Chapter

# Plant-Based Milk Substitutes: Factors to Lead to Its Use and Benefits to Human Health

*Laís Zandona, Caroline Lima and Suzana Lannes*

## Abstract

The consumption of vegetable milk has grown in recent years. Medical reasons are some reasons for the increase in the number of consumers of this type of drink. Lactose intolerance and allergy to cow's milk protein are the major factors that lead to this consumption in addition to the option for a healthier lifestyle, there are also consumers concerned with animal health and welfare who are adept at restrictive diets like vegetarianism and veganism. Vegetable extracts are water-soluble extracts from legumes, oilseeds, cereals, or pseudocereals that resemble bovine milk in appearance, are considered substitutes for cow's milk due to the similar chemical composition and can also be used as substitutes for direct use or in some animal milk-based preparations. In contrast, these substitutes have different sensory characteristics, stability, and nutritional composition of cow's milk. Plant extracts have health-beneficial compounds, phenolic compounds, unsaturated fatty acids, antioxidant activity and bioactive compounds such as phytosterols and isoflavones making plant-based milk substitutes an interesting choice.

**Keywords:** functional food, lactose intolerance, cow protein milk allergy, veganism, bioactive compounds

## 1. Introduction

The animal milk is already a highly consumed and appreciated by the human being for many centuries. Its consumption may exist from 8000 BC to 10,000 BC through the aurochs, ancestors of the actual cows, were domesticated and its milk used for consumption [1].

Milk is a highly valued and important food for the human diet. Since birth, this food can provide nutrients capable of transmitting not only energy but also bioactive components and immune cells that are responsible for anti-inflammatory, anti-infectious, and probiotic actions [2].

Since milk is a food that contains almost all the nutrients necessary for the maintenance of our body, it is still widely consumed, even in adulthood. Nowadays, use the term "milk" for the secreted fluid of the cow, and the secreted fluid of other animals is called "animal name + milk", for example, sheep's milk, goat milk and buffalo milk [3].

Milk consumption is very important, especially in underdeveloped countries, as it is an important source of energy, protein and fat, being one of the most important foods for consumption in malnourished children [4].

For several reasons, more consumers choose alternatives to plant-based milk. The most common reasons are allergies to milk protein, lactose intolerance or lifestyle choices, such as vegetarianism [5].

Because of this, currently an increase in research and development of plant-based milks and their derivatives, such as yogurts, ice cream and fermented beverages, has been carried out in order to bring more consumption options for individuals who cannot or do not wish to consume animal milk. Thus, the objective of this chapter is providing some information on types of milk substitutes and their functionality in food formulations and in human health.

## 2. Animal milk: processing and composition

As a natural food, milk has a rapid multiplication of different microbial groups. Therefore, both raw milk and dairy products, with the exception of some cheeses, must go through a thermal process, such as pasteurization, thermization or ultra-high temperature (UHT) so that pathogenic microorganisms are eliminated and so the milk is safe for consumption [6].

The UHT process for milk is a technique that uses a heat treatment with temperature between 135 and 150°C with pause times between 1 and 10 s. There are two types of heating for this processing: direct and indirect heating. In direct heating, the milk itself encounters a saturated steam. In indirect heating, an external heating medium will indirectly heat milk by conduction and convection through a barrier that acts as a heat exchanger. The indirect heating is the most used by industries [7].

As for milk pasteurization, the milk is heated to a specific temperature, keeping the milk at this temperature for a specific length and successively a rapid cooling step with a temperature below 7°C. The temperature and length of the pasteurization process will depend on which microbial or chemical effects are desirable. When submitting milk to the pasteurization process, one must think that the higher the temperature and the longer the process, the drastic decrease in the number of microorganisms will be possible, but there will also be a damage to the nutritional constituents of milk [8].

As for the thermization technique, a temperature of 63°C is used for 15 s, being milder than pasteurization; this process is used only to improve the quality of the milk, since there is no effective elimination of pathogenic microorganisms that may be present in the milk [8].

From whole milk, several by-products, such as cream, buttermilk, skimmed milk, and derived by-products, such as caseins and whey protein can be produced by the dairy industry. The processing of both whole milk and these by-products can be seen in **Figure 1** [9].

