JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

A review on Plant-based milk probiotic beverages: insights into the process, principle-bioactives, and applications

Akshay Dutt Anna

Department of Food Technology and Nutrition, School of Agriculture, Lovely Professional University, Phagwara- 1444111, (Punjab)

Email: 1999akshaydutt@gmail.com

ABSTRACT

Plant-based beverages have grown in popularity over the past decade among consumers looking for healthier and more environmentally friendly alternatives to typical dairy drinks. Those who are lactose intolerant, have hypercholesterolemia, or are allergic to regular milk like these beverages. Despite the additional sugar and low total protein consumption, plant-based milk substitutes are a fantastic alternative since they include phenolic compounds, unsaturated fatty acids, antioxidant activity, and bioactive ingredients like phytosterols and isoflavones. Almond, cashew, coconut, hazelnut, peanut, sesame, soy, tiger nut, oat, rice, hemp, and walnut are just a few of the plant-based milk substitutes covered in this overview. It also discusses their health advantages. Our comprehensive approach, which presents 4 various plant-based milk alternatives (PBMAs) production methods, makes this review unique**.** Although PBMAs fall short of covering the nutritional profile of cow's milk, enrichment via additives and PBMAs blends is being researched to improve their composition. Most physicochemical characteristics of PBMAs are similar to those of cow's milk. However, as the resultant products' gel formation, water holding capacity, texture, and viscoelastic qualities are subpar, PBMA's technical applications still require enhancement. The key challenges in PBMAs relate to improving stability and reducing antinutrients, off-tastes, and allergies. Emerging technology-based PBMAs treatment appears to assist in overcoming these difficulties.

Keywords: Plants-based milk alternatives, Bioactive compounds, Health effects, Process, Application

INTRODUCTION

The importance of non-dairy probiotic products has gained global importance all the world due to vegetarianism along with lactose intolerance, cholesterol consciousness, and milk protein allergens, it has made the development of non-dairy fermented and beverage products essential. Increased consumer awareness about the impacts of food production and consumption on the environment and health is contributing to a decrease in the demand for animal-derived food products in developed countries (Grasso *et al.*, 2020). Plant-based milk or fermented products are rich in bioactive compounds but differ according to the type of Plant-based milk or fermented products. The bioactive compounds found in these products include β-glucan, which is associated with improved blood glucose insulin phytosterols, which can improve the cardiovascular status and reduce the risk, and isoflavones which can reduce the risk related to the development of cardiovascular diseases, cancer, and osteoporosis lignans, having ability to reduce the blood cholesterol level and omega-3 fatty acids, which are involved in the development and protection against the development of cardiovascular diseases (Munekata *et al.*, 2020). Over the past decade, major research has been emphasized in all sections of food product development to address the changing needs and meet the present demands of the consumer by creating newer alternatives to healthy foods. Increasing urbanization has accelerated these demands; the recent trend is the concerted research effort in functional and specialty beverages for newer products. In today's world, beverages are no longer considered simply thirst quenchers; consumers look for specific functionality in these drinks, which forms a part of their lifestyle. The functionality of these beverages may be to address different needs and lifestyles to boost energy, fight aging, fatigue, and stress, and target specific diseases and the sector is still expanding. In recent years, these changes and developments have led to newer products in the beverages sector many varieties of plant-based milk exist, and soy milk rice milk and coconut milk are the major carrier matrices used in probiotic food development (Sethi *et al.*, 2016). In general, these products are safe for consumption and can be considered a suitable vehicle for delivering probiotics due to Journal Pre-proof 2 to their ability in maintaining sufficient probiotic levels during product shelf life. However, studies that are focusing on the evaluation of functional efficacy of probiotics in these products with special reference to gastrointestinal survival, adhesion to the intestinal epithelium, and immunomodulation are scarce and these aspects need to be further assessed (Rasika *et al.*, 2021).

