REVIEW ARTICLE

Functional and Novel Foods

Advantages and Drawbacks of Plant-Based Beverages as Alternatives to Animal Milk: A Multidimensional Review

Amina Abbou [1] **Nabil Kadri** [2] **Adrien Servent** [3,4] **Khokha Mouhoubi** [1] **Lamia Medouni-Haroune** [1] **Cilia Bouiche** [1] **Samira Negrichi** [1] **Zoubeida Meghlaoui** [1] **Meriem Amrane-Abider** [1] **Sabiha Bechir** [1] **Lamia Taouzinet** [1] **Hind Bougherra** [1] **Khodir Madani** [2] **Nawel Achir** [3]

1 Centre de Recherche en Technologies Agro-alimentaires. Route de Targa Ouzemmour, Campus Universitaire, Bejaia, 06000, Algeria. amina.abbou@crtaa.dz / khokha.mouhoubi@crtaa.dz / lamia.medouni@crtaa.dz / celia.bouiche@crtaa.dz / samira.negrichi@crtaa.dz / zoubeida.meghlaoui@crtaa.dz / meriem.amrane@crtaa.dz / sabiha.bechir@crtaa.dz / lamia.taouzinet@crtaa.dz / hind.bougherra@crtaa.dz /

2 Département de Biologie, Faculté des Sciences de la Nature et de la Vie et Sciences de la Terre, Université de Bouira, 10000 Bouira, Algérie. Laboratoire de Biochimie, Biophysique, Biomathématiques et Scientométrie (L3BS), Faculté des Sciences de la Nature et de la Vie, Université de Bejaia 06000 Bejaia, Algérie. n.kadri@univ-bouira.dz / khodir.madani@univ-bejaia.dz /

3 QualiSud, Univ Montpellier, Avignon Univ, CIRAD, Institut Agro, IRD, Univ de La Réunion, Montpellier, France. CIRAD, UMR QualiSud, F-34398 Montpellier, France. adrien.servent@cirad.fr / nawel.achir@institut-agro.fr

4 Centro Nacional de Ciencia y Tecnología de Alimentos (CITA), Universidad de Costa Rica (UCR), 11501-2060, San José, Costa Rica

ABSTRACT

Background: Plant-based beverages have gained increasing prominence as alternatives to animal milk, particularly for individuals with lactose intolerance, milk protein allergies, or those adhering to vegetarian and vegan diets. The widespread adoption of these products requires a comprehensive evaluation of their multiple properties, as they possess a range of nutritional, technological, economic, and environmental benefits and drawbacks.

Aims: This narrative review provides a multidimensional synthesis of the advantages and limitations associated with plant-based beverages as viable alternatives to animal milk.

Methods: A systematic literature search was conducted across the Google Scholar, Scopus, ScienceDirect and PubMed databases for articles published between 2010 and 2024. A set of defined keywords yielded 183 articles, from which 68 were selected for inclusion based on their methodological rigor and thematic relevance.

Results: The findings indicate that plant-based beverages are naturally free of lactose and cholesterol and often contain beneficial dietary fiber and bioactive compounds. They are also appreciated for their sensory diversity and adaptability to specific dietary preferences. However, they are generally lower in protein and essential micronutrients compared to animal milk. Furthermore, their composition exhibits significant variability, which is influenced by the raw materials (e.g., cereals, legumes, dried fruit, etc.) and the technological processing methods employed. Environmentally, these beverages generally exhibit a lower carbon footprint, yet their retail cost remains a key disadvantage for consumers.

Conclusions: In conclusion, this review highlights the critical need for further research focused on enhancing the formulation of plant-based beverages to more effectively meet consumers expectations regarding nutritional value, sensory quality, and affordability.

Keywords: Plant-based beverages, Animal milk, Advantages, Limitations, Manufacturing process, Nutritional properties.

ARTICLE INFORMATION

✉ **Corresponding author:** Amina Abbou
E-mail: amina.abbou@crtaa.dz
Tel. (+213) 540 552 486

Received: December 19, 2024
Revised: May 27, 2024
Accepted: June 15, 2025
Published: July 12, 2025

Article edited by:
Prof. Khaled Méghit Boumèdiene
Article reviewed by:
Dr. Chakare Benhura
Dr. Evelyne Muinga

Cite this article as: Abbou A., Kadri N., Servent A., Mouhoubi K., Medouni-Haroune L., Bouiche C., Negrichi S., Meghlaoui Z., Amrane-Abider M., Bechir S., Taouzinet L., Bougherra H., Madani K., & Achir N. (2025). Advantages and Drawbacks of Plant-Based Beverages as Alternatives to Animal Milk: A Multidimensional Review. *The North African Journal of Food and Nutrition Research, 9* (20): 74 – 95. https://doi.org/10.51745/najfnr.9.20.74-95

1 INTRODUCTION

Traditionally, animal milk has been considered a fundamental component of the human diet, primarily due to its rich concentration of protein, fat, vitamins and minerals (Mesfine *et al.*, 2015). However, in recent decades, plant-based-beverages — commonly referred to as "vegetable milks" — have attracted growing interest as alternatives to animal milk. These beverages are sought after for their visual and functional resemblance to animal milk and are typically produced by extracting plant matter in water, followed by filtration to collect a liquid with a milky texture (Mäkinen *et al.*, 2016).

The market for plant-based beverages is dominated by common examples such as soy, almond, oat, rice, and coconut milk, with more recent additions including beverages derived from pea, hemp or quinoa (Zandona *et al.*, 2021). Their popularity is notably attributed to factors such as lactose intolerance, cow's milk protein allergies, and the growing adoption of vegetarian or vegan diets (Mäkinen *et al.*, 2016). These products are also appreciated for their content of bioactive compounds, such as phenols, unsaturated fatty acids, and antioxidants. Nevertheless, their nutritional profile is often considered inferior to that of cow's milk, particularly in terms of protein and calcium content (Haas *et al.*, 2019).

The shift towards plant-based alternatives is further encouraged by a number of factors. First, the consumption of animal milk has been associated with certain health concerns, as the quantity and quality of its fats are assumed responsible for raising blood cholesterol levels, its proteins can be allergenic, and its lactose content can cause intolerance symptoms (Zandona *et al.*, 2021). Second, dairy production generates environmental challenges, as it requires significant water and land resources and generates higher greenhouse gas emissions compared to the production of plant-based beverages (Ramsing *et al.*, 2023). Finally, from an economic standpoint, dairy farming is a labor-intensive sector, and in several developing countries, local production is insufficient to meet demand, leading to heavy reliance on imports (Sraïri *et al.*, 2013).

Consequently, despite the well-established nutritional quality of animal milks, these limitations have encouraged the production and consumption of plant-based beverages. These alternatives are valued for their sensory characteristics, sustainability, and plant-derived proteins, fatty acids and minerals, making them a suitable option for individuals with lactose intolerant, allergies, or specific dietary choices (Zandona *et al.*, 2021). These beverages consist in complex colloidal systems, primarily functioning as oil-in-water emulsion. They are generally derived from oilseeds, cereals, and legumes, with soybean beverages, holding a significant market share. Other popular sources include almonds, cashew, rice, oats, and wheat. The increasing interest in these beverages are interesting and increasingly popular due to their sustainability potential and trend (Nawaz *et al.*, 2023).

The primary objectives of this review are to conduct a thorough analysis of the advantages and limitations of plant-based beverages across various dimensions, including nutritional value, economic viability, environmental impact, and sensory properties. This synthesis aims to provide a clear understanding of their potential as substitutes for animal milk, to highlight opportunities for valorizing various seeds and nuts, and to support local economic development, particularly in developing countries. Ultimately, this work is intended to inform consumers and assist them in making decisions that align with their specific needs and preferences.

2 Methodology

This review is based on an exhaustive literature search conducted across multiple scientific databases, including Google Scholar, ScienceDirect, PubMed and Scopus. The search sought to identify peer-reviewed articles, journals and book chapters published predominantly between 2010 and 2024. A combination of keywords such as "plant-based beverages", "plant milk", 'milk', "animal product-free milk", "nutritional value", "processing technologies", "environmental impact", "economic aspects" and "sensory evaluation" were employed to ensure a broad and inclusive search.

The initial search yielded a total of 183 articles. A subsequent screening process, based on an analysis of titles and abstracts, led to the exclusion of 45 articles that were deemed irrelevant to the review's core themes or failed to meet predefined quality criteria, such as lack of peer review or insufficient methodological detail. The selection process was conducted by the principal investigator, with consultation of a second expert to ensure consistency and minimize selection bias. Ultimately, 138 articles were selected for their scientific relevance, methodological rigor and direct contribution to at least one of the main dimensions addressed in this article: nutrition, processing, economics, environment, and sensory characteristics. Only articles in English and French that presented original data or a critical synthesis were included. A narrative review approach was selected to provide an in-depth, multidisciplinary qualitative synthesis, thereby offering a holistic perspective of the benefits and limitations of plant-based beverages.

3 Advantages

3.1 Nutritional Benefits

For several years, cow's milk was considered as a fundamental part of the human diet, essentially due to its rich composition of essential nutrient profile (Gaucheron, 2011). However, the recent proliferation of plant-based beverages has challenged this traditional perception.

Plant based beverages have gained significant popularity owing to their absence of casein, cholesterol, and lactose, , as well as the presence of unsaturated fatty acids from their plant sources. These attributes have been associated with various positive health benefits, such as protecting against cardiovascular disease (Pistollato *et al.*, 2018).

Moreover, plant-based beverages often contain other beneficial bioactive compounds. They are characterized by a richness in vegetable proteins, healthy carbohydrates with a reduced glycemic index and a favorable fatty acid profile. Their content in dietary fiber, vitamins (B, E) and antioxidants (polyphenols, phytosterols) is also notable. They are also rich in minerals (potassium and calcium) and low in sodium, which assists in regulating the calcium to phosphorus ratio and maintaining electrolyte balance (Marafon *et al.*, 2025).

A key advantage is the absence of lactose and caseins, which addresses two common dietary issues. Lactose intolerance, caused by a deficiency of the enzyme lactase, leads to insufficient lactose digestion and can manifest as symptoms such as flatulence, abdominal pain, bloating, nausea, vomiting, constipation, watery diarrhea with acidic stools, anus irritation, dehydration, and metabolic acidosis (Fassio *et al.*, 2018). Similarly, a cow's milk protein allergy is an immunological response, often IgE-mediated, triggered by specific milk proteins. For these reasons, individuals with such conditions are advised to avoid lactose- and casein-containing products and opt for alternatives, such as plant-based beverages (Silva *et al.*, 2020).

3.2 Availability and Variety of Sources

Plant-based beverages are derived from a diverse range of sources, including cereals, nuts, seeds and legumes (Penha *et al.*, 2021) as displayed in Table 1. The nutritional composition of different plant-based beverages varies depending on the source material. For instance, cereal-based beverages typically contain higher sugar (starch) levels than those derived from nuts and legumes. Conversely, legume-based beverages are richer in protein while nut-based beverages are generally higher in lipids, though they also provide a good source of protein (Qamar *et al.*, 2020).

Cereal-based beverage

Cereals are a staple food globally, with common examples including maize, wheat, rice, barley, sorghum, millet, teff, oats, and triticale (Basinskiene & Cizeikiene, 2020). Cereal-based beverages have attracted considerable attention because they supply essential nutrients, including dietary fibers, available carbohydrates, proteins, lipids, vitamins, and antioxidants. Their popularity is also growing due to their potential as a source of prebiotics and probiotic.

Rice and oat beverages constitute two of the most widely consumed cereal-based alternatives. Rice, which is typically composed of approximately 90% carbohydrates and 6%–8% proteins, is the primary ingredient in most rice beverages (Ali *et al.*, 2023). The natural sweetness of these products is often a result of an enzymatic process that breaks down carbohydrates into sugars, particularly glucose. Some varieties are also sweetened with sugarcane syrup or other sweeteners (Basinskiene & Cizeikiene, 2020). Beverages made from red or black rice possess notable nutritional value due to their high concentration of phenolic compounds as well as their antioxidant properties (da Silva *et al.*, 2023). Oat beverages, which are also commercially available in a variety of flavors (e.g., sweet, unsweetened, vanilla, chocolate), are characterized by their naturally creamy texture and distinctive flavor. They are often recommended for individuals with irritable bowel syndrome and inflammatory bowel disease (Ramsing *et al.*, 2023).

Beyond these mainstream industrial products, numerous traditional cereal-based beverages exist worldwide. Examples include Sikhye, a South Korean beverage made from cooked rice, malt extract, sugar, and Kunu (Kunun zaki), a Nigerian beverage prepared from sprouted millet, sorghum, or maize (Basinskiene & Cizeikiene, 2020).

Furthermore, the pseudo-cereal quinoa constitutes another promising source for beverage production. Quinoa is very highly valued for its nutritional quality, particularly its protein profile and digestibility. The high-quality protein is attributed to its complete essential amino acid composition, including high levels of methionine, cysteine, and lysine, which are often deficient in most cereals. Quinoa is categorized as "sweet" or "bitter" based on its saponin content, and beverages derived from it have a substantially higher viscosity than other plant-based liquids (Silva *et al.*, 2020)

Legumes

In recent years, several legumes have been studied as potential sources for beverages, such as soy, chickpea, lentil, pea, lupin, bean, pigeon pea and cowpea. Soy beverages are the most widely consumed globally, as soy is considered the leading plant-based source of complete protein, containing all essential amino acids. Soy is also a rich source of carbohydrates, lipids, proteins, vitamins (B6 and K) and bioactive compounds such as polyphenols and isoflavones. These beverages are recognized for their numerous health benefits, especially in the prevention and treatment of several chronic diseases, such as cardiovascular disease and cancer (Vagadia *et al.*, 2017). Chickpea beverage is another valuable source of both protein and carbohydrates, and it is also rich in unsaturated fatty acids, such as linoleic and oleic acids.