Milk is a complex biological fluid that contains fat, proteins, vitamins, minerals, enzymes and sugar in its composition. Mammalian animals show similarities regarding the nutritional composition of their milks however, the influence of genetic factors, nutritional factors and environmental conditions can alter the composition of milk, even in animals of the same species. **Table 1** presents a general composition of the milk of different mammals [11].

Milk plays a fundamental role in human nutrition and health, which is why the intake of this food is so important to be consumed by both children and adults. The milk consumed by humans comes mainly from the dairy cattle, but in some parts of the world, there is the consumption of milk from other animal species, for example, buffalo, goats, sheep, and camels. Cow's milk protein consists of approximately 80% casein (w/w) and 20% of whey protein (w/w) [13].

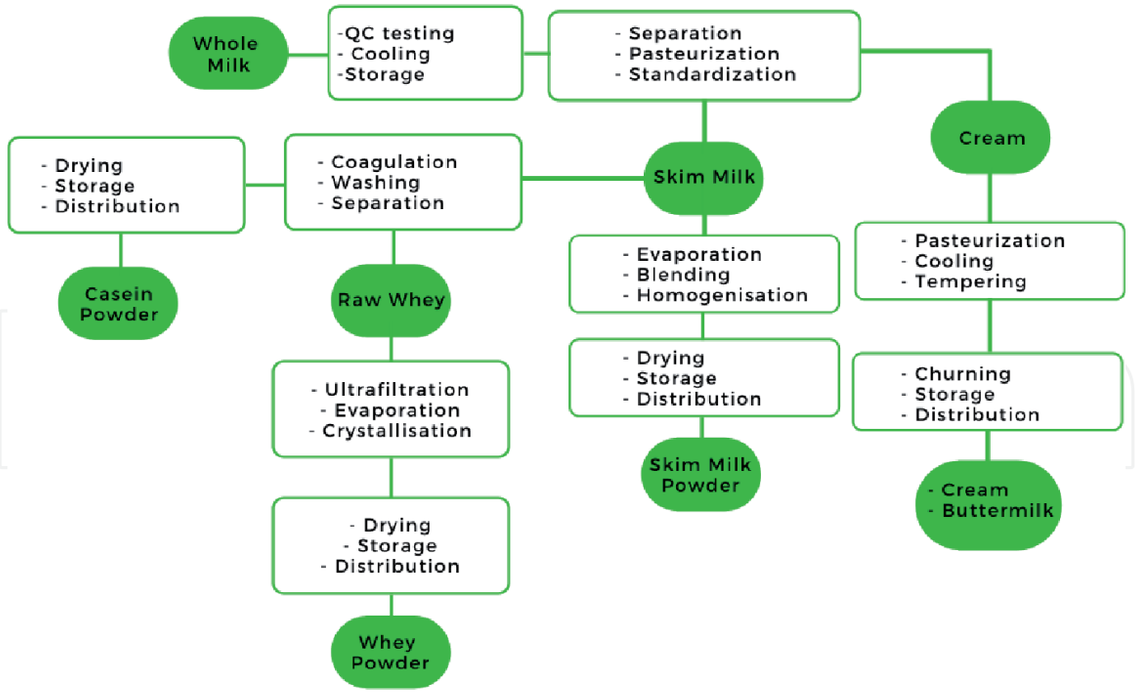


**Figure 1.**
*Processing of whole milk and its by-products [10].*

| Species | Water | Proteins | Fat | Lactose | Ash |
|---|---|---|---|---|---|
| Cow | 87.2 | 3.5 | 3.7 | 4.9 | 0.72 |
| Sheep | 82.7 | 5.5 | 6.4 | 4.7 | 0.92 |
| Goat | 86.5 | 3.6 | 4.0 | 5.1 | 0.82 |
| Camel | 87.7 | 3.5 | 3.4 | 4.7 | 0.71 |

**Table 1.**
*The composition of milk from different mammals in g/100 g milk [12].*

In animal milk, exist four main caseins that are naturally present: αs1, αs2, B e k, with casein k being the most relevant due to its importance in the stability of the micelle and in the processing of various dairy derivatives [12].

As for whey protein, the main proteins are β-lactoglobulin, α-lactalbumin, serum albumin, immunoglobulins (IgG1, IgG2, IgA and IgM) and lactoferrin. This class of proteins is classified as high biological value since it presents essential amino acids and branched chain amino acids (not synthesized by our organism). With this has received a lot of attention for the food development industry, mainly in sports nutrition, since that these amino acids are important for tissue growth and repair [14].