Non-dairy milk alternatives/PBMAs

Plant-based milk substitutes are fluids produced by the breakdown (size reduction) of plant materials (cereals, pseudo-cereals, legumes, oilseeds, and nuts) extracted in water. These fluids are then homogenized to produce particles with a size distribution between 5 and 20 μm, which have similar organoleptic properties to cow's milk. Although these plant-based milk substitutes aren't described or categorized in the literature, an effort has been made to organize them generically into the following five categories. Around 75% of people worldwide suffer from lactose intolerance, which is brought on by a deficiency in the lactase enzyme, which is necessary

to hydrolyze lactose into sugars the body can absorb for energy (particularly glucose and lactose). In addition, there is a considerable need for plant-based probiotic products due to rising vegetarianism in both developed and developing nations. Dairy products with high cholesterol levels can provide serious health risks since they raise the chance of developing cardiovascular disease (Syiemlieh and Morya, 2022).

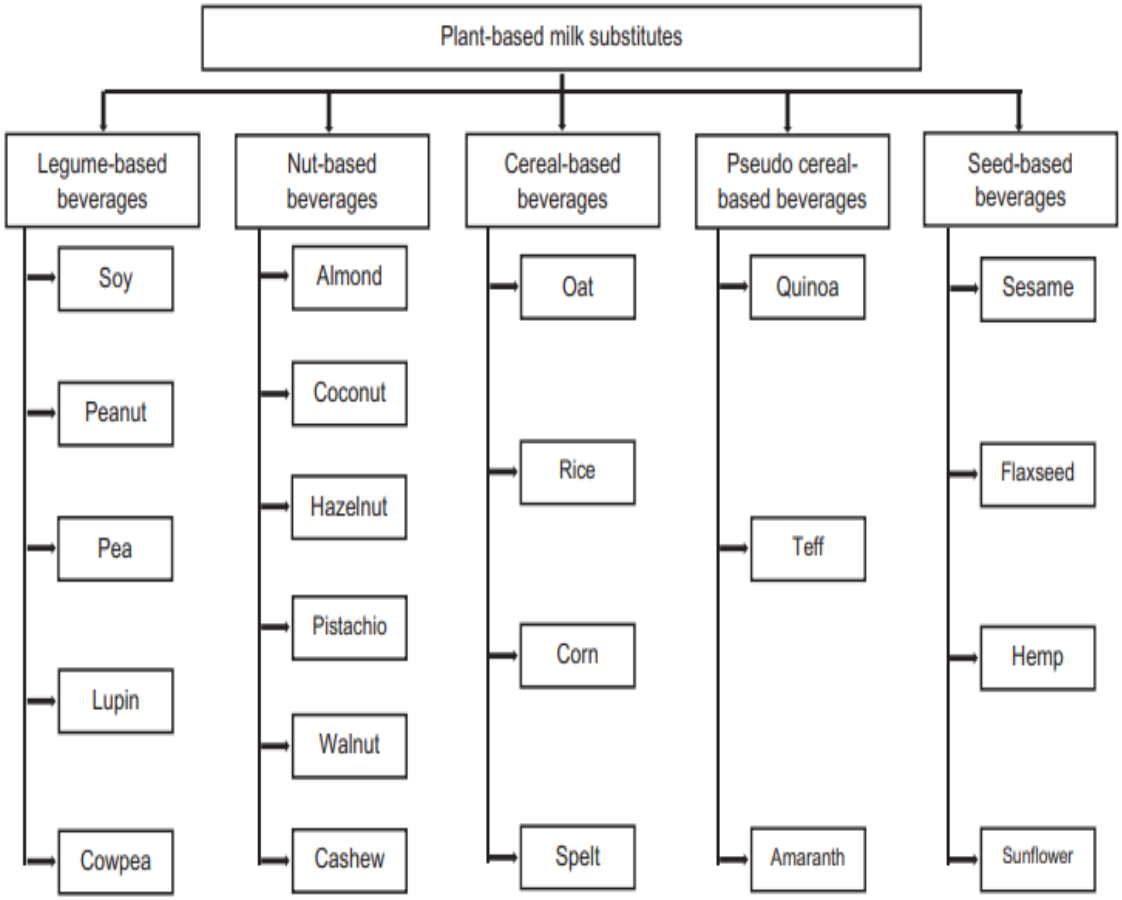

Figure 1. Broad categories of plant-based milk substitutes (Nawaz *et al.*, 2022).