Oleaginous seeds, nuts and fruits

Non-dairy beverages are also derived from oleaginous seeds, nuts or fruits including almonds, cashew, coconut, walnuts, sesame, and hazelnuts. The market success of this plant-based beverages is attributed to their appealing flavor profile and nutritional values (Craig & Fresán, 2021). For instance, almonds provide a notable source of macronutrients, with protein content ranging from 35% to 52%, as well as vitamin E, essential minerals such as calcium, magnesium, selenium, potassium, zinc, phosphorus, and copper, and various antioxidants. However, the low emulsifying power of several nut-based beverages often requires the addition of an emulsifying agent to achieve a product stability (Kundu *et al.*, 2018). In addition to lipids, essential amino acids, antioxidant compounds, vitamins B6, B9, and E, iron, and magnesium, these beverages are notably rich in calcium. Moreover, their typically low or absent galactoside content, compared to legume-based drinks, helps mitigate the likelihood of flatulence (Silva *et al.*, 2020).

Table 1. Examples of Some Sources of Plant-Based Beverages: Recipe, Composition, and Extraction

Source	Composition					Extraction of beverage			Composition of beverage				
Cereals	**DM (%)**	**Proteins (%)**	**Fats (%)**	**Carb. (%)**	**Ash (%)**	**Pre-Treatment**	**Extraction**	**Packaging**	**DM (%)**	**Proteins (%)**	**Fats (%)**	**Carb. (%)**	**Ash (%)**
Rice	4.27	0.94	0.1	7.74	0.082 (Zhou *et al.*, 2002)	Soaking in water for 2 hours Draining Cooking (1:3) for 30 min	Blending 200 g of rice with 400 ml of water Sieving twice to achieve a desirable texture	-	12.85±0.18	1.78±0.20	0.32±0.0 6	10.27±0.69	0.48±0.03 (Atwaa *et al.*, 2019)
Oat	-	11.6±0.35	7.23±0.22	-	3.85±0.64 (Zerlasht *et al.*, 2023)	Soaking 100 grams of oat flakes overnight (12 hours) in water and covering the oats with a cloth during the process	Homogenization using a high-speed mixer grinder for approximately 2 minutes Straining through a fine sieve or muslin cloth into a bowl.	Storage in a sterile glass container under refrigeration conditions		1.87±0.01	0.14±0.05	-	0.42±0.09 (Cui *et al.*, 2023)
Nuts	**DM (%)**	**Proteins (%)**	**Fats (%)**	**Carb. (%)**	**Ash (%)**	**Pre-Treatment**	**Extraction**	**Packaging**	**DM (%)**	**Proteins (%)**	**Fats (%)**	**Carb. (%)**	**Ash (%)**
Walnuts	-	15.65±0.22	72.14±0.2	3.88±0.1	4.23±0.02 (Pereira *et al.*, 2008)	Soaking in water for 12 h Peeling	Mixing for 10 min in a blender with water ratio of 1:5 (water/volume) to achieve a milk product with a total solid content of 10 g per 100 g Filtration using a cloth bag	-	-	0.78±0.20	7.50±0.10	0.42±0.13	(Gocer & Koptagel, 2023)
Hazelnuts		13.33	40	40	-	Grinding unroasted hazelnut kernels Soaking in distilled water	Homogenization for 2 minutes by a laboratory homogenizer. Filtration through two folded cloth filter Homogenization by an ultrasound homogenizer at 100 W and 20 kH for 10 minutes	-	11.63±0.25	2.34±0.0	7.48±0.10		0.54±0.07 (Ermis *et al.*, 2018)
Drupes	**DM (%)**	**Proteins (%)**	**Fats (%)**	**Carb. (%)**	**Ash (%)**	**Pre-Treatment**	**Extraction**	**Packaging**	**DM (%)**	**Proteins (%)**	**Fats (%)**	**Carb. (%)**	**Ash (%)**
Coconut	-	6.03±0.04	4.27±0.12	-	8.55±0.55 (Zhang *et al.*, 2022)	Grating coconut meat Filtration using cloth filter to separate the liquid coconut milk from the solid Adding water with a weight ratio of 1:1	Extraction of milk using a slow juice extractor	-	-	3.81±0.00	36.84±0.57	3.47±0.63	1.07±0.04 (Sanjana *et al.*, 2022)

Almonds	-	17.86	50	21.43	(Silva *et al.*, 2020)	Soaking in distilled water for 12 hours Draining and dehulling	Grinding with water in a blender in optimized ratio for 2 min Straining through a two-layer muslin cloth		-	1.380±0.040	8.257±0.048		3.020±0.049 (Kundu *et al.*, 2018)
Cashew nut	-	14.29	43.86	35.71	(Silva *et al.*, 2020)	Soaking in water overnigh Blanching at 8 ºC for 3-4 min	Adding water in the proportion of 1:4 Extraction using a blender at moderate speed for 3-5 min Filtration through muslin		-	5.65±0.08	4.24±0.22	3.44±1.67	0.76±0.15 (Sanjana *et al.*, 2022)

Seed	DM (%)	Proteins (%)	Fats (%)	Carb. (%)	Ash (%)	Pre-Treatment	Extraction	Packaging	DM (%)	Proteins (%)	Fats (%)	Carb. (%)	Ash (%)
Sesame	-	10	36.67	46.67	(Silva *et al.*, 2020)	Roasting seeds in an oven at 145 °C (0 and 20 min) Soaking in tap water containing 0, 0.5 and 1 g/100 mL NaHCO3 for a least 16 h at room temperature (25 °C). Integration wit water (water: sesame, 2:1) Submersion in steam jacketed kettle Blanching at 95 °C for 0, 15 and 30 min	Grinding in an adequate quantity of distilled water for about 20 min Keeping the slurry remained at room temperature (25 °C) for about 1 h before filtering through a double-layered coarse cloth Homogenization at 55 °C and pressure of 6 MPa	Pasteurization at 85 °C for 30 min Storage at 4 °C	Total solids % 10.19-11.16	2.4-2.6 (It varies depending on roasting T°, soaking condition and Blanching time)	7.05-8.02 (It varies depending on roasting T°, soaking condition and Blanching time)	-	0.243-0.319 (It varies depending on roasting T°, soaking condition and Blanching time) (Ahmadian-Kouchaksaraei *et al.*, 2014)
Quinoa	-	2.86	1.79	20	(Silva *et al.*, 2020)	Cleaning 100 g of quinoa Adding water in the proportion 1:7 (quinoa: water) Autoclaving at 112 °C for 30 min for cooking and gelatinization of starch	Grinding in a semi-industrial blender at medium speed for 6 min Adding heat-stable bacterial alpha – amylase Termamyl 120L for liquefaction of starch in the mixture On the proportion of 3 mL/kg of starch and applied at 90 °C for 120 min Application of Amyloglucosidase AMG 300L at a dose of 2 mL/kg of starch to produce glucose, at 60 °C for 60 min Boiling for 15 min for enzymatic inactivation Cooling to 40 °C Filtration with a cloth Adding sunflower oil (1% of the initial mass of quinoa) with a mixer at medium speed for 6 min	Bottling in sterilized glass bottles Pasteurization at 65 °C for 30 min in a water bath Cooling to 4 °C on ice and water bath (Pineli *et al.*, 2015)	-	1.7±0.01	0.2±0.1	14.7	(Pineli *et al.*, 2015)

Legume	DM (%)	Proteins (%)	Fats (%)	Carb. (%)	Ash (%)	Pre-Treatment	Extraction	Packaging	DM (%)	Proteins (%)	Fats (%)	Carb. (%)	Ash (%)
Soy	-	36.67	33.33	36.67	(Silva *et al.*, 2020)	Soaking in distilled water at a ratio of 1:3 (w/w) and for six hours Dehulling Blanching for 8 min in boiling water with 1% of sodium bicarbonate	Mixing with hot water of 85 °C at the mixing ratio of 1:8 (w/w) Blending at 1600 rpm for 4 min Filtration using a food grade fruit juice nylon filter cloth of 200 mesh		-	2.48±0.12	1.45±0.06	1.92±0.04	0.22 ± 0.04 (Matabura & Rweyemamu, 2022)

Processing methods such as roasting and blanching are known to significantly affect the sensory quality of these beverages. Roasting, in particular, promotes Maillard reactions and caramelization, which enhance flavor by producing desirable roasted and nutty notes while reducing bitterness and undesirable volatile compounds (Gao *et al.*, 2019). Blanching aids in deactivating enzymatic activity and eliminating certain off-flavors, thereby resulting in a smoother and cleaner taste profile. Although these processing methods are crucial for enhancing the overall palatability of plant-based milk alternatives, they can also compromise product stability due to protein denaturation (Grasso *et al.*, 2020).

Given the increasing consumer demand, researchers are exploring novel sources, such as seeds from the Aleppo pine (*Pinus halepensis*). These seeds contain 19.8–36.7% oil, 14.25–26.62% protein, and lipid (37%), along with various minerals, and have been demonstrated to be suitable for producing vegetable-based drinks (Abbou *et al.*, 2022). Overall, the vast availability of sources for plant-based beverages represents a significant advantage, enabling a wide variety of sustainable, healthy and accessible options for consumers.

3.3 Manufacturing Process

The fundamental principle underlying the production of a plant-based beverage is a straightforward two-step process: raw plant material is mixed with water, followed by filtration to remove solid residues. This process is generally considered to be rapid and uncomplicated due to the simplicity of the ingredients (McClements, 2020)

For the initial extraction, raw plant material is typically mixed with water and ground during a wet milling process. The quality of the final product is highly dependent on several parameters, including the water-to-raw-material ratio, milling temperature, pH, milling type, and feed rate (Gao *et al.*, 2020). For example, a higher water ratio directly reduces the concentration of dry matter, resulting in a thinner consistency and potentially lower nutritional density (Li *et al.*, 2023). Conversely, a lower water ratio increases nutrient concentration but can negatively affect viscosity, mouthfeel, and processing efficiency. Similarly, the milling temperature and type influence the extent of particle size reduction and the release of intracellular compounds, which in turn affect both the final texture and the efficiency of nutrient extraction (Abbou *et al.*, 2022).

Following extraction, filtration serves to separate the solid residue (cake) from the liquid beverage. (Mat *et al.*, 2022). Several filtering materials are employed, including double-layered cheesecloth, muslin cloth (25 m), and filter paper of different grades (e.g., 150-mesh sieve, 180 µm sieve, 4 µm-pore-size filters, and 100 m filter) (Nawaz *et al.*, 2023). Advanced techniques such as ultrafiltration was employed in the production of hazelnut, sesame, and corn milk substitutes (Naziri *et al.*, 2017). Centrifugation may also be utilized to further clarify the beverage (Abbou *et al.*, 2022).

3.4 Economic Aspect

In recent years, the global popularity and demand for plant-based beverages have seen a substantial increase, and as a reflection of this demand, the global market for these products has also grown. Figure 1 illustrates the global market value of plant-based beverage in 2019 by type. That year, the global soy milk market was valued at approximately $7.4 billion, holding the largest market share worldwide (Sharma *et al.*, 2024). Almond milk followed closely in second place with a market value of $5.4 billion. By 2022, the total global plant-based beverage market generated revenue of approximately $21 billion (Raneri, 2022), representing an increase of over $6 billion since 2013. According to projections from Statista, market revenue is expected to continue its upward trajectory, surpassing $37 billion by 2026 (Sharma *et al.*, 2024).

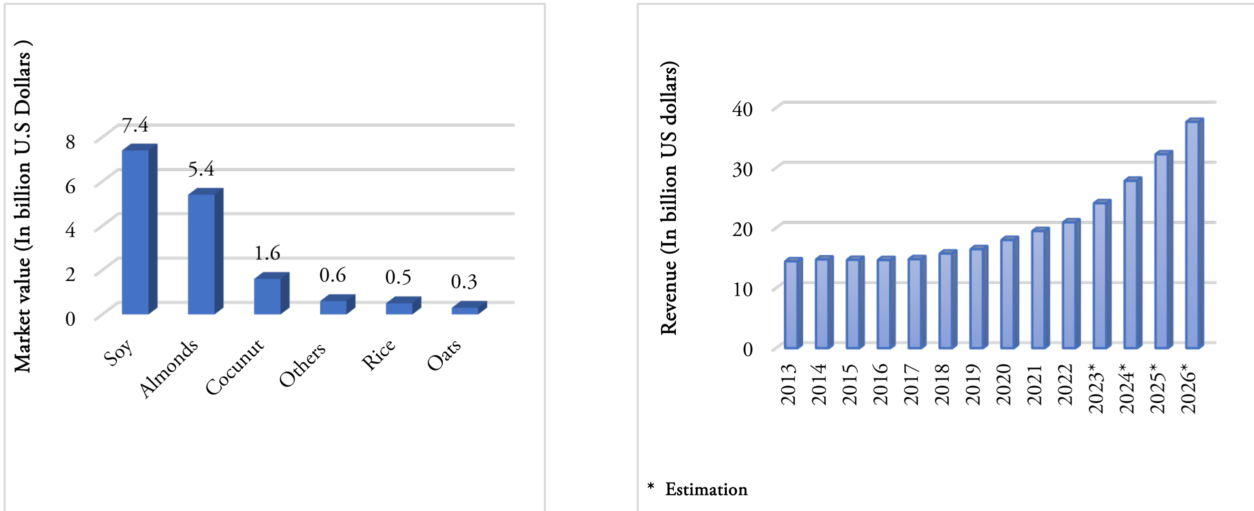

Figure 1. Market Value of Dairy Milk Alternatives Worldwide in 2019, by Type and Revenue from 2013-2026 (In $billion)
Source: Statistics from the links: (Dairy Alternatives: Market Value Worldwide by Type, 2013)

Figure 2 also represents data of the worldwide consumption and the average unit price of milk substitutes from 2013 to 2026. Total consumption reached a new peak of approximately 7 billion kg in 2022, marking an increase of more than 3 billion kg since 2013. Statista estimates that the global consumption of milk substitutes will reach 11.7 billion kg by 2026.

