including flavonoids, carotenoids, tannins, and volatile sterols [5]. Phytochemicals, particularly phenolic compounds, constitute a significant portion of jackfruit and play a crucial role in the development of value-added products. These compounds have potential applications in the food and nutraceutical industries aimed at promoting and sustaining human health [18]. Jackfruit contains a total phenolic content of (0.36) mg GAE per 100 g dry weight (milligrams of gallic acid equivalent per gram of dry weight). Vitamin C is a significant constituent, present at concentrations ranging from (12) to (14) mg per 100 g of fresh fruit. Flavonoids, carotenoids, and related polyphenols, including glutathione and α -lipoic acid, represent a major category of nonenzymatic antioxidants. In addition to carotenoids, compounds such as lutein, lycopene, and beta-carotene are recognized as potent antioxidant [42]. The predominant carotenoids identified in jackfruit include all-trans-lutein, all-trans- β -carotene, all-trans-

neoxanthin, 9-cis-neoxanthin, and 9-cis-violaxanthin, with their respective proportions ranging from (24–44%), (24–30%), (4–19%), (4–9%), and (4–10%) [10].

Health Benefits of Jackfruit

The primary benefit of jackfruit consumption is attributed to its high vitamin C content. Since the human body cannot synthesize sufficient quantities of vitamin C, it is essential to obtain this nutrient through dietary sources. Vitamin C contributes to the neutralization of free radicals via its antioxidant properties, supports the maintenance of healthy gingival tissues, and plays a vital role in enhancing immune system function [18]. Jackfruit is rich in phytonutrients, including saponins, lignans, and isoflavones, which contribute to a variety of health-promoting effects. The fruit demonstrates antiulcer, antiaging, antihypertensive, and anticancer activities by inhibiting cancer cell proliferation, protecting against gastric ulcers, regulating blood pressure, and preventing cellular degradation, thereby promoting youthful skin appearance. Additionally, the niacin (vitamin B3) content in jackfruit plays a crucial role in energy metabolism, hormone synthesis, and the proper functioning of the nervous system [42]. The potassium content in jackfruit has been shown to aid in the regulation of blood pressure by counteracting the effects of sodium, which is known to elevate blood pressure and adversely affect cardiovascular health. Additionally, potassium contributes to the proper functioning of nerves and muscles and helps prevent bone loss. Furthermore, vitamin B6 present in jackfruit plays a role in reducing blood homocysteine levels, thereby lowering the risk of cardiovascular diseases [12]. The presence of various micronutrients in jackfruit contributes to its potential health benefits. Iron (0.5 mg/100 g) plays a crucial role in facilitating efficient blood circulation by preventing anemia. Copper (10.45 mg/kg) is essential for thyroid gland metabolism,



particularly in the synthesis and uptake of thyroid hormones. Magnesium, present at concentrations of (27 mg/100 g) in the fruit and (54 mg/100 g) in the seed, is a key nutrient involved in calcium absorption and works synergistically with calcium to strengthen bone structure and prevent bone-related disorders such as osteoporosis. Additionally, jackfruit supports regular bowel movements and helps prevent constipation due to its high dietary fiber content (3.6 g/100 g). It also protects the colonic mucous membrane by aiding in the removal of carcinogenic compounds from the large intestine [42]. Jackfruit exhibits a wide range of beneficial health effects, including anti-inflammatory, antioxidant, anticancer, and antibacterial properties. It also demonstrates potential in inhibiting melanin biosynthesis, exerting hypoglycemic activity, possessing antineoplastic effects, enhancing sexual function, and promoting wound healing [5].

Conclusion

Superfoods are predominantly plant-derived foods characterized by high nutritional density, providing substantial health benefits with relatively low caloric content. These foods are rich sources of vitamins, dietary fiber, minerals, and antioxidants. Due to their significant bioactive and nutritional properties, superfoods have the potential to contribute to the prevention and management of chronic diseases. Isolation and extraction of bioactive compounds from these foods, followed by their incorporation into various food matrices, present promising opportunities for the development of functional foods within the food processing industry. Increasing scientific evidence supporting the health-promoting effects of superfoods is expected to enhance consumer interest in these products. To substantiate the claimed benefits of superfoods, future research should prioritize well-designed human clinical trials. Additionally, regulatory agencies should establish

standardized definitions for superfoods to facilitate clearer understanding and consistent communication within the scientific community and among consumers.

