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Review Article

Optimization and Nutritional Evaluation of Non-Dairy Milk Blends

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Abstract

Medical conditions such as lactose intolerance, hypercholesterolemia, obesity, protein deficiency, cow milk allergy as well as lifestyle choices including concern about nutrition are arising worldwide. A large proportion of people have shifted their choices from traditional blends to vegan blends due to their therapeutic concern. Plant-based milk substitutes are a growing trend that can be an affordable alternative for people with health issues and for underprivileged populations in developing nations. Globally, the market for plant-based or non-dairy milk alternatives is one of the fastest expanding segments in the newer food product development area of functional and specialty beverages. Various techniques including homogenization and thermal treatments are practiced enhancing the suspension and microbiological stability of end product. Recent research suggested that high hydrostatic pressure (HP) treatment may be an effective non-thermal innovative approach to improve the physicochemical properties, sensory score and nutritional values. The main goal of this study was to evaluate the extrinsic and intrinsic characteristics of non-diary blends with their raw material and technical aspects of the production. In the upcoming years, a concerted research effort will be needed in the functional beverage market to create fresh products that are both palatable and nutritionally appropriate.

Keywords: Dairy Blends; Non-Dairy Blends; Therapeutic Effect; Allergies

Introduction

Milk is enjoyed by everybody since it is considered a complete meal. People are choosing veganism these days as a result of an increased concern for animal rights and a shift in desire for lactose-free meals, and the market for plant-based milk is booming. According to Dairy and Dairy Alternative Beverage Trends (2017), worldwide per capita milk consumption fell by about 23% from 2000 to 2016, but consumption of non-dairy plant-based milks rose significantly [1].

According to estimates from the Food and Agriculture Organization (FAO), 195.9 million people in India are malnourished, accounting for 14.8% of the total population. In addition, anaemia affects 51.4 percent of women between the age of 15 and 49. Furthermore, in India, 38.4 percent of children under the age of five years are stunted, while 21% of children are wasting. According to National Family Health Survey (NFHS-5), the incidence of anaemia among women of reproductive age has grown to 57.2 percent, up from 49.7% in the previous survey [2]. On the other hand, according to NFHS-4, 68.9% of children aged 6 months to 5 years suffer from anaemia, compared to 53.8 percent of children aged 6 months to 5 years. It is critical to incorporate protein and iron-rich food sources in diet to prevent malnutrition and anaemia, especially those that are affordable. Vegans and people with lactose sensitivity will have to replace cow's milk with vegetable-based milks in order to maintain a healthy nutritional status.

Cow milk contains around 87 percent water, 3.5 percent protein, 3-4 percent fat, 5% lactose, and 1.2 percent minerals, which may vary depending on the breed of the cow [3]. The fat level of milk offered in the market is typically standardised – whole (more than 3.5 percent), semi-skimmed (about 1.5 percent), and skimmed (less than 0.5 percent) [4]. The majority of milk fat (98%) is made up of triacylglycerols, which are found as globules surrounded by milk fat globule membrane (MFGM) [5]. Caseins make up the majority of the protein in cow milk (80 percent); whey proteins account for the remaining 20% of the total protein [6]. Lactose is the primary carbohydrate in milk, and it is broken down into glucose and galactose in human body by the enzyme lactase [7]. Milk is high in both fat-soluble and water-soluble vitamins from the B-group. Minerals such as calcium, magnesium, phosphorus, potassium, zinc, and selenium are also found in abundance.

Non-dairy milk substitutes have proven to be a godsend for vegans. They're also acceptable for those who have lactose intolerance or are allergic to cow's milk. Non-dairy milk substitutes are fluids made by soaking plant material in water, draining it, and then combining and blending it with clean water until it mimics cow milk in look and consistency after filtering [8].

The market for non-dairy milks is growing as people become more conscious of the mistreatment of animals that occurs during the production of milks. Non-dairy milk manufacturing also appears to have a lower carbon imprint on the environment [9]. However, when compared to cow milk, these plant-based milks have different sensory characteristics and nutritional compositions. To increase the quality of the final product, pre-treatments such as soaking, peeling, and boiling must be used [10]. The nutritional value of such milks is determined by the source from which it was extracted. As a result, milks derived from more than two sources possess higher nutritional value.

Oat milk is a cereal-based milk made from whole oats (Avena spp.) that is extracted by mixing the soaked plant material with water [11]. According to FAO, the total harvested area for oats production in the globe is 9.8 million ha, with a yield of 23412 hg/ha. Oats production grew from 20 million metric tonnes (MMT) in 2010 to 23 million metric tonnes (MMT) in 2018 [12]. Oats comprise around 60% starch, with sugar accounting for only 1% of the total. Furthermore, it includes about 17 percent protein (globulins are the main proteins in oats, 70-80 percent), 7% lipids, 11% dietary fibre, and 0.54 percent calcium), as well as 7% lipids, 11% dietary fibre, and 0.54 percent calcium [13]. Oat milk has a high nutritional value due to its high content of dietary fibres, particularly beta glucan, polyphenols, and unsaturated fatty acids. Beta glucan, the functionally active component, is a kind of soluble fibre that can produce a viscous film in the small intestine and delay gastric emptying, lowering total and low-density lipoprotein LDL cholesterol levels in the blood [14]. Oats also include antioxidants such as vitamin E, phytic acid, phenolic acid, and avenanthramides, in addition to beta glucan. The antioxidant activity of oats is additionally enhanced by the presence of flavonoids and sterols [15]. It is a crucial substance for those who have lactose intolerance or are allergic to cow's milk.

Oats are mostly made up of starch, which accounts for 50-60% of their weight. The gelatinization feature of starch makes it difficult to heat process oat milk because at high temperatures of 44.7-73.7oC, the liquid can convert into a gel [16]. Oats are also rich in protein, which is a low-cost, high-quality protein. Only 15% of total oat protein is made up of prolamines, whereas globulins make up 80% of total oat protein. Prolamines have greater glutamine and proline concentration than lysine [17].