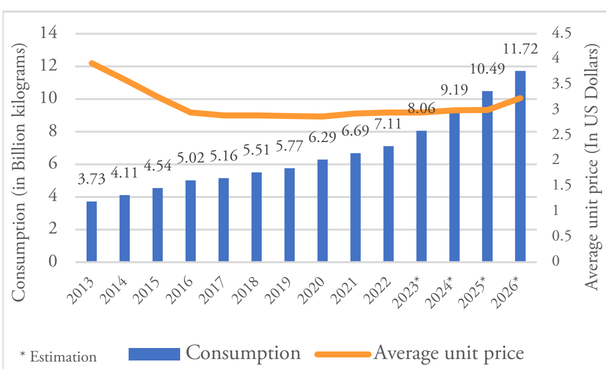

Figure 2. Total Consumption and the Average Unit Price of Milk Substitutes Alternatives Worldwide from 2013-2026 (*Global: Milk Substitute Price per Unit, 2013*)

Available economic data highlights the robust potential of plant-based beverages as a growth driver within the agri-food sector. The sustained increase in global consumption stimulates new business creation, fosters processing innovation, and encourages the development of diverse product lines that address a wide range of nutritional and ethical consumer demands. This dynamic contributes to job creation across agriculture, processing, distribution, and marketing. Furthermore, integrating local raw materials into beverage production enhances the value of regional agricultural resources, supports rural economies and strengthens food sovereignty. The strategic market position of plant-based beverages as sustainable and eco-responsible products market also confers a brand image advantage, opening up promising export opportunities. Thus, the development of this sector actively contributes to the growth of a green, innovative and forward-looking economy.

3.5 Industrial Biotechnology

Plant based beverages, which share physicochemical and sensory similarities with their mammalian counterparts, serve as the foundation for a variety of other dairy analogs, such as cheese, yoghurt, ice creams, and whipped creams (McClements & Grossmann, 2022). These products are typically developed through fermentation processes that enhance the biological activity and organoleptic quality of vegetable materials (Eun *et al.*, 2021). The quality of fermented plant-based products is directly associated with microbial metabolism. During fermentation, microorganisms perform various enzymatic hydrolysis reactions on substances such as proteins, cellulose, and starch, producing amino acids, reducing sugars, and other molecules that affect the final product's quality and flavor (Adebo & Gabriela Medina-Meza, 2020; Xing *et al.*, 2023). The capacity of the initiating microorganism to grow in these vegetable matrices varies significantly depending on the microbial strain, making the control of microbial communities a crucial strategy for regulating fermentation (Erdoğan & Ertekin Filiz, 2023).

Most fermented products documented in the literature have been developed using probiotic bacteria such as *Lactobacillus*, *Bifidobacteria*, and *Streptococcus*. Common raw materials include peas, lupin, potatoes, nuts, corn, almonds, soybeans, coconuts, and rice (Karasakal, 2020; Mårtensson *et al.*, 2000; Sha & Xiong, 2020). Pulses and cereal beverages are considered excellent fermentation substrates for various bacterial strains due to the presence of components with prebiotic properties, such as starch and fiber materials, that also enhance the physical stability of the fermented plant-based beverage (Bosnea *et al.*, 2009; Sindhu & Manickavasagan, 2020). For instance, due its high protein and fat content, marama bean flour has been employed to create a marama beverage, which can also be fermented into a yogurt-like product (Jackson *et al.*, 2010). Numerous examples involve culturing plant-based beverage with the addition of bacteria to produce cheese, yogurt, or ice cream, with a detailed list summarized in Table 2.

The industrial process for developing fermented plant-based products follows a standard sequence: obtaining the plant-based beverage, conditioning it to the ideal growth temperature for the ferments, carrying out the fermentation, and finally, cooling the product to 4 ºC. However, this procedure can be modified depending on the raw material, the specific microorganisms employed (including lactic acid bacteria, bacilli, and yeasts), and the desired characteristics of the final product (Bintsis, 2018). While monocultures remain widely used, recent approaches incorporate mixed cultures of bacteria and yeasts to enhance both nutritional value and flavor (Ferreira *et al.*, 2022). If yeast growth is not desired, it can be controlled through pasteurization, adherence to appropriate manufacturing practices, the utilization of competitive bacterial cultures that rapidly acidify the medium rapidly, and cold storage (Milani & Silva, 2022). An acidifying ingredient such as citric acid, may also be added to reduce or eliminate residual off-flavor

Table 2. Selection of Some Derivatives and Fermented Products of Plant-Based Beverages

Vegan product	Raw material (Prebiotic)	Probiotic bacteria used/ coagulant	Preparation	References
Yoghurt	Peas	*Streptococcus thermophilus, Lactobacillus bulgaricus, Lactobacillus acidophilus, Lactobacillus plantarum and Bifidobacterium lactis.*	After being hydrated, pea protein precipitate was combined with anionic polysaccharide, and by incubating, a protein-polysaccharide electrostatic complex was produced. The incubated product was mixed with sugar, then the product was sterilized (70–121°C/ 0.3–2 hours), and active bacteria were added for fermentation (37–45°C/3–5 hours). Refrigeration was achieved after ripening for 8–12 hours at 0–5°C.	(Liya *et al.*, 2018)
Yoghurt	Almonds, oat and coconuts	*Streptococcus thermophilus and Lactobacillus bulgaricus and Bifidobacterium*	The ingredients (Water, almond, butter, pea protein, glucose, soluble oat fiber and salt) were well mixed, sterilized, homogenized and inoculated with beneficial bacteria (0.02%)	(Margolis *et al.*, 2019)
Yoghurt	Broad Bean (Faba Bean)	*Lactobacillus bulgaricus, Lactobacillus bifidus, Lactobacillus lactis, Lactobacillus casei, Lactobacillus acidophilus, Lactobacillus cremoris, Lactobacillus lactis, Streptococcus thermophilus, or Bifidobacterium bifidus*	After fermentation of liquefied broad bean flour, desired oils, vitamins, stabilizers, sequestrants and flavors were incorporated.	(L'Hocine *et al.*, 2020)
Cheese (for cheesecake or pizza)	Soybeans	Bacillus butyrate	One gram (1 g) of *Bacillus butyricum* powder was added to one liter of soy milk, which was then fermented for 24 hours at 38 °C. One liter of water was added to the resulting curd. The mixture was heated, and maintained at 95°C for five minutes before the solid and liquid components were separated using gauze. Salt and pepper were added to the solid component, which was then dehydrated under a 2 kg load to form a solid block weighing 200 g. Finally, the block was aged in a refrigerator for three months.	(Du *et al.*, 2023)
Goat cheese	Coconuts	Beneficial bacterial, beneficial fungi and plant rennet from Cynara species	Coconut milk was first heated to 70 °C then cooled to 37 °C. Calcium chloride ($CaCl_2$), a defined bacterial culture, and a fungal culture were added, followed by plant-derived rennet. After 24 hours, the milk had fully coagulated. The resulting curds were drained from the whey over a period of 12 hours.	(Iruthayathasan & Lahousse, 2018)
Camembert	Soybeans	*Streptococcus thermophilus, Streptococcus lactis, Lactobacillus casei* and *Penicilium candidum*	Separately, soy milk was pasteurized and cooled to 40–42 °C. A lactic acid bacterial culture (0.5–2% inoculum) was added for acidification, followed by a coagulant. The curd, with a final moisture content of 60–80%, was dehydrated. This product was then aged for 10 days at 10–14°C and 70–90% relative humidity, followed by 7 days of maturation in packaging at 5–8°C.	(Kueppers, 1988)
Fermented walnut milk beverage	Walnuts	kefir grains	a walnut milk beverage was prepared using kefir grains as an inoculum. The fermentation was carried out at 30 °C for 12 hours with an inoculum size of 3 g (wet weight) of kefir grains per 100 mL and a sucrose concentration of 8% (w/v).	(Cui *et al.*, 2013)

and accelerate the fermentation (Gugger *et al.*, 2016). Furthermore, following the fermentation, vitamins, desired oils, stabilizers, viscosity modifiers, gelling agents, sequestrants, oils, and flavors may be incorporated into the final product (L'Hocine *et al.*, 2020).

3.6 Okara as Co-product

Okara is a by-product of food processing, specifically from the manufacturing of plant-based beverages such as soymilk and almond beverages or from tofu production (De Angelis *et al.*, 2023). In addition to minerals and phytochemicals, okara contains a wealth of nutrients, including approximately 50% dietary fiber, 20–30% proteins, and 10–20% lipids. Due to its valuable composition and health-promoting properties, it serves as a low-cost material for human consumption and an excellent substrate for the food industry, with potential benefits in preventing diabetes, obesity and cardiovascular diseases (Perussello *et al.*, 2014).

Several studies focused on using okara in the food industry as a substitute for white or soy flour to increase proteins and fiber in food products or as an ingredient for biscuits preparation without negatively interfering with organoleptic properties. Furthermore, the use of okara in animal feed as a fermentation substrate and environmentally friendly resource has also been documented (De Angelis *et al.*, 2023). For example, a study by Wickramarathna & Arampath, (2003) found that substituting 10% of white flour with okara powder resulted in a bread with nearly identical sensory and physicochemical properties to a control bread, while having a higher energy value (15.9 kJ/g versus 14.4 kJ/g). Another study demonstrated that enzymatically hydrolyzed okara is useful in the bioremediation of chlorpyrifos-contaminated soils as a biofertilizer (Orts *et al.*, 2017).

Okara is produced in massive quantities globally, with an estimated 14 million tonnes annually (Choi *et al.*, 2015), primarily in the United States, Brazil, Argentina and China, which collectively account for more than 86 % of global production (Guimarães *et al.*, 2018). Every year, China produces approximately 2,800,000 tons of okara from the tofu industry (Li *et al.*, 2012). The substantial volumes produced each year pose a significant waste management challenge. Although extensive research has been conducted on the potential use of okara (Perussello *et al.*, 2014), its high moisture content (70–80%) makes fresh okara highly susceptible to spoilage, leading to frequent disposal (Vong & Liu, 2016). To overcome these constraints, fresh okara must be dried as soon as possible to facilitate handling and transportation (Li *et al.*, 2012).

3.7 Environmental Impact

The food system has a profound environmental impact, contributing to biodiversity loss, eutrophication, increased water and land use, and climate change (Aydar *et al.*, 2020). Plant-based beverages are considered a sustainable alternative that promotes animal welfare and helps reduce greenhouse gas emissions and global warming potential due to their low carbon footprint. Their production does not involve animal farming, which is often associated with practices that compromise animal well-being, such as intensive confinement and repeated milking. Moreover, plant-based beverages such as soy, oat, or almond drinks emits significantly fewer greenhouse gases compared to dairy milk, thereby lowering the overall environmental burden (Clune *et al.*, 2017). Overall, plant-based beverages exhibit a lower environmental impact than cow's milk (Silva & Smetana, 2022).

Functional Properties and Health Benefits

Plant-based functional beverages have gained increasing popularity due to their health benefits beyond basic nutrition (Sharma *et al.*, 2024). These beverages are rich in bioactive compounds such as polyphenols, flavonoids, and polysaccharides, which possess antioxidants, anti-inflammatory, and metabolic regulatory properties (Wu *et al.*, 2023). Their composition makes them attractive in the prevention of chronic diseases related to oxidative stress, including coronary heart disease, stroke, and various cancers, as demonstrated by the phenolic content in peanut-based beverages (Sethi *et al.*, 2016).

In addition to their health-promoting effects, plant-based beverages offer valuable technological functionalities. For instance, soy milk is widely used not only as a beverage but also as a functional ingredient in processed foods such as mayonnaise, where it acts as an emulsifier to improve texture and product stability (Rahmati *et al.*, 2014). Moreover, beverages are considered particularly suitable vehicles for delivering nutrients and bioactive compounds due to their convenience, palatability, and versatility (Corbo, 2014). The functional beverage market is expanding rapidly, with growing interest in fortified products and ingredients with enhanced bioavailability (Gupta *et al.*, 2023). These features highlight the potential of plant-based beverages to serve both nutritional and functional purposes, making them essential players in the modern food and health industry landscape.

