

Review Article

# Plant-based dairy substitutes: Current scenario and future prospects

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## ARTICLE INFO

**Received:** September 09, 2023

**Revised:** October 17, 2023

**Accepted:** October 17, 2023

**Published:** October 19, 2023

### Keywords:

Cereals; health benefits;  
legumes; milk; nutrition;  
plant based dairy substitutes

## ABSTRACT

Plant-based dairy substitutes (PBDS) are non-dairy products made from plant ingredients as an alternative to traditional dairy products such as milk, cheese, and yoghurt. These dairy substitutes cater to those with lactose intolerance, dairy allergies, vegans, and those who prefer more sustainable and ethical food options. They provide options for various culinary purposes while reducing reliance on animal-based products. PBDS generally have a low environmental footprint, requiring fewer resources and lower greenhouse gas emissions than dairy farming. Some PBDS are enriched with vitamins and minerals, such as vitamin D and calcium, providing similar nutritional benefits to dairy products. They have advantages over conventional dairy products due to their low glycemic content and hence have better suitability for diabetic patients. Moreover, people with heart ailments or arthritis can also consume PBDS for its hypocholesterolemic and anti-inflammatory properties. They also help in befitting pregnant women, foetus, lactating mothers, infants and elderly people. As plant-based dairy substitutes offer many benefits, selecting products that suit an individual's dietary needs and preferences ensures sufficient intake of essential nutrients. Ongoing research and development in the plant-based industry has improved taste and texture, making these substitutes increasingly attractive for routine human consumption.

## INTRODUCTION

The consumption landscape of dairy products is undergoing significant shifts in many Western countries. Traditional dairy consumption is declining, while the sales of plant-based dairy products are rising, a well-documented trend in the literature [1]. Notably, plant-based milk now constitutes a substantial portion, approximately 15%, of the total milk industry, reflecting the substantial growth of this sector [2]. This transformation is further exemplified by the increasing popularity of various plant-based dairy substitutes, encompassing a broad spectrum of products. These markets have expanded to encompass millions or even billions of economic values (Fig. 1).

While plant-based dairy substitutes (PBDS) offer several health benefits due to antioxidants and certain fatty acids, which reduce the risk of cardiovascular diseases, cancer, atherosclerosis, and diabetes [3], they also have drawbacks such as low protein content, limited bioavailability of nutrients, and potential oral health concerns when sweetened with added sugars. These challenges can be mitigated through strategies like fermentation [4–6] and reducing added sugar content to align with WHO recommendations for better overall health outcomes [5]. Various criteria influence the experience of trying a portion of new food, each of which can shape an individual's willingness to explore and enjoy a novel culinary experience [7]. These include taste, nutrition, health benefits, environmental considerations, cultural influences, presentation, cost, and personal disposition. These factors increase or decrease an individual's willingness to venture into new culinary experiences. A USA survey found that lactose-free cow's milk was preferred over soy milk among adults. This preference was consistent across different participant

demographics, including ethnicity, gender, and dairy intolerance status [8]. An experiment in Sweden revealed that Swedish people tend to prefer oat milk substitutes over medium-fat UHT cow's milk. However, soy milk received a lower preference score in this context [9].

Similarly, a study by [2] explored extrinsic factors and personal values influencing purchasing beverage products, particularly dairy milk. The findings showed that factors such as fat content, packaging size, and label claims substantially impacted consumers' preferences for dairy milk. Most participants preferred milk containing one or two per cent fat, gallon or half-gallon packaging, and conventionally pasteurized store-brand milk.

### Persuasive points about PBDS

In the plant-based milk substitute category, factors such as sugar level, the source of the plant-based milk, and packaging size play essential roles in consumers' purchasing decisions. Among these factors, sugar level was particularly significant. People who are lactose intolerant or desire a balanced diet also consider these factors when choosing dairy and non-dairy milk options. Furthermore, the combination of factors, including taste, nutritional content, packaging, label claims, and personal values, influences consumer preferences for milk and milk substitutes. These preferences can vary by region and individual characteristics, highlighting the diversity in consumer choices within the dairy and plant-based milk categories