Rice (Oryza sativa) is one of the most widely eaten cereal grains on the planet. The total area harvested for rice cultivation in the globe is 167 million hectares, with 44 million hectares harvested in India. Rice is the world's second-largest producer of cereal grains. Rice production grew from 701 million metric tonnes in 2010 to 782 million metric tonnes in 2018 [12]. The world's rice crop yield is 46789 hg/ha, whereas India's production is 38782 hg/ha. In India, total rice output is 172 million tonnes. Carbohydrates, proteins, lipids, fibres, minerals, and vitamins are all abundant in it. Since 2000 BC, rice has been a staple meal in most Asian countries. Uttar Pradesh, Bihar, West Bengal, Orissa, Chattisgarh, Andhra Pradesh, Assam, Punjab, Tamil Nadu, and Haryana are the major rice-producing states in India. Carbohydrate (80%), protein (7-8%), and fat (7-8%) make up most of the rice's makeup (3%). Rice milk is a cereal-based milk with a high glycemic index of 86 and a high digestibility. Lactose intolerant persons, as well as those allergic to soy or milk, and vegans, like it as a dairy alternative. It is high in Vitamin B, which helps to maintain the neurological system and skin healthy [18].

Because of its high lysine content, rice has a high biological value (BV) and protein energy ratio (PER). Both whole and broken rice may be used to make milk, however milk made from broken rice is more cost-effective. Rice contains vitamins such as thiamine, niacin, and folic acid, as well as minerals such as phosphorus, magnesium, manganese, iron, and selenium. Although brown rice is a healthier alternative than white rice, white rice is more popular owing to its low cost, simplicity of preparation, and palatability. Rice has a greater glycaemic load than other grains, however when combined with other meals, it provides a well-balanced diet [19].

Wheat (Triticum) is a staple food in many parts of the world, with Triticum aestivum being the most prevalent species. Wheat ranks third in the globe in terms of cereal grain output, with a total area harvested for wheat production of 214 million hectares worldwide, compared to 29 million ha in India. The world's wheat crop yield is 34254 hg/ha, whereas India's production is 33705 hg/ha. In India, total wheat production is 99 million tonnes. Wheat roduction grew from 641 million metric tonnes in 2010 to 734 million metric tonnes in 2018 [12]. Wheat has a higher trade volume than other grains due to the presence of gluten protein, which has adhesive characteristics and is thus suited for dough creation.

Wheat is a good source of carbohydrates since it is taken in large quantities. It has a protein content of 13%, which is greater than other major grains, however the protein quality is poor due to a lysine deficiency. Wheat is an excellent source of fibre, B vitamins, and phytochemicals in addition to macronutrients. Wheat's dietary fibre lowers the risk of chronic illnesses such as coronary heart disease and Type 2 diabetes [20]. Wheat offers 327 calories per 100 grammes and is an excellent source of vital nutrients such as protein, fibre, minerals, and vitamins. Moisture (13 percent), protein (13 percent), fat (1.5 percent), and carbs make up wheat's makeup (71 percent). Gluten accounts about 75-80 percent of total protein [21]. Wheat is not a complete protein source, thus it must be supplemented with a legume protein source.

Soybean (Glycine max) is a widely cultivated legume with a high nutritional content that is highly consumed by people all over the world. The total area collected for soy cultivation in the globe is 124 million hectares, including 11 million hectares harvested in India. The global yield of soy is 27914 hg/ha, whereas India's production is 12093 hg/ha. Soy output totals 348 million tonnes worldwide, with 13 million tonnes produced in India [12]. Soy protein is highly digestible and includes virtually all necessary amino acids, as well as minerals including calcium, magnesium, potassium, copper, iron, and zinc. Soybeans include around 35 percent carbohydrates, 40 percent protein, 20 percent oil, and 5% ash [22]. Monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA) found in soybeans are helpful to cardiovascular health. Isoflavones, a functionally active component of soybean, may be found at concentrations of up to 1 g/kg. Many illnesses, including cardiovascular disease, osteoporosis, and cancer, are protected by isoflavones. Genistein is a kind of isoflavone abundant in soybeans. Pectic polysaccharides, which are easily fermented by intestinal bacteria, make up most of the soy fibre [23]. Soy's oligosaccharides function as prebiotics [24]. Phytic acid and saponins, two non-isoflavone chemicals found in soy, appear to have antioxidative, anticancer, antiviral, cardiovascular protective, and hepatoprotective activities [25]. Soybean is also high in phytosterols, which are believed to help the body decrease cholesterol levels [26].

Peanut (Arachis hypogaea) is a commonly eaten legume crop in India. The total area collected for peanut cultivation in the globe is 28 million hectares, including 4 million hectares harvested in India. The global crop yield is 16114 hg/ha, whereas India's production is 13553 hg/ha. Peanuts are produced in 45 million tonnes across the world, with 6 million tonnes in India [12]. Peanut milk, with its high fat, protein, and calorie content, is an effective way to treat child malnutrition in underdeveloped nations. Peanuts are a high-energy, protein-, fat-, vitamin-, and mineral-rich food. They also include fibre and phytosterols, which are known to lower cholesterol levels in the blood. Peanuts provide 21.5 percent carbs, 23.7 percent proteins, 49.6% fats, and 8% crude fibre [27]. Peanuts include bioactive components, which are mostly due to the presence of phenolic compounds, which serve as antioxidants and protect against cardiovascular disease, stroke, and cancer.

Peanuts have a significant fat content, however it is not harmful to one's health. Peanut fat includes 50% monounsaturated fatty acids (MUFAs), 33% paraformaldehyde, and 14% saturated fatty acids, which is an excellent mix for heart health. Due to the inclusion of MUFAs, which are easily digested due to the existence of a single unsaturated hydrogen bond, peanut products are better for heart health than low fat goods [28]. Peanuts decreased total cholesterol by 11% and low-Density Lipoprotein cholesterol by 14% when consumed. Triglyceride levels were reduced but high-density lipoprotein (HDL) levels were maintained [29].