INSIGHTS INTO THE PROCESS

Oat Milk

Oat milk due to its possible medicinal advantages, high nutritional value, dietary fiber content, and availability of phytochemicals, oats have drawn a lot of attention. Oats have several health advantages, including hypocholesterolemia and anti-cancer capabilities **(Table 1)**. Dietary fibers including β-glucan, functional proteins, lipid and carbohydrate components, and phytochemicals found in oat grains are all linked to the health advantages of oats. This makes it a potentially useful raw material for making functional plant-based milk. Oats are a good source of high-quality protein with a balanced amino acid composition. Oats contain b-glucan, a functionally active substance with potential health benefits, which is mostly what has sparked interest in them. b-glucan, a soluble fiber, can increase the solution viscosity and can delay gastric emptying time, increasing gastrointestinal transit time which is associated with their reduced blood glucose level (Welch, 1995).

PROCESS

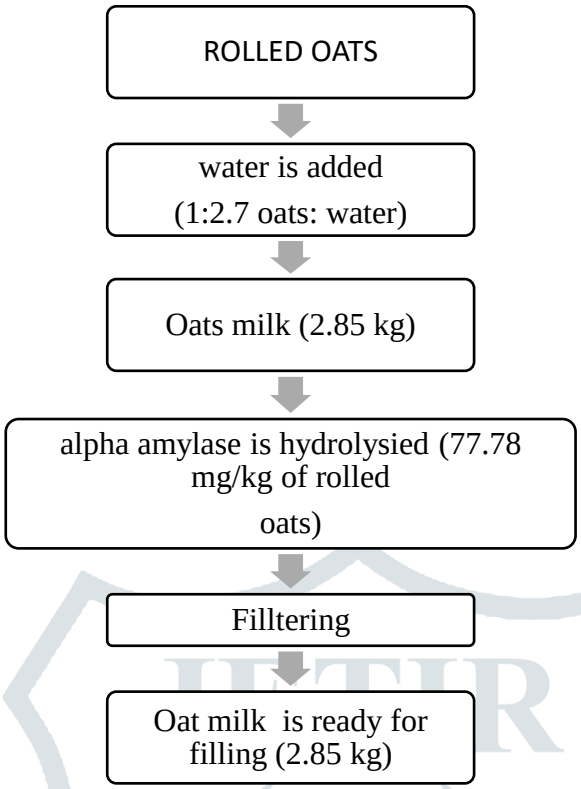

Figure 2. Stepwise preparation of oat milk (Deswal *et al*., 2014)

Another benefit of oat fibers is that they have a hypocholesterolemic impact, which lowers both total and LDL cholesterol (Truswell, 2002). They are also an excellent source of polyphenols and antioxidants. Oats have a carbohydrate content of 60%, a total protein content of 11–15%, lipid content of 9%, dietary fiber content of 2.3–8.5%, and calcium content of 0.54%. Oats are frequently used in gluten-free or celiac diets. There have been efforts to create oat-based drinks or oat milk to diversify the intake of oats (Zhang *et al.,* 2007) Research has shown that oat beverages as such retain their cholesterol-lowering qualities. (Onning *et al.,* 1998).