Authors contribution

Vishal Kumar: Conceptualization, original draft, corresponding author

Akanksha: Literature collection and drafting

Anu Kumari: Literature analysis and editing

Nimisha Tehri: Critical review and supervision

Conflict of Interest

The authors declare no conflict of interest.

References

1. Aggarwal BB, Sundaram C, Malani N, Ichikawa H. Curcumin: the Indian solid gold. The molecular targets and therapeutic uses of curcumin in health and disease. 2007 Jan 1:1-75.
2. Akhtar MS, Ramzan A, Ali A, Ahmad M. Effect of Amla fruit (*Emblica officinalis* Gaertn.) on blood glucose and lipid profile of normal subjects and type 2 diabetic patients. International journal of food sciences and nutrition. 2011 Sep 1;62(6):609-16.
3. Amagase H, Nance DM. A randomized, double-blind, placebo-controlled, clinical study of the general effects of a standardized *Lycium barbarum* (Goji) juice, GoChi™. The Journal of Alternative and Complementary Medicine. 2008 May 1;14(4):403-12.
4. Baliga MS, Dsouza JJ. Amla (*Emblica officinalis* Gaertn), a wonder berry in the treatment and prevention of cancer. European Journal of Cancer Prevention. 2011 May 1;20(3):225-39.
5. Baliga MS, Shivashankara AR, Haniadka R, Dsouza J, Bhat HP. Phytochemistry, nutritional and pharmacological properties of *Artocarpus*



heterophyllus Lam (jackfruit): A review. Food research international. 2011 Aug 1;44(7):1800-11.

6.Bansal V, Sharma A, Ghanshyam C, Singla ML. Coupling of chromatographic analyses with pretreatment for the determination of bioactive compounds in *Emblica officinalis* juice. Analytical Methods. 2014;6(2):410-8.

7.Belay A, Ota Y, Miyakawa K, Shimamatsu H. Current knowledge on potential health benefits of *Spirulina*. Journal of applied Phycology. 1993 Apr;5(2):235-41.

8.Bloedon LT, Szapary PO. Flaxseed and cardiovascular risk. Nutrition reviews. 2004 Jan 1;62(1):18-27.

9.Combs Jr GF. Impact of selenium and cancer-prevention findings on the nutrition-health paradigm. Nutrition and cancer. 2001 May 1;40(1):6-11.

10.De Faria AF, De Rosso VV, Mercadante AZ. Carotenoid composition of jackfruit (*Artocarpus heterophyllus*), determined by HPLC-PDA-MS/MS. Plant foods for human nutrition. 2009 Jun;64(2):108-15.

11.D'souza J, D'souza P, Shivashankara A, Mathai R, Jimmy R, Palatty P, Ravi R, Simon P, Baliga M. Cardioprotective effects of Indian gooseberry (*Emblica officinalis* Gaertn) and its phytochemicals: A review. Current Nutrition & Food Science. 2014 Jun 10;10(2):141-9.

12.Fernando MR, Wickramasinghe SN, Thabrew MI, Ariyananda PL, Karunanayake EH. Effect of *Artocarpus heterophyllus* and *Asteracanthus longifolia* on glucose tolerance in normal human subjects and in maturity-onset diabetic patients. Journal of ethnopharmacology. 1991 Mar 1;31(3):277-82.

13.Goswami C, Chacrabati R. Jackfruit (*Artocarpus heterophyllus*). In Nutritional

composition of fruit cultivars 2016 Jan 1 (pp. 317-335). Academic Press.

14.Graham HN. Green tea composition, consumption, and polyphenol chemistry. Preventive medicine. 1992 May 1;21(3):334-50.

15.Habib-ur-Rehman, Yasin KA, Choudhary MA, Khaliq N, Atta-ur-Rahman, Choudhary MI, Malik S. Studies on the chemical constituents of *Phyllanthus emblica*. Natural Product Research. 2007 Jul 20;21(9):775-81.

16.Hasan MR, Islam MN, Islam MR. Phytochemistry, pharmacological activities and traditional uses of *Emblica officinalis*: A review. International Current Pharmaceutical Journal. 2016 Jan 18;5(2):14-21.

17.Hefferon K. Let Thy Food Be Thy Medicine: Plants and Modern Medicine. Oxford University Press; 2012 Aug 16.