Peanut protein is a high-quality source of all 20 necessary amino acids. Peanuts are the most abundant source of the amino acid "arginine." Arginine boosts immunity by boosting T lymphocyte production. It dilates the arteries and so increases blood flow since it is a precursor to nitric oxide [30]. Certain legume proteins, such as peanut and soy, provide equivalent nutritional benefits to eggs and meat, according to the protein digestibility corrected amino acid score (PDCAAS) [31].

Peanuts have a low glycaemic index and glycaemic load, with values of 14 and 1 respectively. Peanuts are high in vitamin B3, which is beneficial to the neurological system, digestive system, and skin, as well as protecting us from cognitive decline and lowering the risk of Alzheimer's disease [32]. Peanuts also contain folic acid, which aids in the maintenance of cells and tissues during pregnancy. Peanuts are abundant in bioactive components including Coenzyme Q10, which aids the heart in stressful situations such as low oxygen levels at high altitudes or blocked arteries. It also includes fibre, vitamins, minerals, antioxidant minerals including copper, manganese, and selenium, as well as flavonoids and resveratrol [33].

Functional foods are those that provide health benefits in addition to their fundamental nutritional functions. The demand for functional meals is rising as health-conscious consumers become more aware of their options. Probiotics, prebiotics, and fibres are all found in plant-based goods. Vegan milks made from cereals or pulses are the best alternative for cow's milk, keeping the body healthy and disease-free [8].

A brief summary of the research relevant to the current investigation has been provided.

Health benefits of oats

Oats are a good source of soluble dietary fibre (beta glucan), fat-soluble vitamin E, and polyunsaturated fatty acids. Sterna., *et al*. estimated different nutrients such as lipids, protein, fibre, fatty acids, amino acids, and vitamin E to evaluate the bio-chemical composition of naked and husked types of oats. The fat content of the oats varied substantially, ranging from 4.9 to 10.5g per 100g. Fatty acids made about 78-81.5 percent of the total fatty acid content, whereas amino acids made up 35-45g per kg of oats. The fibre level of husked oats was found to be 14.32g per 100g, while naked oats had 17.63g per 100g. The study discovered that oats are high in bioactive compounds that have significant health benefits [34].

The nutritional benefits of oats were investigated by Rasane., *et al.* Oats are high in dietary fibre as well as phytochemicals. They are regarded as a food with great nutritional characteristics, and they are associated with hypocholesterolemic and anticancer capabilities. Furthermore, oats are safe to eat in celiac disease. Biscuits, morning cereals, breads, cookies, baby meals, and probiotic beverages are just a few of the value-added oat products that are getting a lot of attraction [35].

Onning., *et al.* did research to see if drinking oat milk devoid of insoluble fibre might decrease blood cholesterol and LDL levels in individuals with mild hypercholesterolemia. As a control drink, flavoured rice milk was used. Sixty-six people were selected and split into two groups. Three 5-week time periods were used in the research. For 5 weeks, each group received 750 mL of either oat milk or rice milk each day. After then, there was a 5-week washout period before they were given the other drink for the next 5-week period. When compared to rice milk (0.02g/100g), oat milk had a greater fibre content, particularly beta-glucan (0.5g/100g). In terms of sensory characteristics, both beverages were comparable. In conclusion, oat milk dramatically reduced blood cholesterol and LDL levels, but HDL levels were unchanged in both situations. The amount of triglycerides in oat milk was unchanged, whereas it increased considerably in rice milk [36].

Arora and Patel investigated the effect of dietary fibre (DF) consumption on milk calcium availability. One batch of spray dried partially skimmed milk powder was fortified with dietary fibre blend 1, while the other was enriched with fibre blend 2. Only cellulose was present in the control sample. Oat fibre, psyllium husk, microcrystalline cellulose, and inulin made up Blend 1. Oat bran, psyllium husk, inulin, and wheat fibre made up Blend 2. To test the effect of DF on calcium availability in milk, rats were fed the two sets. In terms of outcomes, both sets were comparable. Due to these sets of DF enriched milk powder, there was no influence on calcium availability. As a result, it is recommended to include fibres in milk, emphasising the importance of plant-based milks such as oat milk, which are high in fibre [37].

Development and analysis of oat milk

Deswal., *et al.* produced oat milk and investigated the effects of slurry concentration, enzymatic hydrolysis, and liquefaction duration on milk production, total solid content, and consistency index. One kg of rolled oats was combined with 2.70 kg of water, and the resulting oat slurry was blended with 77.78 mg of alpha-amylase per kg of rolling oats (enzymatic hydrolysis). Finally, the treated slurry was filtered to provide 2.85 kg of oat milk with a total solid content of around 25.01 (weight percent) and a consistency index of roughly 1.01 Pa/s. The best conditions for making oat milk were a 27 percent slurry concentration, 2.1 percent enzyme addition, and a liquefaction duration of 49 minutes [38].

Both soluble and insoluble fibre are abundant in oats. In nature, they are extremely fermentable. For the creation of fermented oat drink, Gupta., *et al*. employed three substrates in varying proportions: oats, sugar, and lactic acid bacteria. The impact of these three chemicals on the fermentation process of Lactobacillus plantarum was investigated.5.5 percent oats, 1.25 percent sugar, and 5% starting culture were the best concentrations for growing 10.4 log CFU/ml. The storage time that was investigated was 21 days. Color, viscosity, microbiological count, pH, and titratable acidity were among the parameters examined. The beta glucan level did not change during the fermentation process and remained constant for the whole 21-day period. The benefits of probiotic culture and the prebiotic beta glucan in oats were combined in this study [39].

Health benefits of rice milk

Swiatecka., *et al.* investigated the physiological response of enterocytes in healthy and allergic individuals *in vitro* using protein hydrolysates from rice milk. Rice milk protein hydrolysates had an effect on gut epithelial cells and the bacteria in the gut. In allergic persons, the peptides and glycopeptides produced by rice protein hydrolysis interfered with attachment to the intestinal epithelium microbiota and, as a result, altered the metabolic activity of enterocytes. In healthy persons, however, these rice protein hydrolysates had a beneficial effect by lowering the production of proinflammatory chemicals like IL-8 [40].