Bovine milk fat has more than 400 fatty acids with different chemical compositions. Its composition consists of triacylglycerol, diacylglycerol, free fatty acids, and cholesterol [15].

The composition of milk fat will in fact depend on external factors to which dairy cattle are subjected, such as factors related to food (feed offered to cattle) or rumen microbial activity. In addition, other factors such as stage of lactation and mastitis can also influence the final composition of milk fat [16].

Milk fat is the natural source that most presents short-chain fatty acids (C4:0 – C8:0) and also contains a high amount of medium chain fatty acids (C10:0 – C14:0) which causes that this food is almost exclusive to certain bioactive fatty acids

considered beneficial to human health. An example of this is butyric acid (C4:0) and conjugated linoleic acid that are not found in significant amounts in other foods in our diet [17, 18].

Regarding carbohydrate, lactose is the main present in the composition of milk. This compound if formed by the union of a D-galactose molecule with a D-glucose molecule. Thus, lactose can be hydrolyzed through an enzymatic action by β-galactosidase that will transform it into its constituent monosaccharides, i.e., galactose and glucose. This action is of great importance for the food industry, since lactose, despite being a sugar, does not have a sweet taste, but its constituents have such a sweet taste, in addition to being more soluble than lactose [12, 19].

In addition, when lactic acid bacteria meet with lactose, they hydrolyze it into lactic acid, thus making milk a favorable medium for fermentation, since the pH of the milk falls and coagulates, and it may then be possible to produce dairy products, like cheese and yogurts. However, this requires controlled fermentation, as unwanted fermentation obviously results in the deterioration of milk [20].

Although lactose has many advantages for the food industry, this component of milk is also responsible for making it impossible for many people around the world to consume milk, since they have a lactose intolerance. The pathophysiological aspects or lifestyles that remove the consumption of milk by the population will be found in more detail in the next topic.

## 3. Adverse reactions to milk composition

Although milk is a good food source of compounds because it is associated with the supply of several essential nutrients to our diet, there are several concerns that must be taken into account for the consumption of this food, both in terms of different health problems and lifestyles that a person can manifest.

One of the adverse effects on human health is allergy to cow's milk protein, which occurs due to an adverse immune response to the cow's milk dietary antigen. The allergic process starts with casein, which makes up about 80% of milk proteins. When these proteins are digested, they are converted into opioid compounds called β-casomorphines that binds to the A1 allele of β-casein, thus causing allergy to the human body, especially in children and newborns, since your body does not yet recognize some proteins of cow's milk [21].

Another adverse cause that can be affected by the consumption of animal milk is lactose intolerance. This condition occurs when a person is unable to digest and absorb lactose from the diet. This is because there is a decline in lactase expression after weaning, commonly called "lactase non-persistence" [22].

Among the symptoms that identify lactose intolerance are gastrointestinal symptoms that can be presented with mild to moderate signs of indigestion, flatulence, nausea, diarrhea, and abdominal cramps after consumption of milk and dairy products [23].

Another factor that excludes animal milk from the diet, but that is not associated with any disease but with lifestyle is the case of vegans. The basic principle of vegetarianism is not consuming any type of red meat, chicken, or fish, but it may or may not include products of animal origin, such as eggs, milk and their derivates. Although it is often not very clear, veganism not only supports the exclusion of animal foods from its diet due to the animal's suffering, but also as a way of supporting the inclusion of plant foods produced by local producers that will present less environmental impact [5, 24].

Therefore, such conditions point to the need for not only animal milk but also its derivatives to obtain an alternative that is as healthy, so that people who cannot

consume this food are also able to digest nutrients necessary for a good diet, in addition to presenting other food alternatives that allow you to diversify eating routines.

## 4. Plant-based milk alternatives

Currently, there are several researches for replacing milk using plant-based milk. This type of milk-like is a water-soluble extract based from vegetables, legumes, cereals, pseudocereals and nuts [25].

Vegetable milk processing can have several types of vegetable milk-like processing that will depend on the raw material from which this vegetable milk-like will be extracted. However, there are processing steps that are common to most vegetable milks, such as pre-treatment of raw material, extraction of milk, incorporation of additives, suspension, stabilization and adequate storage to improve shelf life of the product, as can be seen in **Figure 2** [26].