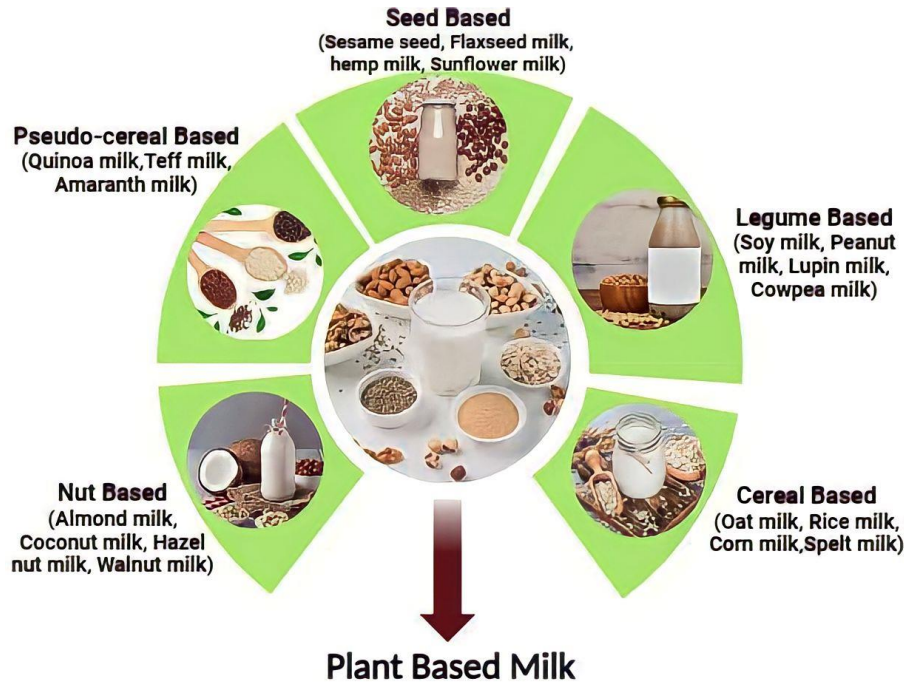


Fig. 1. Different type of plant-based milks from various plant sources.

**Different plant-based dairy substitutes**

**Non-dairy milk options**

Non-dairy milk options have gained popularity over dairy milk for various reasons, including dietary preferences, lactose intolerance, and environmental concerns. Almond milk is made from ground almonds and water. It is often praised for its low-calorie content. Almond milk is a good source of vitamin E and can be fortified with vitamins and minerals [10]. Soy milk is made from whole soybeans and water. It is known for its high protein content. It is a complete protein source, providing essential amino acids [11]. Oat milk is made from whole oat grains and water. It is praised for its creamy texture and mild flavour. Oat

milk is often fortified with calcium and vitamin D, making it nutritionally comparable to dairy milk (Table 1). Coconut milk is derived from the flesh of coconuts and is known for its distinct coconut flavour. It is higher in saturated fats, mainly medium-chain triglycerides (MCTs) [12]. Rice milk is made from milled rice and water. It is often considered a hypoallergenic alternative. It tends to be naturally sweeter but lower in protein than soy or almond milk [13]. Cashew milk is produced from cashew nuts, and water offers a creamy texture and mild flavour and can be a source of healthy fats, vitamins, and minerals [14]. Hemp milk from hemp seeds and water contains omega-3 and omega-6 fatty acids and is often appreciated for its earthy and nutty flavour [15].

Table 1. Nutritional composition (g/100g) and major vitamins and minerals of different PBDS.