Bocquet., *et al.* conducted a research in which they replaced cow milk protein-based formulas with hydrolyzed rice protein formulas to treat babies allergic to cow milk protein. Rice proteins are supplemented with amino acids like lysine, tryptophan, and threonine since their amino acid composition differs from that of human milk proteins. Vitamin D3 is also included in these formulations. As a result, these formulae are suitable for both the growth of newborns with a cow milk protein allergy and healthy infants [41].

Development and analysis of rice milk

Rice is a popular cereal grain that is consumed all over the world as a primary source of nutrients such as carbs, proteins, lipids, fibres, minerals, and vitamins. Due to its greater lysine content among cereals, it has a high BV and digestibility. Padma., *et al*. made rice milk by soaking it for 1, 2, or 3 hours, then cooking and mixing the cooked rice with water in three different ratios - 1:1, 1:2, and 1:3. For all of the milk samples, physicochemical characteristics such as pH, total soluble solids (TSS), titratable acidity, and colour features were assessed. Due to an adequate pH range of about 6.0, the milk sample made with a blending ratio of 1:3 was found to be the most suited. The TSS range was also discovered to be less (4-5oBrix) [42].

Rice bran is a by-product of the rice milling process that is utilised in animal feed and the extraction of oil. Rice bran milk is high in minerals and unsaturated fatty acids. Rice bran was utilised to make rice bran milk (RBM) in a study conducted by Issara and Rawdkuen. Rice milk was compared to soy milk in terms of sensory and nutritional characteristics. Three distinct ratios of rice bran to water were used: 1:5, 1:10, and 1:15. In comparison to soy milk, proximate analysis revealed that the sample with a ratio of 1:15 had a substantial variation in carbohydrate, lipid, and protein content. Total soluble solids (3.7oBrix), total sugars (0.38 percent), and viscosity (3.05cP) were also lower in RBM with a ratio of 1:15 than in soy milk, which had TSS, total sugars, and viscosity of 11.7oBrix, 5.80 percent, and 9.85cP, respectively. Though the colour was similar to soy milk, sensory examination revealed a significant difference in appearance, taste, flavour, sweetness, and overall acceptability. Soy milk had the greatest whiteness index, whereas RBM with a ratio of 1:5 had the best stability. When compared to soy milk, significant changes in macronutrients were identified, but there were little differences in micronutrients. Overall, RBM with a ratio of 1:15 had a satisfactory appeal, indicating that it may be further enhanced in terms of sensory characteristics and flavour in order to be commercialized [43].

Padma., *et al*. used an improved technique to create calcium enriched rice milk from broken grains. Chemical composition was examined in both ordinary and enriched rice milks. After fortification, the protein content fell from 1.12 to 1.05 percent, whereas the ash content, pH, and TSS rose from 0.1 to 0.4, 10.2 to 12.0, and 6.21 to 6.53 percent, respectively. The regular and fortified rice milks were also stored in glass, high density polyethylene (HDPE), and low density polyethylene (LDPE) containers at room and chilled temperatures. For refrigerated storage, microbiological examination was performed every 5 days, and for ambient storage, it was done every one day [42].

Lee., *et al*. performed research on the rheological characteristics, milling fractions, and gelatinization temperature of rice milk made from several rice types. Rice milk was made from two types of rice: Arhent (long grain) and Bengal (middle grain), with various fractions such as brown, head, and broken grains. These rice types, as well as their various fractions, have a substantial impact on the flow and consistency of rice milk. The amylose to amylopectin ratios, the differences in composition of the two kinds, and their varied gelatinization temperatures were among the variables that contributed to the differences in rice milk flow behaviour. When compared to milk made from Arhent rice, milk made from Bengal rice had higher consistency coefficients. Because the viscosity of broken rice milk was comparable to that of head rice milk, broken rice could also be utilised to make rice milk [44].

Lin., *et al.* used response surface technology to improve the rice drink production process. Rice was ground and blended 1:15 with water, then alpha amylase was used to gelatinize it for 15 minutes. It was then centrifuged at 4000 rpm after being maintained in a water bath at 85°C.After filtering the supernatant solution, 5.4 and 1.3 percent non-dairy cream were added. To make the final product, the drink was homogenised, filled, and pasteurized [45].

For its proximate composition and sensory characteristics, Folorunso., *et al*. assessed milk produced from five kinds of rice. For all five types, the usual method was the same. To make rice milk, the rice grains were washed and soaked for 5 hours, then wet milled, sieved, and finally boiled for 20 minutes. Moisture content, protein, fat, carbohydrate, crude fibre, and ash content ranged from 12.06 to 16.05, 6.10 to 7.67, 2.97 to 4.06, 71.65 to 76.50, 0.49 to 0.55, and 0.54 to 1.54 percent, respectively. Color, texture, scent, taste, and overall acceptability all had varied results, ranging from 3.46 to 3.88, 3.62 to 4.24, 3.46 to 4.32, 3.06 to 4.18, and 3.40 to 4.26, respectively. Rice milk samples from all five types contained significant levels of protein, making it a viable substitute for dairy milk [46].

Health benefits of wheat

Shewry and Hey examined the different health advantages of wheat, emphasizing the relevance of crop quality as well as yield. Wheat is high in carbs, protein, dietary fibre, B vitamins and polyphenols. Dietary fibre in wheat helps to prevent chronic illnesses including diabetes, hypertension, and cardiovascular disease. Wheat fibre also has a prebiotic impact since it contains hemicelluloses. The resistant starch of wheat lowers the glycaemic response after a meal. Wheat phytochemicals, such as phenolic acids, have antioxidant properties [20].

Kumar., *et al*. examined the nutritional makeup of wheat as well as its health benefits. Wheat is commonly used in the preparation of chapatti and breads because it contains gluten protein, which helps the dough stay together and retain gas. Wheat has anti-inflammatory and anti-cancer effects. Wheat includes energy-giving starch and protein as well as fibre and minerals including phosphorus in the bran and vitamin B and E in the germ. Vitamin E is lost when the germ component of wheat is removed during processing. As a result, whole wheat protects us from illnesses such as obesity, diabetes, and cardiovascular disease. Wheat bran helps us avoid constipation by facilitating stool movement. It is used as a dietary fibre supplement to help prevent colon illnesses, inflammatory bowel disease, haemorrhoids, hernias, hypertension, diabetes. Wheat is thus a therapeutic food that must be cultivated in such a way that its nutritional value is maximized [47].