As it is still a studied product, there is still no concrete definition and classification in the literature of these plant-based milks. However, a general classification of these milk alternatives is divided into 5 subcategories, which are: cereal based, legume based, nut based, seed based and pseudocereal based [27].

In addition to providing lactose substitution, plant-based milks are also capable of providing health benefits to the general population and not only to those who should restrict lactose from the diet. This occurs because of the raw materials used in the production of these plant-based milks, since they have compounds that bring health benefits due to nutrients and micronutrients present in the composition of these foods that allow such beneficial actions to the human body.

Legumes are an important category in the divisions of vegetable milk, and chickpeas (*Cicer arietinum*) are rich in carbohydrates, proteins, vitamins, minerals, and fiber. Chickpeas have a high content of unsaturated fatty acids, such as linoleic acid (18: 2) and oleic acid (18: 1), and also have an excellent source of phosphorus, potassium, calcium, magnesium, sodium, iron, copper, manganese, and zinc [28].

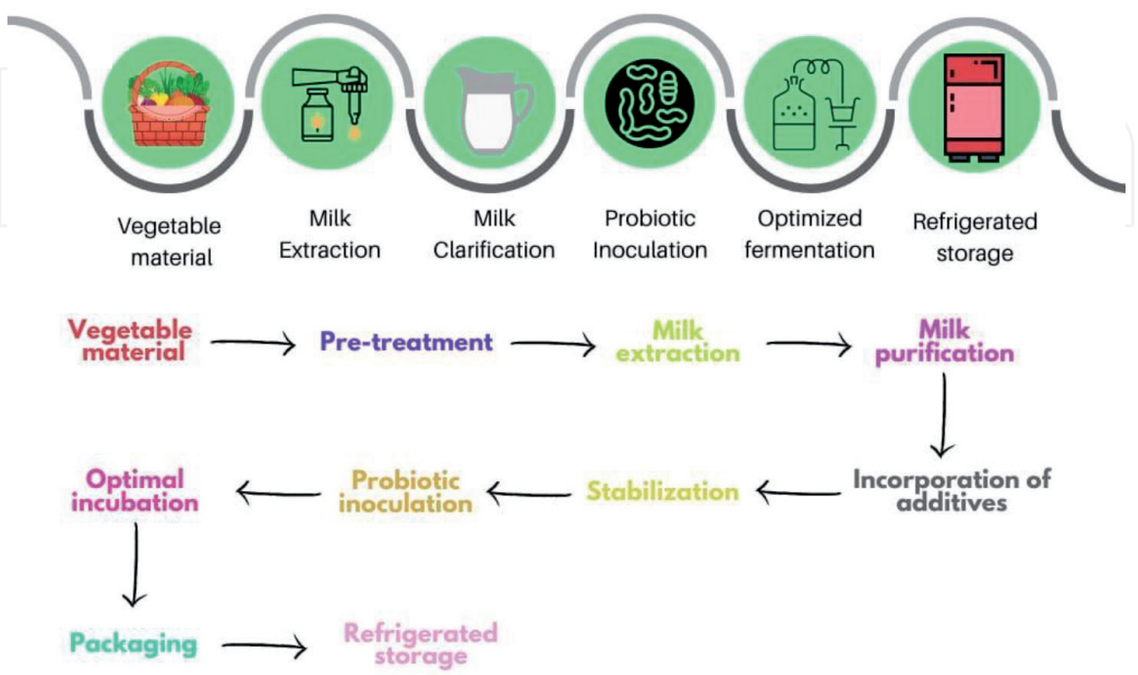


**Figure 2.**
*Basic flow diagram to produce probiotic vegetable milk [26].*

In chickpeas, polysaccharide (starch) is the largest component followed by fibers, contains monosaccharides (ribose, glucose, galactose, and fructose), disaccharides (sucrose, maltose), oligosaccharides (stachyose, ciceritol, raffinose, and verbascose) [29].

The fiber content of chickpeas in chickpeas is 18–22 g for every 100 g of raw material, with 4–8 g of soluble fibers and 10–18 g of insoluble fibers that are major players in cholesterol control total and LDL [30].