3.8 Sensory Properties

Although plant-based beverages are intended to mimic the uniform, creamy-white appearance of cow's milk, their appearance inevitably differs due to their plant-based origins (Sethi *et al.*, 2016). However, the diverse textures and hues of these plant-based beverages—such as light brownish, greenish, or grayish—are generally well-accepted by consumers. The acceptability of plant-based beverages is is also heavily influenced by the processing of raw materials.

Studies have demonstrated that roasting, steaming, and pressure-cooking can improve their flavor (Tangyu *et al.*, 2019). Another study demonstrated that blanching significantly enhanced the aroma and taste acceptance of peanut-based beverage (Jain *et al.*, 2013).

4 LIMITATIONS

4.1 Nutritional Profile and Allergens

While plant-based beverages derived from cereals and pseudocereals display a low saturated fat content, their proteins are frequently of a lower nutritional quality compared to animal-based proteins. This is primarily due to their low protein content, a limited supply of the essential amino acid lysine and poor digestibility. Moreover, these beverages are typically deficient in calcium than their competitors. The use of unfortified plant-based beverages, such as rice beverage has been associated with cases of kwashiorkor in some regions (Anema, 2019). Furthermore, plant-based beverages in general, especially rice and oats beverages, do not provide sufficient level of calcium (Sethi *et al.*, 2016). Therefore, plant-based beverages are usually fortified (Friedman, 1996).

Another significant limitation is the potential for allergic reactions. Depending on the raw material, plant-based beverages can trigger allergic responses in consumers. As noted by Reyes-Jurado *et al.*, (2021), common allergens such as wheat, peanuts, tree nuts, and soybeans are frequently used in these products. Soy milk, as well as nut and almond beverage, pose a particular concern due to their potential to cause severe anaphylactic reactions, with nuts being a leading cause of such events (Reyes-Jurado *et al.*, 2021). It is imperative to note that these substitutes may contain proteins that cause allergies even though they do not contain cow's milk proteins (Rial & Sastre, 2018).

Additionally, while some parents favor plant-based alternatives over cow's milk to avoid allergies and digestive issues in infants, these formulas may not provide the entire spectrum of nutrients required for healthy growth and development (Bodnar *et al.*, 2021; Guilbert, 2004).

The nutritional formulation of plant-based beverages depends on their composition. Firstly, most of these food products do not contain sufficient protein and calcium amounts compared with animal milk, so these two nutrients are most frequently incorporated. Vitamins and minerals can also be supplemented for consumers who use plant-based milk as alternatives to cow's milk (McClements, 2020). To improve the taste of this product, cane sugar, sea salt and flavorings like vanilla or chocolate are also frequently added (Fructuoso *et al.*, 2021). For instance, Manzoor *et al.* (2017) employed sugar syrup to sweeten almond and cashew beverages substitutes and also used vanillin following pasteurization. Sunflower oil was mixed with quinoa milk substitute to increase the velvety look (Lima *et al.*, 2022) and olive oil is included in the ingredient list of plant-based milk substitutes of the fomilk brand (Carreño & Dolle, 2018). Increasing the amount of seed used is required to retain as high protein content as is feasible. Several raw ingredients are blended during manufacture to raise the overall protein quantity and ameliorate the product's sensory and nutritional characteristics (Tangyu *et al.*, 2019). Additional option for increasing the protein level of the plant-based milk substitute is to employ a high-protein raw material such as lentils, which possess sensory qualities comparable to those of soy milk (Aydar *et al.*, 2023). Calcium, vitamins A, B2, B1, B12, D2 and E are also incorporated to increase the vitamin and mineral content and use calcium trinitrate to raise the amount of calcium in the final product (Walther *et al.*, 2022).

4.2 Anti-Nutritional Factors

Although oilseeds, legumes, and cereals constitute excellent sources of nutrients, their consumption and use are limited by the presence of anti-nutritional factors. These factors, which include phytates, oxalates, saponins, enzymes inhibitors; tannins and alkaloids are naturally synthesized by plants to protect against pests (Samtiya *et al.*, 2020). These substances are detrimental to health and limit the bioavailability of essential nutrients such as proteins, vitamins, and minerals. The development of optimization processes to reduce these antinutrients, tailored to the specific raw material, remains a key challenge for the future (Arbab Sakandar *et al.*, 2021).

To mitigate their content, various mechanical, physical, and biological techniques can be employed. Pre-processing steps, such as the mechanical removal of natural shells, can eliminate a high concentration of anti-nutrients (Abbou *et al.*, 2023). Thermal processing methods such as cooking, blanching, or roasting can degrade temperature-sensitive molecules, including enzyme inhibitors (Pal *et al.*, 2017). However, for molecules more resistant to heat, biological processes such as fermentation or sprouting, or physical processes like soaking, are more effective (Samtiya *et al.*, 2020). In beverage production, soaking is frequently preferred over biological processes, which can significantly alter the sensory properties of the raw material. The efficacy of soaking depends on key parameters such as time, temperature, and pH (Gupta *et al.*, 2015; Ravoninjatovo *et al.*, 2022; Rawat & Saini, 2022).

4.3 Stabilization of Plant-Based Beverages

Plant-based beverages are complex colloidal systems, typically consisting of an oil-in-water emulsion with dispersed particles, their production process design constitutes a real challenge. Another issue is to guarantee the microbiological stability and maintenance of the physical integrity of the beverage. Without proper stabilization, beverages are prone to undesirable phenomena such as creaming and sedimentation, which are caused by physical destabilization during thermal processing and are often rejected by consumers (Anema, 2019; Poliseli-Scopel *et al.*, 2013).

The ultimate issue is to obtain a product satisfying the taste of consumers without any green off-notes. The manufacturing scheme from the source to the final product, includes three essential unitary operations: pre-extraction (pre-treatment), extraction (milling and clarification) and post-extraction (physical and microbiological stabilization) (Figure 3). This scheme may significantly vary as a function of the seed and its particular transformation challenges.

Formulation

To overcome the inherent limitations of unprocessed plant-based beverages, which may lack essential nutrients or exhibit undesirable sensory and physical characteristics, food additives are frequently incorporated. These additives are crucial for improving the final product's nutritional composition, sensory attributes (taste, texture, appearance), and stability during processing and storage (Jeske *et al.*, 2018). Stabilizers (e.g., gellan gum, xanthan gum), emulsifiers (e.g., lecithin), plant oils (e.g., sunflower oil), and various micronutrient fortifiers (e.g., calcium, vitamins A, D2, E) are frequently employed (Munekata *et al.*, 2020b).

Emulsifiers and Stabilizers

Plant-based beverages are colloidal systems primarily composed of water, lipids, and proteins, which make their physical stabilization a significant challenge. Without appropriate formulation, these beverages are prone to particle sedimentation and phase separation, which are caused by the flocculation of fats and proteins. To counteract these issues and produce stable emulsions with desirable sensory characteristics, the use of specific emulsifiers and stabilizers is essential.

Lecithin, a natural phospholipid emulsifier, reduces the surface tension between the oil and water phases, thereby enhancing the colloidal stability of these beverages. When combined with stabilizers such as xanthan gum, it has been observed to improve both the physical stability and rheological properties of emulsions, as demonstrated in peanut-based beverages (Gama *et al.*, 2019).

Xanthan gum is widely utilized for its ability to create high viscosity at low concentrations which aids prevent creaming and provides a smooth texture. The synergistic interaction between xanthan gum and locust bean gum further enhances viscosity and reduces phase separation, as observed in whey protein-stabilized emulsions (Khouryieh *et al.*, 2015). Similarly, guar gum has demonstrated excellent stabilizing effects at concentrations as low as 0.5%, improving both the physical stability and color attributes of plant-based beverages formulated with peas, beans, and sunflower seeds (Kulczyk *et al.*, 2023). Additionally, citrus pectin can enhance mouthfeel and contribute to the stabilization of emulsions through its gelling properties.

These stabilizers and emulsifiers are commonly used in plant-based milk alternatives derived from various sources such as nuts, seeds, and legumes, either through oil body extraction or direct emulsion formation (McClements *et al.*, 2019). Together, they play a crucial role in maintaining the homogeneity, texture, and shelf-life of plant-based milk alternatives.

For instance, the incorporation of 0.05 g/100 mL of xanthan gum prior to heat treatment has been shown to enhance the viscosity and colloidal stability of hazelnut milk substitute (Dhankhar & Kundu, 2021). Similarly, xanthan gum at a concentration of 0.33% w/w has been effectively employed in rice milk substitutes to prevent particle precipitation (Aydar *et al.*, 2020).

It is imperative to note that the addition of stabilizers is not limited to the post-grinding process (Madsen *et al.*, 2021). Indeed, the addition of 0.05% of the amylase enzyme aids in the dissolution of starch granules, which helps to prevent gelatinization during the heat treatment. (Codina-Torrella *et al.*, 2018).

After filtering, some authors suggest incorporating antioxidants such as ascorbic acid and antimicrobial agents to the soymilk alternative (Chaowattanapanit *et al.*, 2017).

4.4 Packaging

Sterilization

Heat treatment is a critical method employed to extend shelf life and preserve the quality of plant-based beverages. Typical thermal processes include pasteurization, conventional sterilization, and ultra-high temperature (UHT) sterilization (Silva *et al.*, 2020). Among these, sterilization is usually preferred as it enables ambient-temperature storage by inactivating pathogenic microorganisms and thermoresistant spores. The recommended sterilization temperature for these products is typically 121 °C for 15 to 20 minutes (Soni *et al.*, 2021).

Homogenization

Homogenization serves to improve the physical stability of the finished product by modifying its rheology through the reduction of particle size (Jeske *et al.*, 2019). The literature documents the utilization of low, high, and ultra-high pressure for this purpose. The stability, clarity, and whiteness index of milk substitutes have been reported to increase with rising homogenization pressure (D'Incecco *et al.*, 2018; Valsasina *et al.*, 2017).

Aseptic Packaging and Cold Storage

Following processing, plant-based milk alternatives are aseptically packed for distribution and storage, and usually packed in multilayer carton systems (e.g., Tetra Pak®) or plastic bottles. Additionally, Spray-drying or drum-drying techniques can be utilized to produce a stable powder that is later reconstituted (Reyes-Jurado *et al.*, 2021). However, to achieve a stable product, the plant-based beverages must first be stabilized prior the drying process (Dhankhar & Kundu, 2021). For products requiring a long shelf-life and high stability, aseptic packing in conjunction with cold storage is essential (Aydar *et al.*, 2020).

Novel Technologies Plant-Based Beverage Production

The food industry faces the challenge of adopting innovative processes that enhance the physical stability of plant-based beverages while minimizing the reliance on chemical additives such as hydrocolloids and emulsifiers (Şen & Okur, 2023). A range of novel technologies, including ultrasound pulsed electric field, high-intensity ultrasound irradiation, ohmic heating, and ultra-high-pressure homogenization, are being applied to plant-based beverages (Li *et al.*, 2018). These methods are employed to inactivate microbes and enzymes, reduce particle size and decrease viscosity (Manzoor *et al.*, 2021). Some researchers have explored a combination of thermal innovative technologies, such as ohmic heating with ultra-high- and high-pressure homogenization, to improve the final product's quality (Paul *et al.*, 2020).

For instance, studies on almond beverages have demonstrated that ultrasound treatment reduces particle size, when high-pressure homogenization (50-200 MPa) and ultra-high-pressure homogenization (above 200 MPa), can display the opposite effect on particle size (Maghsoudlou *et al.*, 2016; Vanga *et al.*, 2020). Findings from the same authors indicate that a five-minute increase in ultrasound time resulted in a five-fold reduction in particle size, suggesting that ultrasonication is a superior, non-thermal alternative for achieving higher physical stability. Soy milk alternatives have been subjected to ohmic heating and pulsed electric fields (Cho & Kang, 2022). Research has indicated a negligible increase in protein aggregation following ohmic heating, which can occur as a result of protein denaturation (Bernat *et al.*, 2015; Li *et al.*, 2018). While a direct comparison of ohmic heating and pulsed electric field is difficult due to a lack of numerical data on particle size reduction or microbial or enzymatic inactivation (Makroo *et al.*, 2020), pulsed electric fields are generally favored due to their non-thermal nature.

A significant research gap remains in conducting comprehensive comparative studies of these diverse applications. Such comparisons are necessary to identify the optimal technology for industrial applications. However, non-thermal methods are generally considered to possess more beneficial effects on the final product than thermal technologies, as they better preserve nutritional and sensory qualities.