Development and analysis of wheat beverage

Sharma., *et al*. created a probiotic drink with sprouted wheat flour, bran, oat, and guar gum to boost Lactobacillus acidophilus levels. Lactobacillus acidophilus NCDC-14 was chosen for the study over NCDC-16 because it resulted in the creation of a beverage with a higher pH, acidity, and probiotic count. The beverage contained an acidity of 0.20 to 0.45%, a pH of 4.0 to 4.9, and a probiotic count of 8.30 to 10.95 log10 cfu/ml. The amount of sprouted wheat has a direct relationship with the probiotic count. 7.86 g sprouted wheat flour, 1.42g wheat bran, 5.42 g oats, and 0.6 g guar gum per 100 ml of water ingested were the levels of contents optimum for the creation of the drink. Carbohydrates (11.56%), protein (1.19%), fat (0.33%), crude fibre (0.42%), ash (0.10%), calcium (15.74mg), iron (1.45mg), energy (54kcal), and probiotic count (10.43 log10 cfu/ml) were all present in the optimised probiotic drink [48].

Health benefits of soy

According to Omoni and Aluko, soybeans contain isoflavones, a functionally active component that works with proteins to protect against cardiovascular disease, osteoporosis, and cancer. Isoflavones are found in around 50 mg per 25 g of soy protein. Genestein, diadzein, and glycetin are the three isoflavones found in soy, with genestein being the most common. According to the study, isoflavones, peptide fractions, or a combination of the two that helps to alleviate chronic illnesses. Other bioactive substances with cholesterol-lowering characteristics, saponins with anti-carcinogenic actions, and omega-3 fatty acids with cardio protection potential might supplement the protective aspects [49].

Blood pressure, particularly diastolic blood pressure, is significantly reduced by genistein. Genistein has sodium excretion in the urine and vasodilation characteristics. Rivas., *et al*. investigated the antihypertensive impact of soy milk in 40 persons with mild to moderate hypertension: 25 males (18-70 years) and 15 women (50-70 years). The individuals' systolic blood pressure was between 140 - 179 mm Hg, while their diastolic blood pressure was between 90 - 109 mm Hg. Isoflavonoid levels were almost always undetectable prior to the experiment. The mean blood pressure was reduced by 16.7+_ 9.0 mm Hg after the trial (drinking 500 ml soy milk twice daily) compared to the cow milk consuming group, because of the effect of soy isoflavonoids like genistein and equol [50].

Lydeking-Olsen., *et al*. compared the long-term effects of soymilk, natural transdermal progesterone, and a combination of the two on bone mineral density in the hip and lumbar spine. Four therapy groups were allocated to postmenopausal women: soymilk containing isoflavones, transdermal progesterone (TDP), a combination of soy and TDP, and placebo. Bone Mineral Density and Bone Mineral Content were assessed in the hip and lumbar spine using dual energy X-ray absorptiometry (DEXA) before and after the treatments. In the soymilk and TDP groups, there was no significant change in bone mineral density and content, while there was substantial bone loss in the placebo and combination treatment groups. This resulted in an unfavourable interaction between TDP and soymilk, resulting in bone loss. Soymilk or TDP therapy alone was more effective in preventing bone loss. Soymilk use of two glasses per day reduces lumbar spine bone loss in postmenopausal women [51].

Bricarello., *et al.* compared the effects of soy milk and nonfat cow milk on lipid profile and lipid peroxidation. After providing them a lipid-lowering diet for six and twelve weeks, a group of 60 outpatients with primary hypercholesterolemia were examined. The cholesterol profile was measured before and after a fat-lowering diet was consumed. Subjects consumed 1 litre of soy milk or nonfat cow milk every day for the first six weeks. Plasma thiobarbituric reactive chemicals were used to measure lipid peroxidation in a clinical setting. As a consequence, people who drank soy milk had lower levels of low density lipoprotein cholesterol (before treatment (BT) 157+5 mg/dl and after treatment (AT) 148+4 mg/dl, compared to 158+4 mg/dl in cow milk). In comparison to cow milk, their HDL cholesterol levels increased (BT – 58+2 and AT – 62+2). Furthermore, soy milk consumption decreased plasma thiobarbituric reactive chemicals, indicating that soy milk is a good source for optimising lipid profile [52].

Hajirostamloo evaluated the nutritional content of soymilk and cow milk in one cup (245g). Soymilk was made using a 1:8 blending ratio, which included 1 part soy and 8 parts water. Water, protein, ash, fat, fibre, carbohydrate, lactose, fatty acids, and total solids were found to be 228.51, 6.73, 0.66, 4.64, 3.18, 4.43, 0.00, 0.52, and 10.40 g in soymilk, respectively. Soymilk had 9.80 mg of calcium and 1.42 mg of iron, whereas cow milk had 290.36 mg of calcium and 0.12 mg of iron. The water and protein content of both milks were identical. Soymilk has a considerable quantity of fibre, whereas cow milk lacked totally. Furthermore, soymilk has 10 times the amount of iron as cow milk. Cow milk had twice as much fat and ten times as many fatty acids as soymilk. Cow milk also has 300 times the calcium content of soymilk. Soy milk was shown to be a healthier alternative due to its reduced calorie and fat content [53].

Development and analysis of soy milk

A study by Bansal and Kaur focuses on producing soybean milk from germinated soybeans. pH, moisture, fat, protein, and ash content of raw soybeans were reported to be 6.76, 12, 17.67, 39.6, and

5.3 percent respectively. Soy milk, both non-germinated and germinated was produced in a 28-hour period. Moisture, fat, protein, carbohydrate, and ash content of milk extracted from non-germinated soy were 93, 1.50, 2.64, 2.21, and 0.65 percent respectively, whereas moisture, fat, protein, carbohydrate, and ash content of milk extracted from germinated soy were 95, 1.28, 3.11, 0.50, and 0.56 percent, respectively. Germination was responsible for a substantial increase in protein digestibility as well as a decrease in carbohydrate and fat content [54].