PBDS	Energy (kcal)	Protein	Carbohydrates	Lipids	Saturated Fats	Unsaturated Fats	Fibre	Major Vitamins	Major Minerals	References
Walnut	630	16.66	13.7	66.9	6.13	47.2	6.7	B6, B1, B9	Mn, P, Mg	[16,17]
Hazelnut	628	15.0	16.7	60.7	4.46	7.92	9.7	B2, D	K, P	[18–20]
Sunflower	584	20.8	20.0	51.5	4.46	23.1	8.6	B3, B9, E	Ca, Mg, P	[21–23]
Almond	575	21.22	21.67	49.42	3.73	12.07	12.2	B2, B3, E	Ca, Na, P	[24,25]
Sesame	573	17.6	9.85	49.7	7.09	21.8	14.9	E, B9, B6	K, Mg, P	[26,27]
Peanut	567	25.8	16.1	49.2	6.3	15.6	8.5	A, E	K, Na	[28–30]
Pistachio	560	26.16	29.0	45.4	5.6	13.3	10.6	C, E	K, Mg	[31,32]
Hemp	553	31.6	8.67	48.8	4.6	38.1	4.0	B2, D	Ca, Na	[32,33]
Flaxseed	536	20.0	29.0	42.9	3.57	24.3	28.0	A, D, B12	Ca, Na	[24,34]
Oat	389	16.9	66.3	6.9	1.22	2.54	10.6	E, B3, B1	K, P	[28,35]
Quinoa	368	14.1	64.2	6.07	0.71	3.29	7.0	B2	Ca, Na	[24]
Rice	360	6.61	79.3	7.86	0.16	0.15	0.0	B3, C	Ca, P, Na	[24,28]
Coconut	354	3.33	15.2	33.5	29.7	0.37	9.0	B2, A, D	Ca, Na	[24,36]
Soybean	327	51.46	33.92	1.22	0.14	0.53	17.5	B2, B3	Ca, P	[24,37]
Chickpea	164	6.04	62.95	2.59	0.6	2.73	7.6	A, B2, B3	Ca, Mg	[38,39]

### ***Non-dairy cheese options***

Cashew-based cheeses are made from cashews and often include probiotics for fermentation. They are known for their creamy texture and versatility in making various cheese flavours. Almond-based cheeses are created using almond milk and various thickeners and flavourings. They can be used for spreads, dips, or dish toppings. Soy-based cheeses are made from soybeans and are often fortified with vitamins and minerals. They are known for their reliability and are used in dishes like pizza and lasagna. Coconut-based cheeses are produced from coconut milk and various thickeners. They have a distinctive coconut flavour and can be used in tropical-inspired dishes. Nutritional yeast-based cheeses often create cheesy flavours and textures in vegan dishes. Nutritional yeast, fortified with B vitamins, is a common ingredient in these substitutes. Pea protein-based cheeses are made from yellow pea protein isolate. They can offer a good source of plant-based protein. Some artisanal plant-based cheese makers use fermentation to create complex flavours and textures. These cheeses often incorporate plant-based ingredients, including nuts and legumes [40,41].

### ***Non-dairy margarine options***

Margarine is a common non-dairy butter substitute made from vegetable oils. It may be fortified with vitamins [42]. Coconut oil spread is derived from coconut oil and is praised for its distinct flavour and texture [12]. Olive oil spread is a non-dairy substitute made from olive oil. It is often considered a healthier choice due to its monounsaturated fats [43]. Avocado butter is produced from ripe avocados and offers a creamy texture. It contains healthy monounsaturated fats and various vitamins and minerals. Soy butter is derived from soybeans and can serve as a source of plant-based protein and healthy fats [44].

### ***Non-dairy ice cream options***

Plant-based or vegan ice cream is made without dairy ingredients (milk, cream, etc.). Instead, it utilizes plant-based ingredients to achieve a creamy and delicious texture. The primary ingredients in plant-based ice cream typically include a milk substitute (e.g., almond milk, coconut milk, soy milk, etc.), sweeteners, stabilizers, emulsifiers, flavourings, and optional add-ins like fruit, nuts, or chocolate chips. These dairy-free substitutes are chosen for their creamy texture and ability to mimic the mouthfeel of traditional dairy milk. These milk substitutes serve as the primary liquid component of the ice cream. These ice creams are sweetened to achieve the desired level of sweetness with cane sugar, agave syrup, maple syrup, or even fruit purees like banana or date. Guar gum, xanthan gum, and locust bean gum are added as stabilizers and emulsifiers. Similarly, for natural flavourings, vanilla extract, cocoa powder, fruit puree, or extracts from various sources can be used to impart flavour to these ice creams. Among add-on materials, fruit pieces, nuts, chocolate chips, or cookie chunks can be added [7,45].