Soy milk

In China, the usage of soy milk was originally documented around 2000 years ago. The first plant-based milk to give nutrition to a population with minimal access to milk was soy milk. The communities of people with lactose intolerance and milk protein allergies also found it to be popular. Essential monounsaturated and polyunsaturated fatty acids, which are thought to be helpful for cardiovascular health, are abundant in soy milk. Customers may buy it as a cheap, hydrating beverage with nutritional value. The positive benefits of soybean looked to be caused by isoflavones, which appeared to be its functionally active component. The protective properties of isoflavones against cancer, cardiovascular disease, and osteoporosis are well known (Omoni and Aluko, 2005). The most prevalent isoflavone in soybeans, genistein, is also thought to be the most physiologically active (Cohen *et al.,* 2000). In addition to isoflavones, soy proteins are also known to offer therapeutic and preventative advantages against several diseases. Additionally, it has been shown that soy products are high in phytochemicals such as phytosterols, which are known for decreasing cholesterol (Fukui *et al.,* 2002). Dry soybean normally has a protein content of 40%, oil content of 20%, the carbohydrate content

of 35%, and ash content of 5%. The conventional method of making soy milk results in a product with a short shelf life and a distinctive beany taste. Modern soy milk manufacturing makes use of cutting-edge tools and technology to increase nutritional content, shelf life, and convenience while minimizing beany taste. Due to its popularity, the market offers a huge variety of versions. Light, dairy-like, and rich soy milk are among the various varieties, while sweetened, original, and flavored soy milk and fortified ordinary, enhanced, and blended soy milk is accessible in terms of formulation (Liu, 2004).

Nutritional significance of Soy milk

The USDA Nutrient Database states that soymilk has ash as its nutritional value per 100g (0.27g). Soymilk contains 1.8 g of carbs, 2.8 g of protein, 2.0 g of total lipid fat, 0.214 g of saturated fat, 0.326 g of mono-saturated fat, and 0.833 g of poly-saturated fat. Additionally, 93.3 g of water and 1.3 g of fibre are included in macronutrients. Minerals and vitamins make up micronutrients. Soymilk contains the following vitamins: 0.161 mg thiamine, 0.070 mg riboflavin, 0.147 mg niacin, 0.048 mg pantothenic acid, 0.041 mg vitamin B6, 1.5 g folic acid, 0.0 mg vitamin B12, 0.0 mg ascorbic acid, 3.0 g vitamin A, and 0.010 g vitamin E. (Tocopherols). minerals on hand 4.0 mg of calcium, 0.58 mg of iron, 19.0 mg of magnesium, 49.0 mg of phosphorus, 141.0 mg of potassium, 12.0 mg of sodium, 0.23 mg of zinc, 0.12 mg of copper, 0.17 mg of manganese, and 1.3 g of selenium are among the minerals found in soymilk [16]. According to Kranz (2017), soy milk has a moisture content of 94%, 2% of carbs, 3% of proteins, 1% of lipids, and 0% of lactose, making it an excellent alternative to milk (Saini and Morya, 2021).