The technique for developing milk blends from vegetable sources was established by Kundu., *et al*. Based on sensory and nutritional characteristics, the manufacturing of soy milk and almond milk was optimized and were blended in various ratios. The taste characteristics and nutritional profile of the soy almond mixes were investigated. The soy almond mixes were consumed in three distinct ratios: 60:40, 50:50, and 40:60 soy: almond. In terms of sensory evaluation, the soy almond mix with a ratio of 40:60 was generally approved. Except for calcium and protein, the content of all nutrients in milk mix was higher than in cow's milk. As a result, the study indicated the necessity of drinking such blends as a cow milk alternative [55].

Nelson., *et al.* made a beverage with whole soybeans, sugar, and flavouring. Soaking the entire soybeans and blanching them in a 0.5 percent sodium bicarbonate solution were the first steps, followed by grinding and heating the slurry, homogenizing at the right temperature and pressure, and adding sugar and flavour. Soybeans were blanched to eliminate the beany flavour and to prevent the activities of anti-nutrient components like trypsin inhibitors. Homogenization at 93°C and 3500 pressure prevented particle separation for up to 2 months when stored in the refrigerator. From raw soybeans, this method kept 99 percent of the protein and 90 percent of the total solids [56].

Chiba., *et al.* investigated how to enhance the flavour of soybean products by removing the beany flavour using the enzyme aldehyde dehydrogenase. The irreversible conversion of aldehydes to their corresponding acids is catalysed by this enzyme. The enzyme was isolated and purified from bovine liver. Because the enzyme transformed the alcohols and aldehydes responsible for the beany flavour to acids, adding the enzyme to soybean milk resulted in the elimination or significant decrease of the beany flavour [57].

The impact of preliminary processing procedures on anti-nutrient levels of soy milk was investigated by Nowshin., *et al*. The presence of anti-nutritional elements in soy milk reduces the bioavailability of nutrients. The activity of the lipoxygenase enzyme was reduced solely by soaking. The combination of soaking, blanching, and hot grinding reduced urease, phytate, and abolished trypsin inhibitor activity, but had no effect on protein solubility. When soaking and hot grinding milk was compared to cold grinding, the protein content was higher. It was also shown that increasing the soaking period had no effect on the suppression of anti-nutrient activity such as phytate and urease activity. The combination of soaking (60oC/6 hours), hot grinding (100oC), and blanching (80oC/10 minutes) was shown to be the most effective approach for reducing anti-nutrient activity [58].

Soybean milk (soy to water ratio of 1:8) has a protein content similar to cow's milk but just one-fifth the calcium. Chaiwanon., *et al*. conducted research to fortify soy milk with calcium carbonate and tri-calcium phosphate to achieve a calcium content similar to that of cow's milk. *In vitro* Miller's technique was used to determine calcium bioavailability in soymilk by simulating human digestive system conditions in the lab. The largest quantity of dialyzable calcium was found in soymilk fortified with calcium carbonate, followed by cow milk and soymilk fortified with tri-calcium phosphate, while the least amount of dialyzable calcium was found in non-fortified soymilk. In comparison to non-fortified milk, fortified milk had a higher overall acceptance in terms of sensory rating. Non-fortified soymilk had a Ca: P ratio of 1:2; calcium carbonate fortified soymilk had a Ca: P ratio of 2.6:1; and tri-calcium phosphate fortified soymilk had a Ca:P ratio of 1.3:1 [59].

Murugkar investigated the chemical quality of soymilk and tofu after sprouting soybeans. Soybeans were cooked for 25 minutes at 121°C. Protein coagulation was achieved by adding 3% calcium sulphate at 80°C.Protein, fat, trypsin inhibitor, and phytic acid levels were all higher in milk made from sprouted soy. Protein content increased by 7% in soymilk and 13% in tofu, according to the findings. The fat content of soymilk was reduced by 24% while tofu had a fat reduction of 12%.In soymilk, anti-nutrients trypsin inhibitor and phytic acid were decreased by 73 percent and 59 percent, respectively; in tofu, they were reduced by 81 percent and 56 percent. Tofu made from sprouted soy had a higher protein and whiteness quotient, but it had a 43 percent lower strength than tofu made from non-sprouted soy.The overall acceptability of soymilk and tofu was enhanced by 9.9% and 4.4 percent, respectively, in terms of sensory characteristics. As a result, sprouting is a good non-thermal way to improve the quality of soymilk and tofu [60].

Protein isolates from eleven bean species were tested by Sosulski., *et al*. Although the isolates exhibited identical protein content but they differ in terms of solubility, fat homogenization, conductivity, and viscosity. The colour and viscosity of legume-based milks were quite comparable to cow milk, however the smell and taste of all legume-based imitation milks were impaired. Lima bean= mung bean= pea bean> northern bean= lupine> lentil= soybean> chickpea> fieldbean> faba bean were the imitation milks listed in decreasing order of favour. One of the legume-based milks (based on ethanol-wash protein isolate) was mixed 1:1 with cow milk, resulting in a significant improvement in the flavour of the product as well as an increase in the sensory and chemical scores [61].

A sufficient amount of calcium is required for healthy bones and calcium equilibrium in the body. Soymilk has just 200 mg of calcium per litre compared to 1200 mg in cow milk. As a result, calcium fortification of soymilk is required to give an alternative to cow milk. Zhao., *et al*. conducted a research in young women to evaluate calcium bioavailability in calcium carbonate-fortified soymilk (CCSM) and tricalcium phosphate-fortified soymilk (TCPSM). After an overnight fast, twenty healthy women ingested 250 mg calcium in cow milk, CCSM, or TCPSM, as well as 10 mg 44Ca. 45CaCl2 was used to identify cow milk extrinsically. The 44Ca was inherently labelled in the enriched milks. Another isotope, 43Ca, was injected one hour after cow milk or soymilk intake. Calcium absorption was measured in 24-hour urine samples, and no difference between CCSM and cow milk was discovered. Calcium bioavailability *in vitro* was shown to be lowest in TCPSM. As a result, the bioavailability of calcium in CCSM and cow milk is comparable [62].