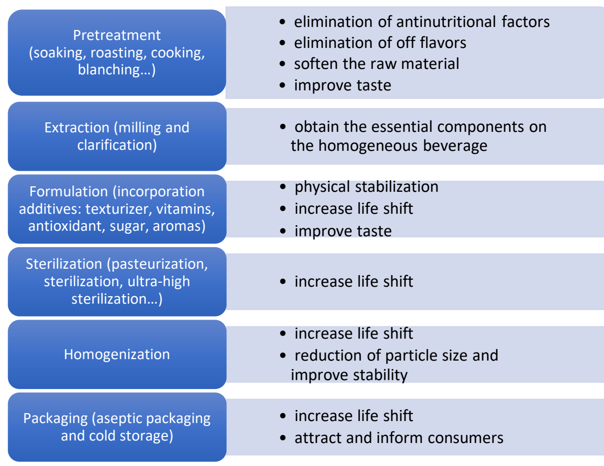

Figure 3. Standard manufacturing diagram of plant-based beverages

4.5 Sensory Attributes

Sensory concerns represent a significant limitation for plant-based beverages, as they can have particle aggregates large enough to impart a gritty or grainy texture, which ultimately reduces consumer acceptance (McClements, 2020). This contrasts sharply with animal milk, being a naturally stable emulsion containing dispersed fat globules and casein micelles. This composition contributes to its smooth and uniform texture, thereby reducing the risk of sedimentation or grittiness (Dickinson, 1997)

Moreover, enzymatic oxidation of polyunsaturated fatty acids by lipoxygenase can lead to the development of undesirable "beany" and "painty" off-flavors in soy milk, a sensory limitation not typically found in animal milk. (Qamar *et al.*, 2020). The familiar and widely accepted flavor profile of cow's milk provides a distinct sensory advantage. While plant-based products frequently fail to meet consumer expectations regarding appearance, aroma, taste, and mouthfeel, animal milk typically satisfies these expectations due to its long-standing cultural integration and consistent sensory profile. Consequently, plant-based alternatives must overcome significant formulation and perception challenges to achieve a comparable level of consumer satisfaction (Aschemann-Witzel & Peschel, 2019).

4.6 Economic Aspects

Despite their rapid market growth, plant-based beverages are subject to several economic limitations. Their production costs are generally higher than those of animal milk, primarily due to the elevated price of raw materials (such as almonds or nuts) and the specialized technological processes required for their transformation (Charrier *et al.*, 2013). This disadvantage is further compounded by the absence of public subsidies that have historically supported the dairy sector, which hinders the large-scale industrial development of plant-based beverages (Perrot *et al.*, 2018).

Additionally, the supply chains for plant-based raw materials are often susceptible to significant price fluctuations, which are influenced by seasonality, climatic hazards or competition from other uses (animal or human food). On the market, this translates into higher retail prices for plant-based beverages compared to cow's milk, which limits their accessibility to certain consumer segments. Therefore, while ethical, environmental, and health considerations drive the growth of plant-based consumption, these economic challenges remain a major barrier to their widespread adoption (Espinosa, 2019).

4.7 Environmental Aspect

The environmental impact of plant-based beverages varies considerably depending on the specific raw materials utilized. For example, the production of almond-based beverages is characterized by a high-water footprint, attributable to the substantial water consumption required for cultivating almond trees (Carlsson Kanyama *et al.*, 2021). Conversely, rice-based beverages, despite requiring a moderate water footprint, necessitate a greater energy input for their production, notably because of the processing requirements.

These variations underscore why some plant-based beverages, despite with a lower overall impact than cow's milk, may have higher water or energy consumption of specific resources. Consequently, a comprehensive environmental assessment of these products must be conducted on a case-by-case basis, taking into consideration the agronomic and industrial particularities of each base ingredient (Silva & Smetana, 2022).

5 Results and Discussion

A review of the selected scientific literature reveals that plant-based beverages are emerging as increasingly popular alternatives to animal milk, driven primarily by ethical, environmental and health considerations. The nutritional profiles of these beverages, present distinct advantages, such as the absence of lactose, cholesterol and animal proteins, which makes them appropriate for individuals with lactose intolerant, milk protein allergies, or those following vegetarian or vegan diets. Furthermore, these beverages are often fortified with fiber and bioactive compounds such as polyphenols, offering additional health benefits.

However, these drinks are also subject to notable limitations. Their protein content is generally lower compared to animal milk, and the protein quality varies according to the raw materials employed. Certain essential vitamins and minerals are sometimes insufficient or absent, which can be problematic, particularly for infants or vulnerable populations. Moreover, the nutritional composition is highly heterogeneous across products, complicating consumer choice and highlighting the need for standardization of formulations.

From a technological standpoint, plant-based beverages frequently incorporate additives such as emulsifiers, stabilizers or vegetable oils designed to improve texture, stability and taste. While these ingredients result in more palatable products, their use can also lead to nutritional imbalances or undesirable sensory effects. The challenges of physical stability (e.g., phase separation, sedimentation) and the presence of unpleasant aromas necessitate innovative processing and formulation improvements. Economically, these products remain generally more expensive than animal milk in various regions, which limits their accessibility to a large part of the population. However, their lower environmental footprint, notably in terms of greenhouse gas emissions, water use, and land consumption, is a strong argument in favor of their development, especially within the context of transition to sustainable food systems.

Finally, the sensory aspect plays a crucial role in the acceptability of plant-based beverages. Consumer preferences vary widely with respect to taste, texture and aroma, underlining the need for a diversified range of products to meet these expectations. Enrichment with functional compounds (e.g., antioxidants, fiber) also serves as a lever for boosting their health appeal. In summary, while plant-based beverages offer a promising alternative to animal milk, they still require major efforts in nutritional, technological and economic optimization to fully meet consumer needs and expectations. The harmonization of quality criteria and enhanced communication regarding their properties would also be advantageous.

6 Conclusion

The market for plant-based beverages continues to expand rapidly, driven by increasing consumer interest in health, sustainability and ethical considerations. These beverages offer several advantages, including the absence of lactose, cholesterol, and animal proteins, which makes them suitable for vegetarians, vegans and individuals with allergies or intolerances. However, their nutritional composition is highly variable, particularly with regard of protein quality and micronutrient content, which are frequently inferior to those of animal milk. This variability stems from differences in raw materials and processing techniques. Unlike animal milk, plant-based beverages offer scope for innovation in formulation and processing, enabling their nutritional profile to be tailored, beneficial compounds to be increased, and anti-nutritional factors to be reduced. Consequently, continuous research is therefore essential to optimize these products to better align with diverse consumer dietary needs and expectations. Ultimately, the selection of a plant-based beverage should be guided by nutritional objectives, sensory preferences, and possible allergenic restrictions, recognizing that no single product currently meets all requirements perfectly.

Acknowledgment: No acknowledgments are necessary for this manuscript.

Source of funding: No funding was received for this review article.

Previous submissions: The manuscript has not been presented at any meeting. There are no previous reports that might be regarded as redundant publication of the same or very similar work.

Authors' Contribution: **Abbou Amina**: Conceptualization, methodology, supervision, validation, visualization, writing-originial draft, writing- review and editing. **Kadri Nabil**, **Servent Adrien**, **Madani Khodir** and **Achir Nawel**: Supervision, validation, visualization, writing-originial draft, writing- review and editing. **Mouhoubi Khokha**, **Medouni-Haroune Lamia**, **Bouiche Cilia**, **Negrichi Samira**, **Meghlaoui Zoubeida**, **Amrane Meriem**, **Bechir Sabiha**, **Taouzinet Lamia** and **Bougherra Hind**: Writing-original draft, writing- review and editing.

Conflicts of Interest: The authors declare that there are no conflicts of interest to disclose regarding the publication of this article.

Preprint deposit: Authors did not share this manuscript as a preprint deposit.

References

Abbou, A., Kadri, N., Giovanetti, G., Morel, G., Aoun, O., Servent, A., Madani, K., Dornier, M., & Achir, N. (2023). Reduction of antinutritional factors during Pinus halepensis seeds beverage processing, a focus on phytates and oxalates. *Journal of Food Composition and Analysis: An Official Publication of the United Nations University, International Network of Food Data Systems*, *124*(105635), 105635. https://doi.org/10.1016/j.jfca.2023.105635 [Crossref] [Google Scholar] [Publisher]

Adebo, O. A., & Gabriela Medina-Meza, I. (2020). Impact of Fermentation on the Phenolic Compounds and Antioxidant Activity of Whole Cereal Grains: A Mini Review. *Molecules* , 25(4). https://doi.org/10.3390/molecules25040927 [Crossref] [Google Scholar] [PubMed] [Publisher]

Ahmadian-Kouchaksaraei, Z., Varidi, M., Varidi, M. J., & Pourazarang, H. (2014). Influence of processing conditions on the physicochemical and sensory properties of sesame milk: A novel nutritional beverage. *Lebensmittel-Wissenschaft Und Technologie [Food Science and Technology]*, *57*(1), 299–305. https://doi.org/10.1016/j.lwt.2013.12.028 [Crossref] [Google Scholar][Publisher]

Ali, A. M., Waheed, A., Shahbaz, M., Mirani, A. A., Shahzad, K., Al-Zahrani, A. A., Nawaz, A. M., & Mahpudz, A. B. (2023). Synergistic evaluation of co-torrefaction performance of rice husk and coffee bean ground blends for biosolid production for industrial fuel sustainability. *Fuel (London, England)*, *343*(127891), 127891. https://doi.org/10.1016/j.fuel.2023.127891 [Crossref] [Google Scholar][Publisher]

Anema, S. G. (2019). Age gelation, sedimentation, and creaming in UHT milk: A review. *Comprehensive Reviews in Food Science and Food Safety, 18*(1), 140–166. https://doi.org/10.1111/1541-4337.12407 [Crossref] [Google Scholar] [PubMed] [Publisher]

Arbab Sakandar, H., Chen, Y., Peng, C., Chen, X., Imran, M., & Zhang, H. (2021). Impact of fermentation on antinutritional factors and protein degradation of legume seeds: A review. *Food Reviews International,* 1–23. https://doi.org/10.1080/87559129.2021.1931300 [Crossref] [Google Scholar][Publisher]

Aschemann-Witzel, J., & Peschel, A. O. (2019). How circular will you eat? The sustainability challenge in food and consumer reaction to either waste-to-value or yet underused novel ingredients in food. *Food Quality and Preference, 77*, 15–20. https://doi.org/10.1016/j.foodqual.2019.04.012 [Crossref] [Google Scholar][Publisher]

Atwaa, E., Elmaadawy, A., & Awaad, E. (2019). Production of fruit flavored probiotic rice milk beverage. *Journal of Food and Dairy Sciences, 10*(12), 453–458. https://doi.org/10.21608/jfds.2019.71360 [Crossref] [Google Scholar][Publisher]

Aydar, E. F., Mertdinç, Z., Demircan, E., Koca Çetinkaya, S., & Özçelik, B. (2023). Kidney bean (Phaseolus vulgaris L.) milk substitute as a novel plant-based drink: Fatty acid profile, antioxidant activity, in-vitro phenolic bio-accessibility and sensory characteristics. Innovative Food Science & Emerging Technologies: *IFSET: The Official Scientific Journal of the European Federation of Food Science and Technology, 83*, 103254. https://doi.org/10.1016/j.ifset.2022.103254 [Crossref] [Google Scholar] [Publisher]

Aydar, E. F., Tutuncu, S., & Ozcelik, B. (2020). Plant-based milk substitutes: Bioactive compounds, conventional and novel processes, bioavailability studies, and health effects. *Journal of Functional Foods, 70*, 103975. https://doi.org/10.1016/j.jff.2020.103975 [Crossref] [Google Scholar] [Publisher]

Basinskiene, L., & Cizeikiene, D. (2020). Cereal-based nonalcoholic beverages. In *Trends in Non-alcoholic Beverages* (pp. 63–99). Elsevier. [Crossref] [Google Scholar] [Publisher]

Bernat, N., Chafer, M., Chiralt, A., Moises Laparra, J., & Gonzalez-Martıne, C. (2015). Almond milk fermented with different potentially probiotic bacteria improves iron uptake by intestinal epithelial (Caco-2) cells. *International Journal of Food Studies*, *4*(1), 49–60. https://doi.org/10.7455/ijfs/4.1.2015.a4 [Crossref] [Google Scholar] [Publisher]

Bintsis, T. (2018). Lactic acid bacteria as starter cultures: An update in their metabolism and genetics. *AIMS Microbiology*, *4*(4), 665–684. https://doi.org/10.3934/microbiol.2018.4.665 [Crossref] [Google Scholar] [PubMed] [Publisher]

Bodnar, L. M., Jimenez, E. Y., & Baker, S. S. (2021). Plant-based beverages in the diets of infants and young children. *JAMA Pediatrics*, *175*(6), 555–556. https://doi.org/10.1001/jamapediatrics.2020.5840 [Crossref] [Google Scholar] [PubMed] [Publisher]

Bosnea, L. A., Kourkoutas, Y., Albantaki, N., Tzia, C., Koutinas, A. A., & Kanellaki, M. (2009). Functionality of freeze-dried L. casei cells immobilized on wheat grains. *Lebensmittel-Wissenschaft Und Technologie [Food Science and Technology]*, *42*(10), 1696–1702. https://doi.org/10.1016/j.lwt.2009.05.011 [Crossref] [Google Scholar] [Publisher]

Carlsson Kanyama, A., Hedin, B., & Katzeff, C. (2021). Differences in environmental impact between plant-based alternatives to dairy and dairy products: A systematic literature review. *Sustainability*, *13*(22), 12599. https://doi.org/10.3390/su132212599 [Crossref] [Google Scholar] [Publisher]

Carreño, I., & Dolle, T. (2018). Tofu steaks? Developments on the naming and marketing of plant-based foods in the aftermath of the TofuTown judgement. *European Journal of Risk Regulation*, *9*(3), 575–584. https://doi.org/10.1017/err.2018.43 [Crossref] [Google Scholar] [Publisher]

Chaowattanapanit, S., Silpa-Archa, N., Kohli, I., Lim, H. W., & Hamzavi, I. (2017). Postinflammatory hyperpigmentation: A comprehensive overview: Treatment options and prevention. *Journal of the American Academy of Dermatology*, *77*(4), 607–621. https://doi.org/10.1016/j.jaad.2017.01.036 [Crossref] [Google Scholar] [PubMed] [Publisher]