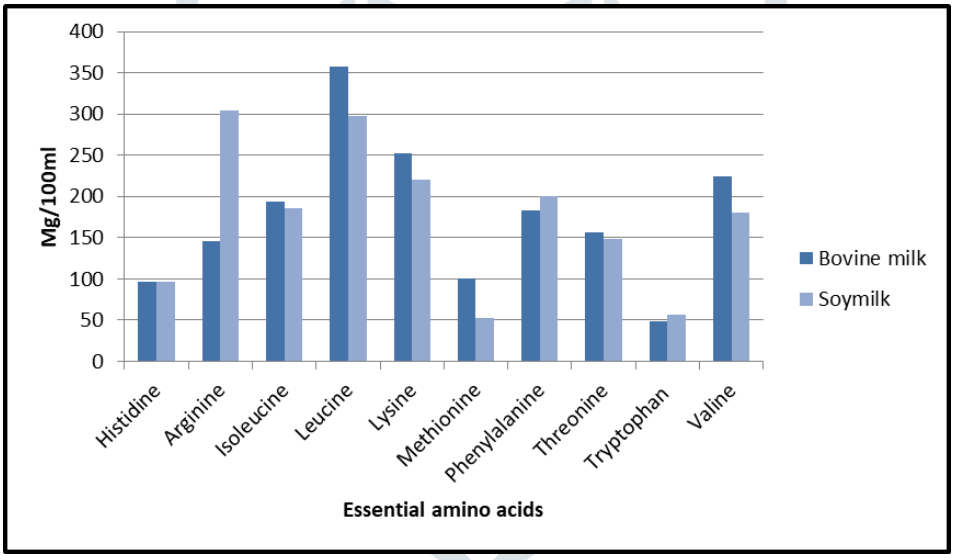

Figure 3: comparison of the nutritional content of soymilk and cow's milk (Saini & moray, 2021).

Basis of physicochemical properties on a structural level

People should find the physical, functional, and sensory aspects of plant-based milk substitutes to be appealing, thus manufacturers must have the ability to identify the key elements that influence their production and structure. The characteristics of the polymers and particles that make up plant-based milk replacements, as well as how they interact with one another, dictate many of their properties (McClements, 2020).

Visual Attributes

Usually, a customer's initial impression of plant-based milk is based on how it looks. Typically, a product of this type has to be uniformly milky white and have apparent characteristics that are comparable to those of milk from cows. However, the anticipated appearance also depends on the product's unique features. For instance,

customers may also accept nut-based milk with a darker brown color. Products with flavors like chocolate, banana, or strawberry milk are anticipated to have recognizable hues like brown, yellow, or pink (McClements, 2020).

The Bioactive and Nutritional Content of the Most Prevalent Plant-Based Beverages

Plant-based beverages are pretty variable in their composition in contrast to cow's milk. The nutrients and quantity of sugar in plant-based milk differ drastically by the production process and product formulation. The dietary composition of most in many instances consumed plant-based beverages and their characteristics are listed in **Table1** Among the exclusive type of plant-based beverages, rice and sesame milk have the perfect total carbohydrates (15%) and calorie amount (130 calories), while quinoa and soy milk comprise the best protein degree (4%). Plant-based beverages are rich in bioactive compounds; however, the particular bioactive compound differs according to the type of beverage. The bioactive compounds observed in this type of product include β-glucan, which is related to expanded blood glucose, and insulin resistance phytosterols, which can improve the cardiovascular repute and minimize the danger associated with related diseases isoflavones, which can decrease the risk associated with improvement of cardiovascular diseases, cancer, and osteoporosis lignans, having the capability to decrease the blood LDL cholesterol degree and omega-3 fatty acids, which are involved in the adequate improvement and protection against the development of cardiovascular diseases, for instance. Conversely, some antinutritional compounds can be additionally determined in plant-based beverages. For instance, sesame and oat contain oxalate and phytates, that shape insoluble complexes with minerals, carbohydrates, and lipids during digestion and decreased the availability of these vitamins. Another essential compound is amandin, an allergenic protein determined in almonds.

Table 1. Nutritive content of various plant-based milk substitutes / 100 ml.

Plant-based milk alternative	Energy (kcal)	Proteins (g)	CHO (g)	Total sugars (g)	Total fat (g)	Fiber (g)	References
Almond milk	17	0.42	0.83	0.42	1.25	0.4	Bridges (2018)
Coconut milk	54.17	1.67	10	7.92	1.04	-	Bridges (2018)
Soybean milk	43	2.6	4.92	3.65	1.47	0.2	Bridges (2018)
Oat milk	66	1.9	4.44	1.27	4.65	0.8	USDA FDC

Bioactive compounds

Foods contain trace amounts of bioactive substances. They are typically referred to as supplemental nutrients that are good for human health but not necessary. As might be expected, plant-based meals include bioactive substances that offer a variety of health advantages, including the ability to prevent cancer encourage brain growth, and reduce the incidence of cardiovascular disease (Gani *et al.,* 2012). based on **Table 2** the bioavailability of numerous bioactive chemicals (isoflavones and phenols) in the raw material may also be enhanced by uncontrolled or forced fermentation (Paul *et al.,* 2020). For instance, short-term (28 h) soybeans

fermentation increased the overall phenolic content of its milk by 28.5 percent in comparison to unfermented soybeans, and 78 % higher of which was retained after 72 hrs of incubation (Jiang *et al.*, 2013).