### ***Beneficial attributes of plant-based dairy substitutes***

PBDS are increasingly popular, and it is no wonder when considering some health benefits. Studies have revealed that going meat-free could prevent, control, and even reverse many chronic illnesses of heart, type-2 diabetes and cancer [46]. Numerous clinical studies have accumulated a wealth of evidence highlighting the substantial benefits of a plant-based diet (Table 2). These advantages extend to the prevention of chronic health conditions and the potential improvement of existing conditions. These conditions include Type-2 diabetes, dyslipidemia, metabolic syndrome, obesity, cardiovascular diseases, hypertension and different types of cancer [47–51].

A growing interest in encouraging people to adopt a plant-based diet as part of their lifestyle, not just as a temporary dietary choice, reflects a

broader movement towards plant-based eating patterns. Beyond health benefits, plant-based diets have sustainability and economic advantages. It notes that the production of animal-based food products typically consumes more energy and resources than plant-based substitutes, which corresponds with the environmental and ethical considerations associated with animal farming [52–55].

### ***Diabetes***

Many plant-based dairy substitutes have a lower glycemic index (GI) than cow's milk. Almond milk and unsweetened soy milk have a lower GI than cow's milk, which can help better blood sugar control for individuals with diabetes [56]. Unsweetened almond or unsweetened coconut milk has fewer carbohydrates than dairy milk, assisting in managing the blood glucose levels in people with diabetes [57]. Likewise, many plant-based dairy substitutes are fortified with essential nutrients like calcium, vitamin D, and vitamin B12, which can help individuals with diabetes maintain their nutritional balance, which is important for bone health and overall well-being [58]. PBDS are often lower in saturated fats than animal-based ones. Reduced saturated fat intake can help improve insulin sensitivity and reduce the risk of cardiovascular complications in individuals with diabetes [59]. Plant-based dairy supplements are naturally lactose-free, making them suitable for individuals with lactose intolerance, which is more common in people with diabetes [60]. Almond or coconut milk can be helpful for those with dairy allergies or sensitivities, which may coexist with diabetes [61].

Plant-based dairy supplements derived from soy, almonds, oats, and other plants have become an alternative to traditional animal-based dairy products. These plant-based options are often chosen for various reasons, including ethical concerns, lactose intolerance, and potential health benefits [62–66].

### ***Cardiovascular Health***

One of the notable health benefits of plant-based dairy supplements is their potential to impact cholesterol levels positively. The relationship between plant-based dairy supplements and human cholesterol levels is an important study area, particularly in nutrition and cardiovascular health. PBDS gained popularity for various reasons, including concerns about cholesterol and other health benefits. Plant sterols and stanols are naturally occurring compounds found in small amounts in various plant-based foods. They have been shown to reduce LDL cholesterol levels when consumed as supplements. A meta-analysis study found that daily consumption of plant sterols/stanols can significantly reduce LDL cholesterol levels, a consequential risk factor for heart disease [67]. Soy-based dairy substitutes, such as soy milk and tofu, contain compounds known as isoflavones, which have been studied for their potential cholesterol-lowering effects. A study suggested that soy protein intake can modestly reduce LDL cholesterol levels by replacing animal protein in the diet [68]. A meta-analysis of 46 studies identified by the FDA demonstrates that soy protein decreases circulating LDL and total cholesterol concentrations in adults [69]. Almonds, a common ingredient in many PBDS rich in monounsaturated fats, fibre, and phytosterols, can contribute to lower cholesterol levels. Non-soy legume consumption also reduces LDL cholesterol levels [70]. Oats contain a type of soluble fibre called beta-glucans, which has been extensively studied for its cholesterol-lowering properties. Oat-based products, such as oatmeal and oat milk, have reduced LDL cholesterol levels [71].