When chickpeas are cooked, they undergo ultrastructural changes that influence their nutritional, physical, and functional properties with significant decreases in antinutritional components and significant increases in dietary fibers and protein digestibility [31].

Chickpeas are a source of carbohydrates and proteins and can be used to develop products with greater added nutritional value, also, phytosterols present in the lipid fraction of chickpeas have antioxidant properties even at high temperatures [30, 32].

Soy (*Glycine max*) is rich in carbohydrates, proteins, and lipids. Soy milk is a good source of monounsaturated and polyunsaturated essential fatty acids, with significant amounts of polyunsaturated fatty acids, such as linoleic (18: 2) and linolenic acids (18: 3), has no cholesterol, and has a considerable content of vitamins and minerals. Soy milk is a good source of monounsaturated and polyunsaturated essential fatty acids. Soy protein is composed of all essential amino acids, many of which are present in quantities that correspond to those necessary for humans [5, 27].

Soy contains up to 35–45% protein and 20% fat and acts as an important source of protein, especially in people who follow a vegetarian diet. Due to its nutritional content, soy milk is used as a cow substitute for more than four decades. It also appears that the total number of calories available is comparable to a balanced nutritional profile [33].

Isoflavones appear to be the functionally active component responsible for the beneficial effects of soy. Isoflavones are well known for their protective effect against cancer, cardiovascular disease, and osteoporosis. Genistein is the most abundant isoflavone in soy and is considered the most biologically active [27].

Soy germination is known to be beneficial in reducing antinutrients as a trypsin inhibitor, phytic acid, flatulent, etc. Soy milk prepared by the traditional method presents some problems, many works and researches are trying to improve the quality by eliminating the strange taste and beans, inhibiting anti-nutritional factors, reducing the phytic acid content, improving the production of soy milk. All efforts generally address one or two of the associated problems and use heat-intensive methods to reduce antinutrients, thereby reducing the overall nutritional quality of soy milk. Germination, which is a natural non-thermal and non-chemical process, results in better quality processed products and soy germination would be an alternative to facilitate the development of products such as soy milk, which are usually prepared by heat treatment and moist protein-causing denaturation [34].

The pea (*Pisum sativum*) contains proteins that are easily digestible and has a high-quality amino acid profile, as well as a high content of lysine and arginine. Pea proteins have a very particular amino acid profile, different from other plant proteins. The amino acid profile of pea proteins is arginine, lysine, and branched-chain amino acids (isoleucine, leucine, and valine), glutamine, and glutamic acid [35].

Pea protein is a rich source of starch, fiber, vitamins, and minerals and easy to digest. Therefore, it can be used successfully as a substitute for animal protein in dairy products. Total pea proteins are divided into two main groups of albumin and globulins. However, pea's main storage proteins are often called legumin, vicilin, and convicilin, which make up the globulin fraction, which does not denature at different temperatures [36].

Lupine (*Lupinus termis*) is rich in alkaloids, amino acids, carbohydrates, and proteins with moderate gelatin properties compared to soy proteins. Lupine is a good source of nutrients, not just proteins, but also lipids, fibers, minerals, and vitamins. Lupines contain phytochemicals with antioxidant capacities, such as polyphenols, mainly tannins, and flavonoids [37].

With a high protein content of 25–40% can be used in milk-like products and substitutes, there is a growing interest in the production of lupine, due to its potential as a protein source, or for pharmaceutical purposes due to the high alkaline content, such as a natural component. Lupine milk-like plays a key role in meeting demand as an alternative to cow or human milk [37, 38].

Plant-based milks elaborated from seeds contain proteins that, like bovine milk proteins, tend to clot when they are acidified, heated, or enzymatically treated. Herewith, this type of vegetable milk-like is also capable of forming many products called "dairy products", such as creams, yogurts, ice cream and cheeses [39].

The most common types of vegetable milk-like produced from the seed is sesame milk. Sesame (*Sesamum indicum*) is a grain that contains high levels of phenolic compounds in their composition, which are considered with high antioxidant activity [40].

However, in sesame only a small amount of these components is present in their free form, the remainder being linked to glucose in the form of mono/di/tri-glucoside lignan, thus not exercising its antioxidant activity. However, when fermenting sesame milk-like with a lactic acid β-glucosidase, the glycoside bonds are broken resulting in a compound called aglycone, which increases the product's antioxidant activity [41].