Cruz., *et al*. investigated the effects of ultra high pressure homogenization (UHPH) on soymilk at 200 and 300 MPa. Soymilk and soymilk base product treated at ultra high temperatures (UHT) were compared to soymilk treated at ultra high temperatures (UHPH). At both pressure levels, spores, initial counts and enterobacteria counts were lower in UHPH treated milks. In the case of UHPH milk, the particle size decreased as well, though aggregates formed at 300 MPa. There was a difference in colour between UHPH and UHT or base product soymilks. Even after 30 and 60 days of storage at 4oC, the UHPH treated milk showed less particle settling than the other milks. Soymilk treated with UHPH at 200 MPa exhibited partial denaturation of proteins, but soymilk treated at 300 MPa showed the same level of denaturation as soymilk treated at extremely high temperatures [63].

Nande., *et al.* made soymilk products and tasted them to see how they tasted and how nutritious they were. They were then compared to animal milk-based products. Pudding, kalakand, ice cream, kadhi, shrikhand, and rasgulla were among the soymilk-based items. These items have a protein content ranging from 2.38 to 10.26%. The fat level, on the other hand, was low as compared to products derived from animal milk, ranging from 1.9 to 3.08 percent. The overall acceptance of pineapple flavoured ice cream was greater, but the organoleptic rating of soymilk pudding was comparable to that of animal milk pudding. When comparing soymilk kadhi to animal milk kadhi, the organoleptic metrics for soymilk kadhi were greater. Overall, goods made from soymilk were determined to be less expensive than those made from animal milk [64].

Nutritional composition of peanuts

Kumar., *et al*. did a research to compare the nutritional makeup of raw and roasted peanuts. Significant variations in physico-chemical parameters, proximate parameters, and mineral values were discovered. The raw peanut has a greater ash level (4.6%) than the roasted peanut (4.1%). The protein and carbohydrate content of roasted peanuts were greater than that of raw peanut. Protein content was 26.1 and 24.9 percent in roasted and raw peanuts respectively, while carbohydrate content was 26.5 and 25.3 percent. Both raw and roasted peanuts had acceptable crude fibre content, with raw peanut having 2.9 percent and roasted peanut having 3.1 percent. In comparison to raw peanuts, roasted peanuts had a lower moisture content (3.6%) due to heat treatment (4.1%). In both types, the energy values were comparable. Calcium, potassium, magnesium, zinc, and phosphorus were all at excellent amounts in both the cases [65].

Development and analysis of peanut milk

Groundnut is a very important food since it is an excellent source of edible oil and protein. Yadachi., *et al* conducted research to develop a substitute for cow milk and analyse its composition. pH, TSS, titratable acidity, specific gravity, reducing sugar, and protein content were all measured in the milk. TSS was 8.6oBrix, pH was 6.9, protein content was 9.62%, and specific gravity was 1.05. In the milk, sugar reduction was determined to be nil. Groundnut intake should rise in poor nations due to its high protein, oil, and energy content, which helps to battle malnutrition [66].

Galvez., *et al*. experimented with different pressure and temperature-time combinations for making peanut drinks. The drinks were cooked for 10, 15, and 20 minutes at 100°C, and for 5, 10, and 15 minutes at 121°C. Pressures of 2000, 4000, and 6000 psi were used to homogenize the samples. All the samples were subjected to sensory evaluation, gas chromatography analysis, and viscosity measurements. The sensory character of the samples was heavily influenced by the processing duration. The best processing conditions were achieved at a temperature of 100°C, a duration of more than 16 minutes, and a pressure of more than 3100 psi [67].

Yadav made peanut milk while keeping malnutrition and lactose sensitivity in mind. Normal soaking, soaking in 1% sodium bicarbonate, roasting, and pressure blanching were the four procedures used to make peanut milk. Moisture, carbohydrate, protein, fat, ash, total solids, and pH levels were determined using proximate analysis. Proteins, carbs, fat, and ash were 3.68, 4.70, 2.16, and 0.24 percent, respectively in the usual soaking technique. The figures for the soaking in 1% sodium bicarbonate technique were 3.11, 5.58, 1.86, and 0.26 percent, respectively whereas the values for the roasting method were 3.23, 3.78, 3.53, and 0.18 percent, respectively. After 2 minutes of pressure blanching, the results were

3.51, 5.05, 1.76, and 0.19 percent respectively. Results shown that the greatest protein level (3.74%) was discovered in milk produced by pressure blanching for 2 minutes and the lowest (3.11%) in milk prepared by soaking in 1% sodium bicarbonate. The carbohydrate content of sodium bicarbonate treated milk was greatest (5.58%) and lowest (3.78%) in milk produced by roasting technique. The greatest fat level (3.53%) was found in milk prepared by roasting, while the lowest (1.63%) was found in pressure blanched milk for 3 minutes. For 3 and 5 minutes, ash content was highest (0.26 percent) in sodium bicarbonate treated milk and lowest (0.15 percent) in pressure blanched milk [68].

Lee and Beuchat looked examined how processing conditions affected the physical, chemical, and sensory properties of peanut milk. It was discovered that soaking peanuts in 1% sodium bicarbonate prior to milk extraction resulted in a lighter colour. Cooking the peanuts before grinding them resulted in a decrease in protein and total solids content. The most favourable conditions for the manufacture of peanut milk were determined to be soaking peanuts in 0.5 percent sodium bicarbonate, heat treatment for 10 minutes, and homogenization of the milk at 4000 psi [69].