### ***Skin diseases***

PBDS also play a role in managing certain dermatological diseases and improving skin health. Dermatological conditions like acne, eczema, and

psoriasis often involve inflammation. Certain non-dairy products, such as fruits, vegetables, and whole grains, are rich in antioxidants and anti-inflammatory compounds. They can help reduce inflammation and improve the skin's overall health [72]. Non-dairy sources of omega-3 fatty acids, such as flaxseeds, chia seeds, and walnuts, have anti-inflammatory properties and may benefit individuals with skin conditions like psoriasis and atopic dermatitis and can help reduce skin inflammation and improve skin barrier function [73–76]. Some individuals with lactose intolerance may experience skin issues from consuming dairy products, which can manifest in skin symptoms, including urticaria (hives) and eczema. By avoiding dairy and switching to PBDS, individuals can often reduce the occurrence of these skin reactions [77,78]. Dairy products, especially those made from cows bred traditionally, may include hormones and growth factors that can also affect the condition of the skin.

The skin is a critical barrier that shields internal organs and cells from various external factors. Its health and the ageing process are influenced by a combination of intrinsic and extrinsic factors, including skin thickness, microvasculature structure, sex hormones, and external factors like diet, sleep, humidity, and exposure to UV radiation [75,79]. One significant aspect of skin ageing is the decrease in estrogen levels that occurs with age. This hormonal shift can lead to undesired changes in the skin. However, an intriguing connection exists between skin health and consuming estrogen or phytoestrogens, compounds in certain plant-based products. Phytoestrogens, such as genistein, daidzein, and glycitein, are commonly present in different PBDAAs [80–82]. Genistein, one of these phytoestrogens, can bind to  $\beta$ -estrogen receptors in the body, restoring skin integrity and preventing dermal breakdown.

Meanwhile, daidzein, another phytoestrogen, exhibits potent antioxidant, anti-ageing, and anti-inflammatory properties. These qualities can help combat the effects of skin ageing and maintain skin health. Although glycitein is present in lower concentrations in soy milk and has lower binding activity to estrogen receptors than genistein, it still demonstrates a significant estrogenic response, primarily due to its higher bioavailability [83].

### **Arthritis**

PBDS can benefit individuals who have arthritis and several joint-related problems, too. Dietary choices can play a role in managing symptoms and reducing inflammation of this cause. Many PBDS are rich in nutrients with anti-inflammatory properties, such as antioxidants and polyphenols. These compounds can help reduce inflammation, a critical factor in arthritis [84]. Many PBDS have lower saturated fat content than traditional dairy products. High intake of saturated fat has been associated with increased inflammation and a higher risk of certain types of arthritis, such as rheumatoid arthritis. Switching to low-fat PBDS may mitigate this risk (Lordan and [85]). Some PBDS, like flaxseed-based milk, are fortified with omega-3 fatty acids, which have been studied for their potential to reduce inflammation, improve symptoms, and help mitigate joint pain and stiffness [86]. Plant-based dairy substitutes are naturally lactose-free, making them suitable for lactose intolerance, which can co-occur with arthritis. Consuming dairy products (when lactose intolerant) can lead to gastrointestinal discomfort, which may exacerbate arthritis symptoms [87].

### **Pregnancy**

It is crucial for pregnant women following plant-based diets to work closely with healthcare providers or registered dietitians who can provide personalized guidance and monitor nutrient levels to ensure a healthy pregnancy. Meeting special dietary needs during pregnancy is achievable on a plant-based diet with careful planning and attention to

nutrient-rich food choices and, when necessary, supplementation. Dietary choices have a significant impact on both maternal and foetal health in this crucial period. Avoiding dairy products from cow milk can stem from various reasons, with medical concerns including lactose intolerance, cow's milk protein allergy (CMPA), cholesterol-related issues, and apprehensions about growth hormones or antibiotic residues in cow's milk. However, due to changes in the content of amino acids and how the body absorbs and uses them, plant-based proteins are frequently thought to be of a slightly poorer nutritional grade than proteins obtained from animals [7].

Additionally, the processing methods used can significantly influence the final composition of plant-based products [7]. To meet the nutritional quality of plant-based beverages, the fortified options should contain a protein content of at least 24 grams per litre of drink. This protein fortification is essential to ensure that individuals who rely on these products as dairy substitutes receive an adequate intake of essential amino acids and other nutrients [88]. While plant-based proteins may have differences in amino acid profiles compared to animal proteins, a well-balanced diet with various protein sources can provide all the essential amino acids necessary for human health. Additionally, the nutritional quality of plant-based products can vary depending on factors such as the type of plant protein used and the fortification process [89–92].