18.Jagtap UB, Panaskar SN, Bapat VA. Evaluation of antioxidant capacity and phenol content in jackfruit (*Artocarpus heterophyllus* Lam.) fruit pulp. Plant foods for human nutrition. 2010 Jun;65(2):99-104.

19.Jain SK, Khurdiya DS. Vitamin C enrichment of fruit juice based ready-to-serve beverages through blending of Indian gooseberry (*Emblica officinalis* Gaertn.) juice. Plant Foods for human nutrition. 2004 Apr;59(2):63-6.

20.Joseph JA, Shukitt-Hale B, Casadesus G. Reversing the deleterious effects of aging on neuronal communication and behavior: beneficial properties of fruit polyphenolic compounds. The American journal of clinical nutrition. 2005 Jan 1;81(1):313S-6S.

21.Kannamkumarath SS, Wrobel K, Wrobel K, Vonderheide A, Caruso JA. HPLC-ICP-MS determination of selenium distribution and



speciation in different types of nut. Analytical and bioanalytical chemistry. 2002 Jul;373(6):454-60.

22.Kaur S, Michael H, Arora S, Härkönen PL, Kumar S. The in vitro cytotoxic and apoptotic activity of Triphala—an Indian herbal drug. Journal of ethnopharmacology. 2005 Feb 10;97(1):15-20.

23.Kluczkowski AM, Martins M, Mundim SM, Simões RH, Nascimento KS, Marinho HA, Junior AK. Properties of Brazil nuts: A review. African Journal of Biotechnology. 2015 Apr 13;14(8):642-8.

24.Leone A, Spada A, Battezzati A, Schiraldi A, Aristil J, Bertoli S. Moringa oleifera seeds and oil: Characteristics and uses for human health. International journal of molecular sciences. 2016 Dec 20;17(12):2141.

25.Maguire LS, O'sullivan SM, Galvin K, O'connor TP, O'brien NM. Fatty acid profile, tocopherol, squalene and phytosterol content of walnuts, almonds, peanuts, hazelnuts and the macadamia nut. International journal of food sciences and nutrition. 2004 May 1;55(3):171-8.

26.Mahata S, Pandey A, Shukla S, Tyagi A, Husain SA, Das BC, Bharti AC. Anticancer activity of *Phyllanthus emblica* Linn.(Indian gooseberry): inhibition of transcription factor AP-1 and HPV gene expression in cervical cancer cells. Nutrition and cancer. 2013 Jan 1;65(sup1):88-97.

27.Mehta S, Singh RK, Jaiswal D, Rai PK, Watal G. Anti-diabetic activity of *Emblica officinalis* in animal models. Pharmaceutical Biology. 2009 Nov 1;47(11):1050-5.

28.Meyerding SG, Kürzdörfer A, Gassler B. Consumer preferences for superfood ingredients—The case of bread in Germany. Sustainability. 2018 Dec 7;10(12):4667.

29.Mirunalini S, Krishnaveni M. Therapeutic potential of *Phyllanthus emblica* (amla): the ayurvedic wonder. Journal of basic and clinical physiology and pharmacology. 2010 Feb;21(1):93-105.

30.Moodley R, Kindness A, Jonnalagadda SB. Elemental composition and chemical characteristics of five edible nuts (almond, Brazil, pecan, macadamia and walnut) consumed in Southern Africa. Journal of Environmental Science and Health, Part B. 2007 Jun 11;42(5):585-91.

31.Mozaffarian, D. (2016). Dietary and policy priorities for cardiovascular disease, diabetes, and obesity: a comprehensive review. Circulation, 133(2): 187–225.

32.Mukprasirt A, Sajjaanantakul K. Physico-chemical properties of flour and starch from jackfruit seeds (*Artocarpus heterophyllus* Lam.) compared with modified starches. International Journal of Food Science and Technology. 2004 Mar;39(3):271-6.

33.Pacheco A, Scussel V. Aflatoxins evaluation on in-shell and shelled dry Brazil nuts for export analysed by LC-MS/MS-2006 and 2007 harvests. World Mycotoxin Journal. 2009 Aug 1;2(3):295-304.

34.Pardeshi S, Dhodapkar R, Kumar A. Molecularly imprinted microspheres and nanoparticles prepared using precipitation polymerisation method for selective extraction of gallic acid from *Emblica officinalis*. Food chemistry. 2014 Mar 1;146:385-93.