Because of this, initially, only sesame milk-like may not be considered an advantageous vegetable milk-like when compared to other plant-based milks, but in application of yogurts and fermented beverages, this food can have great nutritional advantages.

Another type of seed that can be used to elaborated vegetable milk is pumpkin seed (*Cucurbita maxima* Linn*)*. This seed is widely consumed in the form of snacks in different regions of the word, but due to its nutritional advantages, it has been thought about its use in the development of other types of products [42].

This seed is an important nutritional source, as it contains lipids (30.66%), protein (33.48%) and carbohydrate (28.68%). Still, its extract proved to be effective against diabetes and hypercholesterolemia due to the components present in its composition [43].

Flaxseed is a food rich in all essential fatty acids, especially omega-3 that is responsible for increased immunity and brain function. In addition, it has amino acids that are responsible for maintaining proper cellular function through the synthesis of protein. As a result, flaxseed has gained presence in research for the development of vegetable milks-like since its use improves the nutritional quality of the final product [44].

Another subcategory of plant-based milks is those obtained from pseudocereals, such as Quinoa *(Chenopodium quinoa* Willd.), a plant that belongs to the *Chenopodiaceae* family. Because it has a high amount of protein and an adequate balance of amino acids, this plant has been considered of great importance, especially for individuals who do not, or make little intake of foods rich in proteins and amino acids such as meat, eggs and milk [45].

Despite its great nutritional advantages, quinoa is still not a widely used food for developing new types of food products, as it has a high cost when compared to other types of food available, especially in the case of the development of plant-based milks-like [46].

Cereals are another subcategory that can develop a vegetable milk-like. Although there are countless cereals present around the word, the most common types of vegetable milk-like obtained from cereals are rice and oats.

Oat (*Avena sativa* L.) is a specie of cereal grain rich in biological substances, such as soluble dietary fiber, β-glucan, vitamin E and polyunsaturated fatty acids that make the consumption of this food of great importance for human health in the long term [47].

Among the components present in oats, β-glucan is the most important since this component has a prebiotic function in the gastrointestinal tract supporting the growth of microorganisms beneficial to our body; In addition, β-glucan moderates the glycemic response of the oat starch portion. In addition, this cereal contains several bioactive phytochemical, such as, for example, phenolic acids, flavonoids, carotenoids and phytosterols, in addition to the avenanthramides and steroidal saponins, which are found exclusively in this food [48, 49].

Although rice is low in protein, it is still a food to be taken into account for the production of plant-based milks, due to its underutilization and high nutrient profile. A natural fermentation with lactic acid bacteria there is a break in the antinutritional factors that cause an increase in the content of calcium, iron and magnesium, causing the beneficial bacteria in our gastrointestinal tract to collaborate in digestion and in the immunity of other internal organs [50].

Therefore, the use of isolated rice milk-like may not appear to be of any benefit, but when subjected to a fermentation process, which occurs in the production of many dairy products, this vegetable milk-like can have positive advantages for the final product.

Another subcategory that can be found to produce vegetable milk are nuts. Almond (*Prunus dulcis*) has as main components proteins, lipids, soluble sugars, minerals, and fibers. Most almonds are fatty, between 35 and 52%, followed by protein, 22 to 25%, with lipids mainly as unsaturated fatty acids and proteins as essential amino acids. Also they are rich in nutrients such as calcium, magnesium, selenium, potassium, zinc, phosphorus, and copper and, due to the presence of arabinose, they have prebiotic properties [5].

Almonds are rich in monounsaturated fatty acids (MUFA), which are considered useful for weight loss and control. There is also much convincing evidence that MUFA helps to reduce the content of low-density lipoproteins (LDL) in the blood. Almonds are also an essential source of various nutrients, including protein, fiber, vitamin E, manganese, and antioxidants, and are therefore reflected in almond milk-like. Its consumption has beneficial effects on human health, and it is especially related to the blood lipid profile and the risk of cardiovascular diseases [33].

Coconut (*Cocos nucifera*) milk-like can increase HDL (high-density lipoprotein) levels, which helps to reduce harmful LDL (low-density lipoprotein). Coconut fats have lauric fatty acid, which mainly contributes to increasing HDL cholesterol levels, which helps to lower LDL cholesterol levels in the bloodstream [33].