### **Foetal health**

As far as foetus nutrition is concerned, protein is vital for growth and development. Plant-based proteins include legumes (beans, lentils), tofu, tempeh, nuts, seeds, and plant-based dairy substitutes like soy milk, which are excellent options for mothers to nurture their foetus. Ensuring an adequate intake of these protein-rich foods is essential [93]. Calcium and vitamin D are also crucial for foetal bone development. Many PBDS, like fortified almond milk or soy milk, are fortified with calcium and vitamin D, which help to grow foetal bones properly. Pregnant women on plant-based diets should ensure they consume these products or seek alternative sources like fortified cereals or supplements [94]. Plant-based diets can provide iron and folate from fortified cereals, legumes, and leafy greens. These nutrients are essential for preventing anaemia and supporting embryonic development [95]. Researches have emphasized the importance of adequate iron and folate intake during pregnancy [96,97]. Since vitamin B12 is primarily found in animal products, pregnant women following a strict plant-based diet should consider B12 supplementation, too, since a deficiency can lead to neurological issues for both the mother and the baby. The American College of Obstetricians and Gynaecologists recommends B12 supplementation for pregnant vegetarians and vegans [98].

### **Breastfeeding mothers**

Breastfeeding mothers and their infants have special dietary needs to ensure proper nutrition and healthy development. PBDS can also be part of a balanced diet for breastfeeding mothers and infants, but careful consideration is needed to meet essential nutrient requirements. Although PBDS like soy and almond milk can be good protein sources, the protein quality of plant-based options can vary. Therefore, it is essential to choose fortified products when available [99]. Calcium is also essential for maintaining bone health in breastfeeding mothers. Many plant-based milk substitutes are fortified with calcium and vitamin D, essential for breastfeeding mothers, especially those with limited sun exposure, who may require vitamin D supplementation [100]. Breast milk is the ideal source of nutrition for infants, providing essential nutrients, antibodies, and bioactive compounds. For breastfeeding mothers on a plant-based diet, it is crucial to maintain a well-balanced diet to ensure that breast milk

remains nutritionally adequate for the infant [101,102]. As infants transition to solid foods, parents should provide a diverse, nutrient-rich diet that meets their needs. PBDS can be appropriate in this condition, but parents should consider iron, protein, and vitamin B12 sources [103].

### Old aged persons

With the prolonged lifespan and a growing population of elderly individuals in several nations, a crucial demographic shift towards an ageing population coincides with maintaining or enhancing health, elevated quality of life, and adequate social and economic support [104]. In recent decades, dietary strategies for preventing frailty have gained popularity. To date, the prevailing scientific consensus suggests that higher consumption of vegetables and fruits, coupled with more excellent adherence to legumes and grains while minimizing the intake of red and processed meat, has been associated with a decreased incidence of frailty [105]. PBDS is currently being explored as a potential substitute for animal-based dairy products, driven by evolving market preferences for maintaining a well-rounded diet. Consequently, research is needed to enhance the safety and quality of these alternative dietary sources. Due to the changing market demands, these sources are now considered potential replacements for animal-based dairy products. Therefore, more research should be focused on improving the safety and quality of these alternative dietary sources. Some objectives to achieve PBDS safety for consumption by the elderly population are focused on techno-functional aspects and production factors to achieve

phenotypic properties [106]. While PBDS is rapidly gaining popularity, even among older adult, concerns persist about their nutritional aspects, especially regarding calcium, vitamin D, and vitamin B12 intake, because specific nutritional standards need to be met for such products.

## THE FUTURE PROSPECTS

The future of PBDS holds excellent promise, driven by the increasing consumer demand for these products. Food manufacturers and researchers are poised to continue exploring and developing novel plant-based ingredients to enhance these taste, texture, and nutritional quality of these substitutes [135]. Consumers are progressively leaning towards clean-label products with minimal processing, prompting future PBDS to prioritize simpler, whole-food ingredients to meet this demand [66]. Furthermore, a more comprehensive array of PBDS can be anticipated, including an expanded selection of cheeses, yoghurts, ice creams, and other dairy substitutes. To make these substitutes more nutritionally equivalent to traditional dairy products, they may also undergo fortification to boost critical nutrients such as calcium, vitamin D, and vitamin B12 [100]. As sustainability concerns continue to rise, PBDS stand to benefit from their lower environmental impact compared to animal-based dairy products [52]. Finally, the popularity of plant-based dairy substitutes is on track to expand globally, reaching new markets and regions and further solidifying their position in the food industry [136].