35.Patel SS, Goyal RK. *Emblica officinalis* Geart.: a comprehensive review on phytochemistry, pharmacology and ethnomedicinal uses.

36.Ranasinghe RA, Maduwanthi SD, Marapana RA. Nutritional and health benefits of jackfruit (*Artocarpus heterophyllus* Lam.): a review.



International journal of food science. 2019;2019(1):4327183.

37.Ryan E, Galvin K, O'connor TP, Maguire AR, O'brien NM. Fatty acid profile, tocopherol, squalene and phytosterol content of brazil, pecan, pine, pistachio and cashew nuts. International journal of food sciences and nutrition. 2006 Jan 1;57(3-4):219-28.

38.Santos OV, Corrêa NC, Soares FA, Gioielli LA, Costa CE, Lannes SC. Chemical evaluation and thermal behavior of Brazil nut oil obtained by different extraction processes. Food Research International. 2012 Jul 1;47(2):253-8.

39.Siró I, Kápolna E, Kápolna B, Lugasi A. Functional food. Product development, marketing and consumer acceptance—A review. Appetite. 2008 Nov 1;51(3):456-67.

40.SM SUN S, Altenbach SB, Leung FW. Properties, biosynthesis and processing of a sulfur-rich protein in Brazil nut (*Bertholletia excelsa* HBK). European Journal of Biochemistry. 1987 Feb;162(3):477-83.

41.Strunz CC, Oliveira TV, Vinagre JC, Lima A, Cozzolino S, Maranhão RC. Brazil nut ingestion increased plasma selenium but had minimal effects on lipids, apolipoproteins, and high-density lipoprotein function in human subjects. Nutrition Research. 2008 Mar 1;28(3):151-5.

42.Swami SB, Thakor NJ, Haldankar PM, Kalse SB. Jackfruit and its many functional components as related to human health: a review. Comprehensive Reviews in Food Science and Food Safety. 2012 Nov;11(6):565-76.

43.Tacer-Caba Z. The concept of superfoods in diet. In: The role of alternative and innovative food ingredients and products in consumer wellness 2019 Jan 1 (pp. 73-101). Academic Press.

44.Ullah R, Nadeem M, Khalique A, Imran M, Mehmood S, Javid A, Hussain J. Nutritional and therapeutic perspectives of Chia (*Salvia hispanica* L.): a review. Journal of food science and technology. 2016 Apr;53(4):1750-8.

45.Van den Driessche JJ, Plat J, Mensink RP. Effects of superfoods on risk factors of metabolic syndrome: a systematic review of human intervention trials. Food & function. 2018;9(4):1944-66.

46.Variya BC, Bakrania AK, Patel SS. *Emblca officinalis* (Amla): A review for its phytochemistry, ethnomedicinal uses and medicinal potentials with respect to molecular mechanisms. Pharmacol Res. 2016;111:180-200..

47.Weitkamp E, Eidsvaag T. Agenda building in media coverage of food research: Superfoods coverage in UK national newspapers. Journalism Practice. 2014;8(6):871-86.

48.Wolfe D. Superfoods: the food and medicine of the future. Berkeley (CA): North Atlantic Books; 2009

49.Yang F, Yaseen A, Chen B, Li F, Wang L, Hu W, et al. Chemical constituents from the fruits of *Phyllanthus emblica* L. Biochem Syst Ecol. 2020;92:104122

50.Yang J. Brazil nuts and associated health benefits: A review. LWT Food Sci Technol. 2009;42(10):1573-80

51.Granato, D., Branco, G. F., Nazzaro, F., Cruz, A. G., & Faria, J. A. F. (2020). Functional foods and nondairy probiotic food development: Trends, concepts, and products. Comprehensive Reviews in Food Science and Food Safety, 19(3): 2021–2040.

52.Jaiswal P, Kumar P, Singh VK, Singh DK. A review on phytochemical and pharmacological properties of Amla (*Emblca officinalis*) and its



traditional uses. Asian J Pharm Clin Res. 2016;9(6):1–8.

53.Granato, D., Branco, G. F., Nazzaro, F., Cruz, A. G., & Faria, J. A. F. (2020). Functional foods and nondairy probiotic food development: Trends, concepts, and products. Comprehensive Reviews in Food Science and Food Safety, 19(3): 2021–2040