Coconut milk-like is used as a milk substitute (cow's milk) in dairy products such as cheese, yoghurt, chocolate, and frozen dessert. In this way, coconut milk is considered one of the most suitable substitutes for milk. Therefore, milk and coconut milk can serve as substitutes for each other, depending on the purpose of the substitution [51].

Young coconut milk contains carbohydrates (mainly sucrose and some starch), lipids, and minerals, such as phosphorus, calcium, and potassium. Coconut protein is rich in lysine, methionine, and tryptophan. Coconut water extracted from young coconuts has a pleasant taste and balance of sodium, potassium, calcium, and magnesium since many plant extracts are mixed with the water of the coconut itself for yield and stability [52].

| Milk alternative | Subcategory | Health benefits | Author, year |
|---|---|---|---|
| Oat Milk | Cereal | It has an anti-carcinogenic component and reduces LDL cholesterol levels; Rich in fibers, antioxidants and polyphenols. | Paul; Kumar; Sharma, 2019 [50] |
| Soy Milk | Legume | Source of essential fatty acids, considered good for cardiovascular health; Therapeutic properties and protective roles against several age-related diseases. | Nawaz, et al., 2020 [53] |
| Almond Milk | Nuts | Rich in monounsaturated fatty acids, which help in weight management and can lower LDL cholesterol | Vanga, et al., 2020 [54] |
| Quinoa Milk | Pseudocereal | Contains all essential amino acids and high quality fatty acids; Contains minerals and amino acids that help in memory and reducing anxiety in stressful situations. | Bianchi, et al., 2014 [55] |

**Table 2.**
*Examples of raw materials in vegetable milks-like and their health benefits.*

A summary of health benefits provided by the different raw materials used in the production of vegetable milk-like is presented in **Table 2**.

## 5. Use of milk substitutes in dairy products

Currently, there are not many researches focused on the use of plant-based milks in the production of dairy products such as fermented beverages, ice cream, yoghurt and cheese, for example. Despite this, the work that has been carried out in this area produces results that help not only to improve previous research but also to conduct new research and new products at the market.

Recently, a fermented beverage produced from lentil grains fermented with *Lactobacillus* strain was evaluated in order to analyze its biochemical and nutritional composition, in addition to the viable cell count during its storage time. The work concluded through the obtained results that the protocol used showed to have adequate potential for applications in other types of fermented beverages and with the possibility of using other types of legumes [56].

Adding the nutritional value of the legumes, and their generated vegetable extract, it can lead to the production of ice cream, with soy extract and soybean protein, with functional properties, that also impose specific structural characteristics of product. With the obtained results it is possible to conclude that the use of soy for the preparation of gelato shows differentiating characteristics in terms of protein content, solubility and viscosity of the final product, which is also well accepted by consumers [57].

An alternative to soy milk-like was made by the production of fresh and fermented chickpeas, producing plant-based beverages. The fresh chickpeas presents a good result in the nutritional and organoleptic quality of the product, being a potential substitute for soy in plant-based beverages, although further research is necessary to minimize the syneresis of the elaborated product [58].

Texture properties are related to sensory acceptance by consumers. Vegetable yogurts based on oats is possible, nevertheless the perception of the plant-based yoghurt in the mouth has greater variation compared to traditional yoghurt, due to its textural properties, such as thickness and creaminess inferior to the product elaborated with animal milk. Therefore, to be acceptable by consumers, it is recommended that its final texture properties be considered during the product development phase [59].

Another oat base to produce a fermented product like the traditional yoghurt can be used, leading to acceptable appearance and taste. However, is necessary to evaluate the physical and nutritional quality of products [60].

Ice creams fermented with *Lactobacillus acidophilus* (Bb-12) and *Bifidobacterium bifidum* (La-05) can be prepared from cow's milk, soy, or coconut, as well as the combination of cow's milk or coconut milk (1 = 25%, 2 = 50% and 3 = 75%) with soy milk (75%, 50%, and 25% respectively). The substitution of cow's milk for soy and coconut milk increase the probiotic growth of (Bb-12) and (La-05), thus showing that soy and coconut vegetable milk-like ice creams provide a richer growth in amino acids and sugars for Bb12- and La-05 than cow's milk. Thus, ice creams produced with plant extracts can be a good vehicle to deliver probiotic content [61].