Probiotic benefits

The bidirectional relationship between the gut and the brain benefits from the presence of gut probiotic bacteria, which aids in the synthesis, control, and up-regulation of glutamate, dopamine, serotonin, histamine, acetylcholine, and norepinephrine. These monoamines are crucial for lowering depressive symptoms. Additionally, probiotic bacteria contribute to the creation of butyrate, a short-chain fatty acid that stimulates the 5hydroxytryptamine receptors necessary for boosting serotonin levels. On the other hand, dopamine-hydroxylase, an enzyme required for the conversion of monoamines like dopamine and norepinephrine, is blocked by clostridia metabolites such 4-cresol and 4-hydroxyphenylacetate (4-HPA). The bacteria in the gut, such as Lactobacillus reuteri, Lactobacillus plantarum, Lactobacillus gasseri, Lactobacillus kefiranofaciens, Lactobacillus bevis, and Bifidobacterium, all operate as antidepressants (Syiemlieh and Morya, 2022)

Table 2. Bioactive compounds of selected PBMAs and their health benefits.

PBMAs	Bioactive compounds	Health benefits	References
Soybean milk	Isoflavones Phytosterol α-tocopherol	• Binds with estrogen to show properties like the estrogenic • Reduce menopause symptoms • Effective against breast prostate and colon cancer • Healing of osteoporosis and heart-related diseases • Lowering cholesterol • Anti-inflammatory	Bridges (2018)
Almond milk	α-tocopherol, arabinose, flavonoids and phytosterols	• Lowers plasma LDL cholesterol level • Decreases lipid peroxidation • Improves gastrointestinal health • Prebiotic properties	Bridges (2018)
Coconut milk	Lauric acid Medium chain triglycerides	• Helps in brain development • Improving the elasticity of blood vessels • Boosts immune system • Reduces the LDL cholesterol and promotes HDL cholesterol	Bridges (2018)
Oat milk	β-glucan and phytosterols	• Decrease the time of gastric emptying • Reduction of postprandial glycemic response because of increase in gastrointestinal transit.	USDA FDC

		• Effective against total and LDL cholesterol • Maintains bp & body weight	

Conclusion

Due to growing levels of lactose intolerance, hypercholesterolemia, and flexitarianism in food intake, the demand for cow's milk replacements has surged. Non-dairy plant-based drinks are wise choices since they contain bioactive ingredients with health-promoting properties that appeal to consumers who are concerned about their health. The lower dietary cost, however, poses a significant challenge to their position in the market. and sensory appeal of plant-based drinks (such as flavor, taste, and solubility) as opposed to cow's milk. Plant-based beverages are regularly subjected to thermal treatments to maintain their high-quality while being stored. The availability of amino acids and the protein digestibility of replacements for dairy-free plant-based beverages, however, may very well be reduced by the use of high temperatures as they can promote the damage of heat-sensitive- sensitive chemicals as well as some unfavourable procedures. Modern food processing methods such as high-pressure processing, high-pressure homogenization, pulsed electric fields, and ultrasound are being studied by researchers to address problems with the shelf-life extension, emulsion stability, nutritional content maintenance, and sensory acceptance of the end product. However, there isn't any current study on the use of non-thermal processing methods to affect the physicochemical and nutritive qualities of drinks made from plants. To prepare more contemporary, tailored meals that are both pleasant and nutrient-sufficient, targeted research efforts in the domain of deliberate plant-based drinks are needed in the next years.