The study by de Albuquerque., *et al*. sought to fight malnutrition in developing nations by providing low-cost access to high-quality protein to the poor. Peanuts, which are high in protein and fat, were utilised as raw materials in the creation of plant-based milk. Two peanut-based milks, one with umbu pulp and the other with guava pulp, were created. The researchers looked at things including titratable acidity, pH, ash, protein, and moisture. The milks were kept at a temperature of -18oC for 5 months in deep freezing conditions. The protein content of the milks was shown to have decreased during storage. The pH of peanut extract was discovered to be higher than that of peanut milk. The umbu pulp-based milk had a greater titratable acidity than the guava pulp-based milk, while the guava pulp-based milk had a larger ash content [70].

Jain and coworkers used three techniques to make peanut milk: conventional, soaking in 1% sodium bicarbonate solution, and pressure blanching at 121oC/15 psi for 2, 3, and 5 minutes. The drinks were evaluated both in terms of organoleptic and nutritional profiles. Pressure blanching at 121oC/15 psi for 3 minutes was determined to be the most acceptable of the three methods. Protein, fat, ash, total solids, and moisture content of milk produced by pressure blanching were 3.27, 1.65, 0.16, 11.78, and 88.22 percent, respectively. Pressure blanching also cut the soaking period in half, from 16-18 hours in conventional treatments to just 6 hours with pressure blanching. Pressure blanching has also been found to have negative impacts on protein content and total solid extraction, despite being the most acceptable technique [71].

To extract milk, Saleem-ur-Rehman., *et al*. used raw and roasted peanuts. To improve taste and acceptability, many temperature-time combinations were practised. The results showed that soaking peanuts in plain water for 1 hour at 40°C produced the most acceptable product. The milk was made by blending soaked peanuts with an equivalent amount of water. The resulting slurry was mixed with additional water to get 100 mL milk from 100 g of peanuts. Sugar and skimmed milk powder (SMP) were added in various quantities. The product that was combined with 10% SMP and 1% sugar on a total solid basis was judged to be the most acceptable. The protein level of the peanut milk mix was greater (5.02%) than the protein content of cow milk. Furthermore, the peanut milk blend had greater iron, potassium, and magnesium levels [72].

The goal of Zhang., *et al*. was to create a stable peanut mango milk. The emulsifier used was a 0.24 percent combination of sucrose fatty acid ester, monoglyceride, and polyglycerol fatty acid ester in equal quantities. Guar gum was used as a stabiliser at a concentration of 0.15 percent. Therefore, a healthy and stable peanut mango milk was created [73].

Salve., *et al*. (2019) used non-thermal processing approaches to prepare peanut milk, including ultrasonication (US) at various intensities (200W, 300W, 400W) and hydrodynamic cavitation (HC) at various pressures (6 bar, 8 bar, 10 bar). The influence of these approaches on physico-chemical characteristics of peanut milk, microbial inactivation, and variables including sedimentation index, viscosity, and colour measures were all considered. For the milk treated at pressure 10 bar, the HC treatment resulted in the greatest log decrease in Total Plate Count, which was about 1.2.In terms of microbial inactivation, the US treatment was the most successful, with a log decrease of 0.9 at 400W for yeast and mould. In terms of separation index and colour characteristics, the US treated milk was also effective. After both treatments, the viscosity appeared to be lower. These two non-thermal procedures improve the quality of both dairy and non-dairy milk [74].

Nondairy vs dairy

McCarthy., *et al*. performed an online poll to evaluate public opinions of cow milk vs plant-based milk purchases in order to better understand the trend of cow milk purchases declining in favour of plant-based milk purchases. Individual interviews with 75 dairy drinkers, 68 non-dairy drinkers, and 78 drinkers of both beverages were done. Fat was the most important feature for dairy milk consumers, followed by package size and label claims. Dairy consumers chose a fat level of 1-2 percent, half or one gallon container, and traditional pasteurisation. The sugar level, on the other hand, was the most important feature for non-dairy customers, followed by plant source and package size. Almond milk and a half gallon packaging size were chosen by non-dairy consumers. Lactose-free was a problem for both dairy and non-dairy drinkers, as well as those who consumed both. The findings of the interview also revealed an important aspect concerning non-dairy consumers: they were made aware of the animal mistreatment that occurred during the process, as well as a perception of a lower carbon impact on the environment. Dairy consumers, on the other hand, regarded milk to be a basic food. According to the findings, if lactose-free dairy products are created, the market for dairy milk is expected to grow significantly [9].

Cow milk allergy (CMA) is most commonly found in babies and persists into adulthood, and it is diagnosed via blood or skin testing. El-Agamy (2007) investigated cow milk's hyperallergenic characteristics. Cow milk contains around 20 proteins that might trigger an allergic response in human bodies. The two most frequent allergies in cow milk are casein and lactoglobulin. Lactoglobulin is found in buffalo, goat, sheep, and donkey milk in addition to cow milk; however, it is absent from human and camel milk. Human and goat milk casein is not the same as cow milk casein. People with CMA can drink goat, mare, camel, or soy milk, all of which are completely plant-based [75].

Vegan diets may be nutritionally sound if they are well planned, and milk obtained from many plant sources has a higher nutritional content than milk derived from a single source. As a result, including plant-based milk blends in one's diet can help to enhance one's nutritional status and keep one health.

Conclusion

Plant-based milk substitutes are known to exhibit properties of "health foods," however the nutritional profiles of the products in the market vary greatly, with some having incredibly low protein and mineral concentrations. Manufacturers must take into account protein quality, quantity, and fortification in order to make it close resemblance to cow's milk in terms of composition and nutritional value. Due to the therapeutic properties of non-diary blends, which are described above, advanced non-thermal technologies, such as pulse electric field technology and ultra-high-pressure homogenization, serve to be useful in addressing the factors that are preventing the widespread processing of such plant-based milks and these techniques lead to the improvement in the nutritional content and sensory profile of plant-based milks. This will help to provide the non-diary blend to the population with cow milk allergies with affordable, nutrient-rich newer alternatives. Additionally, it is important to ensure that this imitate milk is both palatable and widely accepted by the general public.

Declaration

- **Ethical approval and consent to participate:** Our institute do not require review based studies to be undergone Ethical approval or any consent.
- **Consent for Publication:** All the authors have given their consent for publication of review article in your journal.
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