Charrier, F., Magrini, M.-B., Charlier, A., Fares, M., Le Bail, M., Messéan, A., & Meynard, J.-M. (2013). Alimentation animale et organisation des filières : une comparaison pois protéagineux-lin oléagineux pour comprendre les facteurs freinant ou favorisant les cultures de diversification. *OCL*, *20*(4), D407. https://doi.org/10.1051/ocl/2013011 [Crossref] [Google Scholar][Publisher]

Cho, E.-R., & Kang, D.-H. (2022). Intensified inactivation efficacy of pulsed ohmic heating for pathogens in soybean milk due to sodium lactate. *Food Control*, *137*(108936), 108936. https://doi.org/10.1016/j.foodcont.2022.108936 [Crossref] [Google Scholar][Publisher]

Choi, I. S., Kim, Y. G., Jung, J. K., & Bae, H.-J. (2015). Soybean waste (okara) as a valorization biomass for the bioethanol production. *Energy (Oxford, England)*, *93*, 1742–1747. https://doi.org/10.1016/j.energy.2015.09.093 [Crossref] [Google Scholar][Publisher]

Clune, S., Crossin, E., & Verghese, K. (2017). Systematic review of greenhouse gas emissions for different fresh food categories. *Journal of Cleaner Production*, *140*, 766–783. https://doi.org/10.1016/j.jclepro.2016.04.082 [Crossref] [Google Scholar][Publisher]

Codina-Torrella, I., Guamis, B., Zamora, A., Quevedo, J. M., & Trujillo, A. J. (2018). Microbiological stabilization of tiger nuts' milk beverage using ultra-high pressure homogenization. A preliminary study on microbial shelf-life extension. *Food Microbiology*, *69*, 143–150. https://doi.org/10.1016/j.fm.2017.08.002 [Crossref] [Google Scholar] [PubMed] [Publisher]

Corbo, M. (2014). Functional beverages: the emerging side of functional foods: commercial trends, research, and health implications. *Comprehensive Reviews in Food Science and Food Safety*, *6*, 1192–1206. [Crossref] [Google Scholar][Publisher]

Craig, W. J., & Fresán, U. (2021). International analysis of the nutritional content and a review of health benefits of non-dairy plant-based beverages. *Nutrients*, *13*(3), 842. https://doi.org/10.3390/nu13030842 [Crossref] [Google Scholar] [PubMed] [Publisher]

Cui, L., Jia, Q., Zhao, J., Hou, D., & Zhou, S. (2023). A comprehensive review on oat milk: from oat nutrients and phytochemicals to its processing technologies, product features, and potential applications. *Food & Function*, *14*(13), 5858–5869. https://doi.org/10.1039/d3fo00893b [Crossref] [Google Scholar] [PubMed] [Publisher]

Cui, X.-H., Chen, S.-J., Wang, Y., & Han, J.-R. (2013). Fermentation conditions of walnut milk beverage inoculated with kefir grains. *Lebensmittel-Wissenschaft Und*

Technologie [Food Science and Technology], *50*(1), 349–352. https://doi.org/10.1016/j.lwt.2012.07.043 [Crossref] [Google Scholar][Publisher]

da Silva, L. R., Velasco, J. I., & Fakhouri, F. M. (2023). Use of rice on the development of plant-based milk with antioxidant properties: From raw material to residue. *Lebensmittel-Wissenschaft Und Technologie [Food Science and Technology]*, *173*(114271), 114271. https://doi.org/10.1016/j.lwt.2022.114271 [Crossref] [Google Scholar][Publisher]

Dairy Alternatives: Market Value Worldwide by Type. (2013).

De Angelis, D., Pasqualone, A., Squeo, G., & Summo, C. (2023). Almond okara as a valuable ingredient in biscuit preparation. *Journal of the Science of Food and Agriculture*, *103*(4), 1676–1683. https://doi.org/10.1002/jsfa.12286 [Crossref] [Google Scholar] [PubMed] [Publisher]

Dhankhar, J., & Kundu, P. (2021). Stability aspects of non-dairy milk alternatives. In *Milk Substitutes - Selected Aspects*. IntechOpen. [Crossref] [Google Scholar] [PubMed] [Publisher]

Dickinson, E. (1997). Properties of emulsions stabilized with milk proteins: Overview of some recent developments. *Journal of Dairy Science, 80*(10), 2607–2619. https://doi.org/10.3168/jds.s0022-0302(97)76218-0 [Crossref] [Google Scholar][Publisher]

D'Incecco, P., Rosi, V., Cabassi, G., Hogenboom, J. A., & Pellegrino, L. (2018). Microfiltration and ultra-high-pressure homogenization for extending the shelf-storage stability of UHT milk. *Food Research International (Ottawa, Ont.)*, *107*, 477–485. https://doi.org/10.1016/j.foodres.2018.02.068 [Crossref] [Google Scholar] [PubMed] [Publisher]

Du, L., Chen, W., Wang, J., Huang, L., Zheng, Q., Chen, J., Wang, L., Cai, C., Zhang, X., Wang, L., Zhong, Q., Zhong, W., Fang, X., & Liao, Z. (2023). Beneficial effects of Bacillus amyloliquefaciens D1 soy milk supplementation on serum biochemical indexes and intestinal health of bearded chickens. *Microorganisms*, *11*(7). https://doi.org/10.3390/microorganisms11071660 [Crossref] [Google Scholar] [PubMed] [Publisher]

Erdoğan, A. K., & Ertekin Filiz, B. (2023). Menaquinone content and antioxidant properties of fermented cabbage products: Effect of different fermentation techniques and microbial cultures. *Journal of Functional Foods, 102*, 105467. https://doi.org/10.1016/j.jff.2023.105467 [Crossref] [Google Scholar][Publisher]

Ermis, E., Güner, K. Ö., & Yilmaz, M. T. (2018). Characterization of hazelnut milk powders: A comparison of spray-drying and freeze-drying. *International Journal of Food Engineering*, *14*(11–12). https://doi.org/10.1515/ijfe-2018-0085 [Crossref] [Google Scholar][Publisher]

Espinosa, R. (2019). L'éléphant dans la pièce. Pour une approche économique de l'alimentation végétale et de la condition animale. *Revue d'economie politique, 129*(3), 287–324. https://doi.org/10.3917/redp.293.0287 [Crossref] [Google Scholar][Publisher]

Eun, S. Y., Cheon, Y.-H., Park, G. D., Chung, C. H., Lee, C. H., Kim, J.-Y., & Lee, M. S. (2021). Anti-Osteoporosis Effects of the Eleutherococcus senticosus, Achyranthes japonica, and Atractylodes japonica Mixed Extract Fermented with Nuruk. *Nutrients, 13*(11). https://doi.org/10.3390/nu13113904 [Crossref] [Google Scholar] [PubMed] [Publisher]

Fassio, F., Facioni, M. S., & Guagnini, F. (2018). Lactose maldigestion, malabsorption, and intolerance: A comprehensive review with a focus on current management and future perspectives. *Nutrients, 10*(11), 1599. https://doi.org/10.3390/nu10111599 [Crossref] [Google Scholar] [PubMed] [Publisher]

Ferreira, I., de Sousa Melo, D., Menezes, A. G. T., Fonseca, H. C., de Assis, B. B. T., Ramos, C. L., Magnani, M., Dias, D. R., & Schwan, R. F. (2022). Evaluation of potentially probiotic yeasts and Lactiplantibacillus plantarum in co-culture for the elaboration of a functional plant-based fermented beverage. *Food Research International (Ottawa, Ont.)*, *160*(111697), 111697. https://doi.org/10.1016/j.foodres.2022.111697 [Crossref] [Google Scholar] [PubMed] [Publisher]

Friedman, M. (1996). Relationship between the geometry and quantitative morphology of the left anterior descending coronary artery. *Atherosclerosis, 125*(2), 183–192. https://doi.org/10.1016/s0021-9150(96)05869-8 [Crossref] [Google Scholar] [PubMed] [Publisher]

Fructuoso, I., Romão, B., Han, H., Raposo, A., Ariza-Montes, A., Araya-Castillo, L., & Zandonadi, R. P. (2021). An Overview on Nutritional Aspects of Plant-Based Beverages Used as Substitutes for Cow's Milk. *Nutrients, 13*(8). https://doi.org/10.3390/nu13082650 [Crossref] [Google Scholar] [PubMed] [Publisher]

Gama, A. P., Hung, Y.-C., & Adhikari, K. (2019). Optimization of emulsifier and stabilizer concentrations in a model peanut-based beverage system: A mixture design approach. *Foods (Basel, Switzerland), 8(*4), 116. https://doi.org/10.3390/foods8040116 [Crossref] [Google Scholar] [PubMed] [Publisher]

Gao, W., Chen, F., Wang, X., & Meng, Q. (2020). Recent advances in processing food powders by using superfine grinding techniques: A review. *Comprehensive Reviews in Food Science and Food Safety, 19*(4), 2222–2255. https://doi.org/10.1111/1541-4337.12580 [Crossref] [Google Scholar] [PubMed] [Publisher]

Gao, Y., Hamid, N., Gutierrez-Maddox, N., Kantono, K., & Kitundu, E. (2019). Development of a probiotic beverage using breadfruit flour as a substrate. *Foods (Basel, Switzerland),* *8*(6), 214. https://doi.org/10.3390/foods8060214 [Crossref] [Google Scholar] [PubMed] [Publisher]

Gaucheron, F. (2011). Milk and dairy products: A unique micronutrient combination. *Journal of the American College of Nutrition,* *30*(sup5), 400S-409S. https://doi.org/10.1080/07315724.2011.10719983 [Crossref] [Google Scholar] [PubMed] [Publisher]

Global: Milk Substitute Price per Unit. (2013).

Gocer, E. M. C., & Koptagel, E. (2023). Production of milks and kefir beverages from nuts and certain physicochemical analysis. Food Chemistry, 402. [Crossref] [Google Scholar] [PubMed] [Publisher]

Grasso, N., Alonso-Miravalles, L., & O'Mahony, J. A. (2020). Composition, physicochemical and sensorial properties of commercial plant-based yogurts. *Foods (Basel, Switzerland),* *9*(3), 252. https://doi.org/10.3390/foods9030252 [Crossref] [Google Scholar] [PubMed] [Publisher]

Gugger, E. T., Galuska, P., & Tremaine, A. (2016). Legume-based dairy substitute and consumable food products incorporating same (USPTO Patent No. 20160309732:A1). *In US Patent* (20160309732:A1). https://patentimages.storage.googleapis.com/5a/98/eb/5b40ffadb366be/US20160309732A1.pdf [Google Scholar] [Publisher]

Guilbert, J.-J. (2004). Une vision OMS des facultés de médecine à travers le monde. *Pédagogie Médicale, 5*(3), 167–170. https://doi.org/10.1051/pmed:2004024 [Crossref] [Google Scholar][Publisher]

Guimarães, R. M., Silva, T. E., Lemes, A. C., Boldrin, M. C. F., da Silva, M. A. P., Silva, F. G., & Egea, M. B. (2018). Okara: A soybean by-product as an alternative to enrich vegetable paste. *Lebensmittel-Wissenschaft Und Technologie [Food Science and Technology]*, *92*, 593–599. https://doi.org/10.1016/j.lwt.2018.02.058 [Crossref] [Google Scholar][Publisher]

Gupta, A., Sanwal, N., Bareen, M. A., Barua, S., Sharma, N., Joshua Olatunji, O., Prakash Nirmal, N., & Sahu, J. K. (2023). Trends in functional beverages: Functional ingredients, processing technologies, stability, health benefits, and consumer perspective. *Food Research International (Ottawa, Ont.), 170*(113046), 113046. https://doi.org/10.1016/j.foodres.2023.113046 [Crossref] [Google Scholar] [PubMed] [Publisher]

Gupta, R. K., Gangoliya, S. S., & Singh, N. K. (2015). Reduction of phytic acid and enhancement of bioavailable micronutrients in food grains. *Journal of Food Science and Technology,* *52*(2), 676–684. https://doi.org/10.1007/s13197-013-0978-y [Crossref] [Google Scholar] [PubMed] [Publisher]

Haas, R., Schnepps, A., Pichler, A., & Meixner, O. (2019). Cow milk versus plant-based milk substitutes: A comparison of product image and motivational structure of consumption. *Sustainability,* *11*(18), 5046. https://doi.org/10.3390/su11185046 [Crossref] [Google Scholar][Publisher]

Iruthayathasan, E. E., & Lahousse, B. (2018). method of preparing a vegan cheese (EPO Patent No. 3 366 144 A1). *In European Patent* (3 366 144 A1). https://patentscope.wipo.int/search/en/detail.jsf?docId=EP279868219&_cid=P11-LF9E8A-77158-1

Jackson, J. C., Duodu, K. G., Holse, M., Lima de Faria, M. D., Jordaan, D., Chingwaru, W., Hansen, A., Cencic, A., Kandawa-Schultz, M., Mpotokwane, S. M., Chimwamurombe, P., de Kock, H. L., & Minnaar, A. (2010). The morama bean (Tylosema esculentum): a potential crop for southern Africa. *Advances in Food and Nutrition Research,* *61*, 187–246. https://doi.org/10.1016/B978-0-12-374468-5.00005-2 [Crossref] [Google Scholar] [PubMed] [Publisher]

Jain, P., Yadav, D. N., Rajput, H., & Bhatt, D. K. (2013). Effect of pressure blanching on sensory and proximate composition of peanut milk. *Journal of Food Science and Technology,* *50*(3), 605–608. https://doi.org/10.1007/s13197-011-0373-5 [Crossref] [Google Scholar] [PubMed] [Publisher]

Jeske, S., Bez, J., Arendt, E. K., & Zannini, E. (2019). Formation, stability, and sensory characteristics of a lentil-based milk substitute as affected by homogenisation and pasteurisation. *European Food Research and Technology*, *245*(7), 1519–1531. https://doi.org/10.1007/s00217-019-03286-0 [Crossref] [Google Scholar][Publisher]

Jeske, S., Zannini, E., & Arendt, E. K. (2018). Past, present and future: The strength of plant-based dairy substitutes based on gluten-free raw materials. *Food Research International (Ottawa, Ont.),* *110*, 42–51. https://doi.org/10.1016/j.foodres.2017.03.045 [Crossref] [Google Scholar] [PubMed] [Publisher]

Karasakal, A. (2020). Determination of Trace and Major Elements in Vegan Milk and Oils by ICP-OES After Microwave Digestion. *Biological Trace Element Research, 197*(2), 683–693. https://doi.org/10.1007/s12011-019-02024-7 [Crossref] [Google Scholar] [PubMed] [Publisher]

Khouryieh, H., Puli, G., Williams, K., & Aramouni, F. (2015). Effects of xanthan-locust bean gum mixtures on the physicochemical properties and oxidative stability of whey protein stabilised oil-in-water emulsions. *Food Chemistry, 167,* 340–348.

https://doi.org/10.1016/j.foodchem.2014.07.009 [Crossref] [Google Scholar] [PubMed] [Publisher]

Kueppers, C. (1988). Camembert cheese-like product made from soya bean milk (Patent No. DE:3730384:A1). *In Patent* (DE:3730384:A1).