Cow's milk can be replaced by soy and coconut milk-like, and various combinations with cow's milk for producing ice creams. The addition of vegetable milk-like increases the pH and decreased the melting rate, varying the viscosity and particle size [62].

In the development of technological products based on vegetable milk-like, the production of desserts with chocolate based on yams and rice, a difference on textural properties can be found. In comparison with products produced with animal milk such as *brigadeiro* (typical Brazilian desert), a difference in flavor is observed, due to the lack of some components of the plant extract, such as low-fat content. Among the chocolate desserts, the rice based presents a mild starchy flavor, which can end up providing less acceptance by consumers. The coconut-based dessert, with rice milk-like and yam, can stood out for its flavor and characteristics [63].

Curd can be developed by substituting cow's milk for different plant extracts such as oats, rice, and almonds, adding *Lactobacillus* sp. Milk-like and curd from almond can be highly acceptable, with adequate pH and nutritious values. Milk-like and curd developed from plant sources may represent safe food as part of diet for people with lactose intolerance [64].

Yoghurt is an excellent probiotic source and because of that, when using a plant-based milk substitute for yoghurt production, it is interesting to consider whether such beverages are capable of maintain the minimum required of the population that are responsible for maintaining the probiotic characteristics of this type of product, as it was analyzed in a developed work, in which yogurts were produced using a vegetable beverages made from soy, rice and coconut. With the results achieved, it was possible to conclude that not only fermented beverages, but also non-fermented ones are able to supply and transport lactic acid bacteria and also other microorganisms, even without the fermentation process and subjecting the products to storage under refrigeration. Thus indicating that a yoghurt produced from a plant-based beverage is also capable of promoting desirable characteristics for consumers for this type of product, thus promoting a wider range of plant-based dairy derivatives also for consumers who are unfit to consume dairy derivatives from animal sources [65].

The effect of syneresis on yoghurt is very important for evaluating the final product. Because of this, it is very important to evaluate this property of a yoghurt elaborated with plant extract. Therefore, a work evaluated the effect of storing a yoghurt elaborated from a plant extract on the syneresis of yoghurt and concluded that this property increased as the storage time passed and that the syneresis is inversely related to the pH of the product, thus being in agreement with other related works [66].

As noted, soy is the most used food and cited in research to replace milk and the use of plant extracts. A work conducted a functional and physical analysis of a product fermented using soy extract, fermented with a probiotic culture of kefir, and with added soy fiber and the results concluded that the product elaborated with the addition of fiber was firmer and with a lower syneresis value when compared to the

product elaborated without the added fiber. With this, the product can be considered as an alternative to the existing products on the market, since, in addition to presenting such advantages even at the end of the storage analysis period, it presented an adequate probiotic culture count to be considered as a functional product [67].

Currently, a greater demand for symbiotic products, that is, those in which there is a combination of probiotic and prebiotic means has been offered to consumers in order to benefit human health. Therefore, several studies have developed products with symbiotic characteristics also for consumers who are unable to consume animal milk, and therefore, they use plant extracts to produce such analogs.

A work developed a symbiotic oat-based beverage, produced with a probiotic culture (*L.plantarum*) and prebiotic product (inulin) in order to evaluate its physical–chemical properties and its probiotic survival. Therefore, the work concluded that the probiotic culture of the product remained with adequate values for food during its storage period and its physical–chemical analysis showed a product with a low fat content and a high content of dietary fiber, being then a healthy alternative to be presented to consumers [68].

## 6. Conclusions

Although animal milk is a very important food for the human diet due to its supply of essential nutrients, which in some cases are not found in other foods, the use of vegetable milk-like is a viable alternative to offer consumers who cannot or do not choose to consume animal milk.

Therefore, plant-based milk substitutes have gained market share, as they are beneficial to health due to the raw materials that are used in their production. However, in the development field, much research must still be carried out for the formulation its products, since there is still not much works mainly in the elaboration of vegetable milk based dairy derivatives, improving the offer and the consumption options for the population.

## Conflict of interest

The authors declare no conflict of interest.

## Author details

Laís Zandona, Caroline Lima and Suzana Lannes*
Pharmaceutical-Biochemical Technology Department, Pharmaceutical Sciences School, University of Sao Paulo, Sao Paulo, Brazil

*Address all correspondence to: scslan@usp.br

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