**Table 2. Different PBDS milk analogues with their bioactive elements and their effect on health.**

PBDS Milk Analogs	Bioactive Elements	Effect on Health	References
Walnut	Catechin, chlorogenic acid	Antioxidant activity, stables blood sugar levels, improves gut microbiome, good for brain health, neuroprotective properties	[107,108]
Hazelnut	B-sitosterol, tocopherols, flavonols	Prevents cardiovascular diseases, improves bowel movement, fights free radicals	[109]
Sunflower	Luteolin, quercetin	Anti-inflammatory enhances metabolism and maintains blood pressure and cholesterol.	[110]
Almond	Tocopherol, arabinose	Maintains gut microbiome, prevents lipid oxidation, and potent antioxidant properties	[88,111]
Sesame	sesamin, sesamol	hypocholesterolemic, anticancerous, antiviral properties	[27,112]
Peanut	Niacin, phenols	Good for heart health, prevents oxidative stress, enhances the immune system	[88,113]
Pistachio	Phenols, phytosterols	Prevents atherosclerosis and cardiovascular diseases, helps in cell repair	[114,115]
Hemp	$\gamma$ -tocopherol, linolenic acid	Prevents blood clots, relaxes blood vessels, helps in skin and neurodegenerative diseases	[116–118]
Flaxseed	$\alpha$ -linolenic acid, omega-3 fatty acid, secoisolariciresinol diglucoside	Aids in brain, heart and bone health, boosts immune system, relieves constipation	[119,120]
Oat	$\beta$ -glucan, avenanthramides	It lowers LDL cholesterol, maintains body weight, stabilizes blood pressure, and has antioxidant and anti-inflammatory properties	[121–123]
Quinoa	Phenolic components	Management of hypertension and diabetes, better substitute for obese	[124]
Rice	$\beta$ -sitosterol, $\gamma$ -oryzanol	Useful in diabetes, hypertension and inflammation, hypoallergic and antioxidant properties	[88,125,126]
Coconut	Gallic acid, lauric acid, phenolics	Nourishes brain and skin cells, promotes weight loss, improves digestion and immune system	[88,127,128]
Soybean	Daidzein, genistein	Maintains lipid profile, promotes bone density, prevents cancers of colon, breast, and prostate, benefits people with osteoporosis	[129–132]
Chickpea	Carotenoids, isoflavones	Management of cardiovascular health, Antidiabetic, anti-inflammatory, neuroprotective, and anticancerous properties,	[38,133,134]

## CONCLUSION

PBDA has proven to be an established substitute in the modern food industry for its immense nutritional benefits, especially for people struggling with lactose intolerance or dairy allergies. With various non-dairy substitutes such as milk, cheese, margarine, and ice cream, PBDA is becoming the preferential food for people following its many beneficial health impacts. These effects correspond to lowering the glycemic index and hence maintaining the blood sugar levels, preventing chronic cardiovascular problems by controlling the LDL cholesterol, promoting anti-ageing effect on the skin, healing dermatitis and other inflammatory conditions inside the body, boosting maternal and foetal health during pregnancy or breastfeeding, and supporting a balanced diet for the old aged population who cannot rely on animal food for nutrition, etc. PBDA could be a better replacement choice of food for today's contemporary vegan lifestyle, which may prove a boon for the growth of PBDA products among the masses for their overall advantageous potential. Despite the increasing popularity of PBDA, there are still lingering concerns regarding their nutritional characteristics in terms of calcium, vitamin D, or B12. Such concerns require more rigorous and detailed information to meet current food or health standards.

## FUNDING

This research received no external funding.

## INSTITUTIONAL REVIEW BOARD STATEMENT:

Not applicable.

## INFORMED CONSENT STATEMENT:

Not applicable.

## CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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