Kulczyk, E., Drozłowska-Sobieraj, E., & Bartkowiak, A. (2023). Novel milk substitute based on pea, bean and sunflower seeds with natural bioactive stabilisers. *Plants, 12*(12). https://doi.org/10.3390/plants12122303 [Crossref] [Google Scholar] [PubMed] [Publisher]

Kundu, P., Dhankhar, J., & Sharma, A. (2018). Development of non dairy milk alternative using soymilk and almond milk. *Current Research in Nutrition and Food Science Journal, 6*(1), 203–210. https://doi.org/10.12944/crnfsj.6.1.23 [Crossref] [Google Scholar] [Publisher]

L'Hocine, L., Martineau-Côté, D., Achouri, A., Wanasundara, J. P. D., & Loku Hetti Arachchige, G. W. (2020). Broad bean (Faba bean). In *Pulses* (pp. 27–54). Springer International Publishing. [Crossref] [Google Scholar][Publisher]

Li, B., Qiao, M., & Lu, F. (2012). Composition, Nutrition, and Utilization of Okara (Soybean Residue). *Food Reviews International, 28*(3), 231–252. https://doi.org/10.1080/87559129.2011.595023 [Crossref] [Google Scholar][Publisher]

Li, X., Ye, C., Tian, Y., Pan, S., & Wang, L. (2018). Effect of ohmic heating on fundamental properties of protein in soybean milk. *Journal of Food Process Engineering, 41*(3), e12660. https://doi.org/10.1111/jfpe.12660 [Crossref] [Google Scholar][Publisher]

Li, Y., Gao, J., Lv, J., Lambo, M. T., Wang, Y., Wang, L., & Zhang, Y. (2023). Replacing soybean meal with high-oil pumpkin seed cake in the diet of lactating Holstein dairy cows modulated rumen bacteria and milk fatty acid profile. *Journal of Dairy Science, 106*(3), 1803–1814. https://doi.org/10.3168/jds.2022-22503 [Crossref] [Google Scholar] [PubMed] [Publisher]

Lima, M., Costa, R., Rodrigues, I., Lameiras, J., & Botelho, G. (2022). A Narrative Review of Alternative Protein Sources: Highlights on Meat, Fish, Egg and Dairy Analogues. *Foods (Basel, Switzerland), 11*(14). https://doi.org/10.3390/foods11142053 [Crossref] [Google Scholar] [PubMed] [Publisher]

Liya, L., Sumei, Z., Shujie, Tong, P. L., Lili, W., & Xianrong, Z. (2018). Pea protein vegan plant-based yoghurt and preparation method thereof (Patent No. CN109566747). *In Patent* (No. CN109566747). https://patentscope.wipo.int/search/en/detail.jsf?docId=CN241313696&_cid=P11-LF9OSN-65921-1

Madsen, S. K., Thulesen, E. T., Mohammadifar, M. A., & Bang-Berthelsen, C. H. (2021). Chufa Drink: Potential in Developing a New Plant-Based Fermented Dessert. *Foods (Basel, Switzerland), 10*(12). https://doi.org/10.3390/foods10123010 [Crossref] [Google Scholar] [PubMed] [Publisher]

Maghsoudlou, Y., Alami, M., Mashkour, M., & Shahraki, M. H. (2016). Optimization of ultrasound-assisted stabilization and formulation of almond milk. *Journal of Food Processing and Preservation, 40*(5), 828–839. https://doi.org/10.1111/jfpp.12661 [Crossref] [Google Scholar][Publisher]

Mäkinen, O. E., Wanhalinna, V., Zannini, E., & Arendt, E. K. (2016). Foods for special dietary needs: Non-dairy plant-based milk substitutes and fermented dairy-type products. *Critical Reviews in Food Science and Nutrition, 56*(3), 339–349. https://doi.org/10.1080/10408398.2012.761950 [Crossref] [Google Scholar] [PubMed] [Publisher]

Makroo, H. A., Rastogi, N. K., & Srivastava, B. (2020). Ohmic heating assisted inactivation of enzymes and microorganisms in foods: A review. *Trends in Food Science & Technology, 97*, 451–465. https://doi.org/10.1016/j.tifs.2020.01.015 [Crossref] [Google Scholar][Publisher]

Manzoor, M. F., Siddique, R., Hussain, A., Ahmad, N., Rehman, A., Siddeeg, A., Alfarga, A., Alshammari, G. M., & Yahya, M. A. (2021). Thermosonication effect on bioactive compounds, enzymes activity, particle size, microbial load, and sensory properties of almond (Prunus dulcis) milk. *Ultrasonics Sonochemistry, 78*, 105705. https://doi.org/10.1016/j.ultsonch.2021.105705 [Crossref] [Google Scholar] [PubMed] [Publisher]

Marafon, K., Prestes, A. A., Carvalho, A. C. F., de Souza, C. K., & Prudencio, E. S. (2025). Bioactive compounds' importance in plant-based beverages: a review. *Current Opinion in Food Science*, *63*(101304), 101304. https://doi.org/10.1016/j.cofs.2025.101304 [Crossref] [Google Scholar] [Publisher]

Margolis, G., Myers, S., & Newbold, D. (2019). Manufacturing of plant-based yogurt (USPTO Patent No. 20190274324:A1). *In US Patent* (20190274324:A1). https://patentimages.storage.googleapis.com/ac/79/60/12f2702cf50591/US20190274324A1.pdf

Mårtensson, O., Öste, R., & Holst, O. (2000). Lactic Acid Bacteria in an Oat-based Non-dairy Milk Substitute: Fermentation Characteristics and Exopolysaccharide Formation. LWT - *Food Science and Technology, 33*(8), 525–530. https://doi.org/10.1006/fstl.2000.0718 [Crossref] [Google Scholar][Publisher]

Mat, K., Abdul Kari, Z., Rusli, N. D., Che Harun, H., Wei, L. S., Rahman, M. M., Mohd Khalid, H. N., Mohd Ali Hanafiah, M. H., Mohamad Sukri, S. A., Raja Khalif, R. I. A., Mohd Zin, Z., Mohd Zainol, M. K., Panadi, M., Mohd Nor, M. F., & Goh, K. W. (2022). Coconut Palm:

Food, Feed, and Nutraceutical Properties. *Animals : An Open Access Journal from MDPI, 12*(16). https://doi.org/10.3390/ani12162107 [Crossref] [PubMed] [Google Scholar] [Publisher]

Matabura, V. V., & Rweyemamu, L. M. P. (2022). Formulation of plant-based food and characterisation of the nutritional composition: A case study on soy-moringa beverage. *Journal of Food Science and Technology, 59*(10), 3794–3805. https://doi.org/10.1007/s13197-022-05397-1 [Crossref] [Google Scholar] [PubMed] [Publisher]

McClements, D. J. (2020). Development of Next-Generation Nutritionally Fortified Plant-Based Milk Substitutes: Structural Design Principles. *Foods (Basel, Switzerland), 9*(4). https://doi.org/10.3390/foods9040421 [Crossref] [Google Scholar] [PubMed] [Publisher]

McClements, D. J., & Grossmann, L. (2022). Dairy Alternatives – Cheese, Yogurt, Butter, and Ice Cream. In D. J. McClements & L. Grossmann (Eds.), Next-Generation Plant-based Foods: Design, Production, and Properties (pp. 443–521). *Springer International Publishing.* https://doi.org/10.1007/978-3-030-96764-2_9 [Crossref] [Google Scholar][Publisher]

McClements, D. J., Newman, E., & McClements, I. F. (2019). Plant-based milks: A review of the science underpinning their design, fabrication, and performance. *Comprehensive Reviews in Food Science and Food Safety, 18*(6), 2047–2067. https://doi.org/10.1111/1541-4337.12505 [Crossref] [Google Scholar] [PubMed] [Publisher]

Mesfine, S., Feyera, T., & Mohammed, O. (2015). Microbiological quality of raw cow's milk from four dairy farms in Dire Dawa City, Eastern Ethiopia. Eastern Ethiopia. *World Journal of Dairy & Food Sciences, 10*(1), 9–14. [Crossref] [Google Scholar] [Publisher]

Milani, E. A., & Silva, F. V. M. (2022). Pasteurization of beer by non-thermal technologies. *Frontiers in Food Science and Technology*, 1. https://doi.org/10.3389/frfst.2021.798676 [Crossref] [Google Scholar][Publisher]

Munekata, P. E. S., Domínguez, R., Budaraju, S., Roselló-Soto, E., Barba, F. J., Mallikarjunan, K., Roohinejad, S., & Lorenzo, J. M. (2020a). Effect of Innovative Food Processing Technologies on the Physicochemical and Nutritional Properties and Quality of Non-Dairy Plant-Based Beverages. *Foods (Basel, Switzerland), 9*(3). https://doi.org/10.3390/foods9030288 [Crossref] [Google Scholar] [PubMed] [Publisher]

Munekata, P. E. S., Gullón, B., Pateiro, M., Tomasevic, I., Domínguez, R., & Lorenzo, J. M. (2020b). Natural antioxidants from seeds and their application in meat products. *Antioxidants (Basel, Switzerland), 9*(9), 815. https://doi.org/10.3390/antiox9090815 [Crossref] [Google Scholar] [PubMed] [Publisher]

Nawaz, M. A., Buckow, R., Katopo, L., & Stockmann, R. (2023). Plant-based beverages. *In Engineering Plant-Based Food Systems (pp. 99–129). Elsevier*. https://doi.org/10.1016/b978-0-323-89842-3.00015-4 [Crossref] [Google Scholar] [PubMed] [Publisher]

Naziri, E., Koupantsis, T., Mantzouridou, F. T., Paraskevopoulou, A., Tsimidou, M. Z., & Kiosseoglou, V. (2017). Influence of thermal treatment on the stability of vegetable "milk" obtained by ultrafiltration of aqueous oil body extracts from various sources. *European Journal of Lipid Science and Technology: EJLST, 119*(7), 1600362. https://doi.org/10.1002/ejlt.201600362 [Crossref] [Google Scholar][Publisher]

Orts, A., Cabrera, S., Gómez, I., Parrado, J., Rodriguez-Morgado, B., & Tejada, M. (2017). Use of okara in the bioremediation of chlorpyrifos in soil: Effects on soil biochemical properties. *Applied Soil Ecology: A Section of Agriculture, Ecosystems & Environment, 121*, 172–176. https://doi.org/10.1016/j.apsoil.2017.09.042 [Crossref] [Google Scholar][Publisher]

Pal, R. S., Bhartiya, A., Yadav, P., Kant, L., Mishra, K. K., Aditya, J. P., & Pattanayak, A. (2017). Effect of dehulling, germination and cooking on nutrients, anti-nutrients, fatty acid composition and antioxidant properties in lentil (Lens culinaris). *Journal of Food Science and Technology, 54*(4), 909–920. https://doi.org/10.1007/s13197-016-2351-4 [Crossref] [Google Scholar] [PubMed] [Publisher]

Paul, A. A., Kumar, S., Kumar, V., & Sharma, R. (2020). Milk Analog: Plant based alternatives to conventional milk, production, potential and health concerns. *Critical Reviews in Food Science and Nutrition, 60*(18), 3005–3023. https://doi.org/10.1080/10408398.2019.1674243 [Crossref] [Google Scholar] [PubMed] [Publisher]

Penha, C. B., Santos, V. D. P., Speranza, P., & Kurozawa, L. E. (2021). Plant-based beverages: Ecofriendly technologies in the production process. Innovative Food Science & Emerging Technologies 72. [Crossref] [Google Scholar][Publisher]