References

1. Nelson, A. I., Steinberg, M. I., & Wei, L. S. (1976). Illinois process for the preparation of soymilk. Journal of food science, 41(1), 57-61.
2. 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.
3. 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.
4. Munekata, P., Domínguez, R., Budaraju, S., Roselló-Soto, E., Barba, F. J., Mallikarjunan, K., Roohinejad, S., & Lorenzo, J. M. (2020). 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), 288.
5. Saini, A., & Morya, S. (2021). A Review based study on Soymilk: Focuses on production technology, Prospects and Progress Scenario in last Decade. The Pharma Innovation Journal, 10(5): 486-494.

6. Welch, R. W. (1995). Oats in human nutrition and health. In The oat crop (pp. 433-479). Springer, Dordrecht.
7. Olayinka J, Eugene Y, Olalekan O, Richard I, Chuka M. (2018). Physicochemical, microbiological, and sensory characteristics of cashew milk formulated yogurt. African Journal of Food Science12(8):204-9.
8. Grasso, Nadia, Loreto Alonso-Miravalles, and James A. O'Mahony. (2020). Composition, physicochemical and sensorial properties of commercial plant-based yogurts. Foods 9.3 252.
9. Omoni, A. O., & Aluko, R. E. (2005). Soybean foods and their benefits: potential mechanisms of action. Nutrition reviews, 63(8), 272-283.
10. Liu, Z. S., & Chang, S. K. C. (2004). Effect of soy milk characteristics and cooking conditions on coagulant requirements for making filled tofu. Journal of agricultural and food chemistry, 52(11), 3405-3411.
11. Syiemlieh, I., & Morya, S. (2022). Dairy and non-dairy based probiotics: A review. The Pharma Innovation Journal, 11(6S), 2956-2964.
12. Uesugi, T., Fukui, Y., & Yamori, Y. (2002). Beneficial effects of soybean isoflavone supplementation on bone metabolism and serum lipids in postmenopausal Japanese women: a four-week study. Journal of the American College of Nutrition, 21(2), 97-102.
13. Chalupa-Krebzdak, S., Long, C. J., & Bohrer, B. M. (2018). Nutrient density and nutritional value of milk and plant-based milk alternatives. International dairy journal, 87, 84-92.
14. 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.
15. Maria, M. F., & Victoria, A. T. (2018). Influence of processing treatments on quality of vegetable milk from almond (Terminalia catappa) kernels. ACTA Sci. Nutr. Health, 2(6), 37-42.
16. Bridges, M. (2018). Moo-Ove over, cow's milk: The rise of plant-based dairy alternatives. Practical Gastroenterology, 21, 20-27.
17. U. S. Department of Agriculture. Food Data Central. https://fdc.nal.usda.gov/ (accessed April 24, 2020).
18. Deswal, A., Deora, N. S., & Mishra, H. N. (2014). Optimization of the enzymatic production process of oat milk using response surface methodology. Food and Bioprocess Technology, 7(2), 610-618.
19. Nawaz, M. A., Tan, M., Øiseth, S., & Buckow, R. (2022). An emerging segment of functional legume-based beverages: A review. Food Reviews International, 38(5), 1064-1102.
20. Zhang, H., Önning, G., Triantafyllou, A. Ö., & Öste, R. (2007). Nutritional properties of oat-based beverages as affected by processing and storage. Journal of the Science of Food and Agriculture, 87(12), 2294-2301.
21. Gani, A., Wani, S. M., Masoodi, F. A., & Hameed, G. (2012). Whole-grain cereal bioactive compounds and their health benefits: a review. J Food Process Technol, 3(3), 146-156.
22. 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.
23. Jiang, S., Cai, W., & Xu, B. (2013). Food quality improvement of soy milk made from short-time germinated soybeans. Foods, 2(2), 198-212.