Pereira, J. A., Oliveira, I., Sousa, A., Ferreira, I. C. F. R., Bento, A., & Estevinho, L. (2008). Bioactive properties and chemical composition of six walnut (Juglans regia L). *Juglans Regia L.) Cultivars. Food and Chemical Toxicology, 46*, 2103–2111. [Crossref] [Google Scholar] [PubMed] [Publisher]

Perrot, C., Chatellier, V., Gouin, D.-M., Richard, M., & You, G. (2018). Le secteur laitier français est-il compétitif face à la concurrence européenne et mondiale ? *Économie Rurale,* 364, 109–127. https://doi.org/10.4000/economierurale.5624 [Crossref] [Google Scholar][Publisher]

Perussello, C. A., Mariani, V. C., & Amarante, Á. C. C. do. (2014). Thermophysical Properties of Okara During

Drying. *International Journal of Food Properties, 17*(4), 891–907. https://doi.org/10.1080/10942912.2011.628430 [Crossref] [Google Scholar][Publisher]

Pineli, L. de L. de O., Botelho, R. B. A., Zandonadi, R. P., Solorzano, J. L., de Oliveira, G. T., Reis, C. E. G., & Teixeira, D. da S. (2015). Low glycemic index and increased protein content in a novel quinoa milk. Lebensmittel-Wissenschaft Und Technologie *[Food Science and Technology], 63*(2), 1261–1267. https://doi.org/10.1016/j.lwt.2015.03.094 [Crossref] [Google Scholar][Publisher]

Pistollato, F., Iglesias, R. C., Ruiz, R., Aparicio, S., Crespo, J., Lopez, L. D., Manna, P. P., Giampieri, F., & Battino, M. (2018). Nutritional patterns associated with the maintenance of neurocognitive functions and the risk of dementia and Alzheimer's disease: A focus on human studies. Pharmacological Research: *The Official Journal of the Italian Pharmacological Society, 131*, 32–43. https://doi.org/10.1016/j.phrs.2018.03.012 [Crossref] [Google Scholar] [PubMed] [Publisher]

Poliseli-Scopel, F. H., Hernández-Herrero, M., Guamis, B., & Ferragut, V. (2013). Characteristics of soymilk pasteurized by ultra high pressure homogenization (UHPH). Innovative Food Science & Emerging Technologies: *IFSET: The Official Scientific Journal of the European Federation of Food Science and Technology, 20,* 73–80. https://doi.org/10.1016/j.ifset.2013.06.001 [Crossref] [Google Scholar][Publisher]

Qamar, S., Manrique, Y. J., Parekh, H., & Falconer, J. R. (2020). Nuts, cereals, seeds and legumes proteins derived emulsifiers as a source of plant protein beverages: A review. *Critical Reviews in Food Science and Nutrition, 60*(16), 2742–2762. https://doi.org/10.1080/10408398.2019.1657062 [Crossref] [Google Scholar] [PubMed] [Publisher]

Rahmati, K., Mazaheri Tehrani, M., & Daneshvar, K. (2014). Soy milk as an emulsifier in mayonnaise: physico-chemical, stability and sensory evaluation. *Journal of Food Science and Technology, 51*(11), 3341–3347. https://doi.org/10.1007/s13197-012-0806-9 [Crossref] [Google Scholar] [PubMed] [Publisher]

Ramsing, R., Santo, R., Kim, B. F., Altema-Johnson, D., Wooden, A., Chang, K. B., Semba, R. D., & Love, D. C. (2023). Dairy and plant-based milks: Implications for nutrition and planetary health. *Current Environmental Health Reports*. https://doi.org/10.1007/s40572-023-00400-z [Crossref] [Google Scholar] [PubMed] [Publisher]

Raneri, C. (2022). An analysis of Plant-based Meat Consumption Trends and the State of the Industry. [Google Scholar] [Publisher]

Ravoninjatovo, M., Ralison, C., Servent, A., Morel, G., Achir, N., Andriamazaoro, H., & Dornier, M. (2022). Effects of soaking and thermal treatment on nutritional quality of three varieties of common beans (Phaseolus vulgaris L.) from Madagascar. *Legume Science, 4*(4), e143. https://doi.org/10.1002/leg3.143 [Crossref] [Google Scholar][Publisher]

Rawat, R., & Saini, C. S. (2022). Effect of soaking conditions in the reduction of antinutritional factors in sunnhemp (Crotalaria juncea) seeds. *Food Chemistry Advances*, 1, 100092. https://doi.org/10.1016/j.focha.2022.100092 [Crossref] [Google Scholar][Publisher]

Reyes-Jurado, F., Soto-Reyes, N., Dávila-Rodríguez, M., Lorenzo-Leal, A. C., Jiménez-Munguía, M. T., Mani-López, E., & López-Malo, A. (2021). Plant-Based Milk Alternatives: Types, Processes, Benefits, and Characteristics. *Food Reviews International*, 1–32. https://doi.org/10.1080/87559129.2021.1952421 [Crossref] [Google Scholar][Publisher]

Rial, M. J., & Sastre, J. (2018). Food allergies caused by allergenic lipid transfer proteins: What is behind the geographic restriction? *Current Allergy and Asthma Reports, 18(*11), 56. https://doi.org/10.1007/s11882-018-0810-x [Crossref] [Google Scholar] [PubMed] [Publisher]

Samtiya, M., Aluko, R. E., & Dhewa, T. (2020). Plant food anti-nutritional factors and their reduction strategies: an overview. *Food Production, Processing and Nutrition, 2*(1). https://doi.org/10.1186/s43014-020-0020-5 [Crossref] [Google Scholar][Publisher]

Sanjana, K., Hema, V., & Sinija, V. R. (2022). Development of plant-based milk beverage from coconut and cashew nut milk. *The Pharma Innovation Journal, 11*(7), 3743–3748. [Google Scholar]

Şen, L., & Okur, S. (2023). Effect of hazelnut type, hydrocolloid concentrations and ultrasound applications on physicochemical and sensory characteristics of hazelnut-based milks. *Food Chemistry, 402*, 134288. https://doi.org/10.1016/j.foodchem.2022.134288 [Crossref] [Google Scholar] [PubMed] [Publisher]

Sethi, S., Tyagi, S. K., & Anurag, R. K. (2016). Plant-based milk alternatives an emerging segment of functional beverages: a review. *Journal of Food Science and Technology, 53*(9), 3408–3423. https://doi.org/10.1007/s13197-016-2328-3 [Crossref] [Google Scholar] [PubMed] [Publisher]

Sha, L., & Xiong, Y. L. (2020). Plant protein-based alternatives of reconstructed meat: Science, technology, and challenges. *Trends in Food Science & Technology, 102,* 51–61. https://doi.org/10.1016/j.tifs.2020.05.022 [Crossref] [Google Scholar][Publisher]

Sharma, N., Yeasmen, N., Dube, L., & Orsat, V. (2024). Rise of plant-based beverages: A consumer-driven perspective.

Food Reviews International, 1–27. https://doi.org/10.1080/87559129.2024.2351920 [Crossref] [Google Scholar][Publisher]

Silva, A. R. A., Silva, M. M. N., & Ribeiro, B. D. (2020). Health issues and technological aspects of plant-based alternative milk. *Food Research International (Ottawa, Ont.), 131*(108972), 108972. https://doi.org/10.1016/j.foodres.2019.108972 [Crossref] [Google Scholar] [PubMed] [Publisher]

Silva, B. Q., & Smetana, S. (2022). Review on milk substitutes from an environmental and nutritional point of view. *Applied Food Research, 2*(1), 100105. https://doi.org/10.1016/j.afres.2022.100105 [Crossref] [Google Scholar][Publisher]

Sindhu, & Manickavasagan, A. (2020). Adzuki Bean. In A. Manickavasagan & P. Thirunathan (Eds.), Pulses: Processing and Product Development (pp. 1–15). *Springer International Publishing*. https://doi.org/10.1007/978-3-030-41376-7_1 [Crossref] [Google Scholar][Publisher]

Soni, A., Samuelsson, L. M., Loveday, S. M., & Gupta, T. B. (2021). Applications of novel processing technologies to enhance the safety and bioactivity of milk. *Comprehensive Reviews in Food Science and Food Safety, 20*(5), 4652–4677. https://doi.org/10.1111/1541-4337.12819 [Crossref] [Google Scholar] [PubMed] [Publisher]

Sraïri, M. T., Benyoucef, M. T., & Kraiem, K. (2013). The dairy chains in North Africa (Algeria, Morocco and Tunisia): from self sufficiency options to food dependency? *SpringerPlus, 2*(1), 162. https://doi.org/10.1186/2193-1801-2-162 [Crossref] [Google Scholar] [PubMed] [Publisher]

Tangyu, M., Muller, J., Bolten, C. J., & Wittmann, C. (2019). Fermentation of plant-based milk alternatives for improved flavour and nutritional value. *Applied Microbiology and Biotechnology, 103*(23–24), 9263–9275. https://doi.org/10.1007/s00253-019-10175-9 [Crossref] [Google Scholar] [PubMed] [Publisher]

Vagadia, B. H., Vanga, S. K., & Raghavan, V. (2017). Inactivation methods of soybean trypsin inhibitor – A review. *Trends in Food Science & Technology, 64*, 115–125. https://doi.org/10.1016/j.tifs.2017.02.003 [Crossref] [Google Scholar][Publisher]

Valsasina, L., Pizzol, M., Smetana, S., Georget, E., Mathys, A., & Heinz, V. (2017). Life cycle assessment of emerging technologies: The case of milk ultra-high pressure homogenisation. *Journal of Cleaner Production, 142*, 2209–2217. https://doi.org/10.1016/j.jclepro.2016.11.059 [Crossref] [Google Scholar][Publisher]

Vanga, S. K., Wang, J., Orsat, V., & Raghavan, V. (2020). Effect of pulsed ultrasound, a green food processing technique, on the secondary structure and in-vitro digestibility of almond milk protein. *Food Research International , 137,* 109523. https://doi.org/10.1016/j.foodres.2020.109523 [Crossref] [Google Scholar] [PubMed] [Publisher]

Vong, W. C., & Liu, S.-Q. (2016). Biovalorisation of okara (soybean residue) for food and nutrition. *Trends in Food Science & Technology, 52*, 139–147. https://doi.org/10.1016/j.tifs.2016.04.011 [Crossref] [Google Scholar][Publisher]

Walther, B., Guggisberg, D., Badertscher, R., Egger, L., Portmann, R., Dubois, S., Haldimann, M., Kopf-Bolanz, K., Rhyn, P., Zoller, O., Veraguth, R., & Rezzi, S. (2022). Comparison of nutritional composition between plant-based drinks and cow's milk. *Frontiers in Nutrition, 9*, 988707. https://doi.org/10.3389/fnut.2022.988707 [Crossref] [Google Scholar] [PubMed] [Publisher]

Wickramarathna, G. L., & Arampath, P. C. (2003). Utilization of okara in bread making. *Citeseer.* https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=12799320dadbdfe53281efd2c9dfc29763f0e47b [Google Scholar][Publisher]

Wu, T., Zhu, W., Chen, L., Jiang, T., Dong, Y., Wang, L., Tong, X., Zhou, H., Yu, X., Peng, Y., Wang, L., Xiao, Y., & Zhong, T. (2023). A review of natural plant extracts in beverages: Extraction process, nutritional function, and safety evaluation. *Food Research International (Ottawa, Ont.), 172*(113185), 113185. https://doi.org/10.1016/j.foodres.2023.113185 [Crossref] [Google Scholar] [PubMed] [Publisher]

Xing, L., Zhang, M., Liu, L., Hu, X., Liu, J., Zhou, X., Chai, Z., & Yin, H. (2023). Multiomics provides insights into the succession of microbiota and metabolite during plant leaf fermentation. *Environmental Research, 221*, 115304. https://doi.org/10.1016/j.envres.2023.115304 [Crossref] [Google Scholar] [PubMed] [Publisher]

Zandona, L., Lima, C., & Lannes, S. (2021). Plant-based milk substitutes: Factors to lead to its use and benefits to human health. *In Milk Substitutes - Selected Aspects. IntechOpen.* https://doi.org/10.5772/intechopen.94496 [Crossref] [Google Scholar][Publisher]

Zerlasht, M., Javaria, S., Murtaza, M. A., Iqbal, R. K., Quddoos, M. Y., Azhar, S., Syed, A., & Elgorban, A. M. (2023). Antimicrobial potential and phyto-physio-chemical characterization of brans from wheat, oat, and rice. *Journal of King Saud University. Science, 35*(5), 102709. https://doi.org/10.1016/j.jksus.2023.102709 [Crossref] [Google Scholar][Publisher]

Zhang, Y., Kan, J., Tang, M., Song, F., Li, N., & Zhang, Y. (2022). Chemical composition, nutritive value, volatile profiles and antioxidant activity of coconut (cocos nucifera L.) haustorium with different transverse diameter. *Foods (Basel, Switzerland), 11*(7).

https://doi.org/10.3390/foods11070916 [Crossref] [Google Scholar] [PubMed] [Publisher]

Zhou, Z., Robards, K., Helliwell, S., & Blanchard, C. (2002). Composition and functional properties of rice. *International Journal of Food Science & Technology, 37*(8), 849–868. https://doi.org/10.1046/j.1365-2621.2002.00625.x [Crossref] [Google Scholar] [Publisher]