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Review Paper / Derleme Makale

A Plant-Based Milk Type: Hemp Seed Milk

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ABSTRACT

Plant-based milk industry has been enlarged with increasing demand for plant milk types and their products. Demand is based on some factors such as vegan consumption, nutritional content, carbon emissions, lactose intolerance, and other factors. According to raw material, plant-based vegetable milk types can be divided into five categories as cereal-based (oat, rice, corn and spelt milks), legume-based (soy, peanut, lupine and cowpea milks), nut-based (almond, coconut, hazelnut, pistachio, walnut and cashew milks), seed-based (sesame, flax, hemp and sunflower milks) and pseudo-cereal based (quinoa, teff, amaranth and buckwheat milks). Hemp seed milk is one of the seed-based milks and it has high nutrition values because it is composed of lipids (1.25-5.00%), proteins (0.83-4.00%), carbohydrates (2.5-20.0%), vitamin E, minerals (sodium, phosphorus, potassium, magnesium, calcium, sulfur, iron, and zinc) and all essential amino acids with high in polyunsaturated fatty acids (linolenic acid and linoleic acid). This review evaluated hemp seed milk in comparing with other plant milk types, presented its nutritional aspect, and formed a perspective with current studies.

Keywords: Hemp, Hemp seed milk, Seed based milks, Plant based milks

Bitkisel Sütlerden Biri: Kenevir Tohumu Sütü

ÖZ

Bitkisel süt endüstrisi, bitkisel sütlere ve ürünlerine olan talebin artmasına bağlı olarak genişlemektedir. Söz konusu talepler temel anlamda vegan tüketim, besinsel içerik, karbon emisyonu, laktoz intoleransı ve diğer faktörler olmak üzere bazı hususlara bağlıdır. Bitkisel sütler hammaddelerine göre tahıl bazlı (yulaf, pirinç ve mısır sütü), baklagil bazlı (soya, yer fıstığı, acı bakla ve börülce sütü), yemiş bazlı (badem, hindistan cevizi, fındık, fıstık, ceviz ve kaju sütü), tohum bazlı (susam, keten, kenevir ve ayçiçeği sütü) ve yarı-tahıl bazlı (kinoa, teff, amaranth ve karabuğday sütü) olmak üzere beş kategoriye ayrılmaktadır. Kenevir tohumu sütü, tohum bazlı sütlerden biri olup; yağ (%1.25-5.00), protein (%0.83-4.00), karbonhidrat (%2.5-20.0), E vitamini, mineraller (sodyum, fosfor, potasyum, magnezyum, kalsiyum, kükürt, demir ve çinko), çoklu doymamış yağ asitleri (linolenik asit ve linoleik asit) ve esansiyel amino asit içeriği ile yüksek besinsel değere sahiptir. Bu çalışma, kenevir tohumu sütünün besleyici yönünün ortaya çıkarılması, diğer bitkisel sütlerle karşılaştırılması ve güncel çalışmalarla bir bakış açısı oluşturulması için derlenmiştir.

Anahtar Kelimeler: Kenevir, Kenevir tohumu sütü, Tohum bazlı sütler, Bitkisel sütler

INTRODUCTION

Today, the increasing demand for plant-based milk expands the product variety and market size. The demand for the plant-based milk market was expected to reach a value of US$ 13.24 billion in 2021 and is expected to reach an overall market value of US$ 30.79 billion by 2031 [1]. Plant-based milk is one of the most popular vegan products due to various factors and perspectives. The factors are health issues, plant-based milk contains no lactose sugar, making it a favored alternative for customers with lactose intolerance, and it is free of animal hormones and cholesterol. Moreover, recent studies have established the significant role of plant-based milk in improving or enhancing the immune system, having potential antimicrobial effects, lowering the risk of cardiovascular and gastrointestinal diseases, lowering the risk of low bone mass, and having extremely high antioxidant levels with free radical scavenging properties [2]. Concerns regarding the use of animal products have also spurred ethical discussions. In terms of environmental concerns, it has been determined that the carbon emissions produced by the production of plant-based milk are significantly lower than those created by dairy milk production [3].

The sources of plant-based milk, can be divided into five categories as cereal-based (oat milk, rice milk, corn milk, spelt milk), legume-based (soy milk, peanut milk, lupine milk, cowpea milk), nut-based (almond milk, coconut milk, hazelnut milk, pistachio milk, walnut milk, cashew milk), seed-based (sesame milk, flax milk, hemp seed milk, sunflower milk) and pseudo-cereal based (quinoa milk, teff milk, amaranth milk, buckwheat milk) [4, 5].

Over the last several years, hemp and its derivatives (both edible and non-edible) have grown in popularity. The global hemp seed drink market was approximately USD 185 million in 2018 [6]. Since hemp and marijuana are both derived from the same plant, the Latin name *Cannabis Sativa* is used to describe useful or industrial hemp [7]. Industrial hemp contains only about 0.3% to 1.5% of delta-9 tetrahydrocannabinol (THC), the principal psychoactive compound, whereas marijuana contains 5% to 10% or more, and this is the main difference between both types [7]. Thus, the production of all these products from industrial hemp can be carried out with no issue related to illegality. This plant is used for many purposes, like the production of rope and textile [8], roof and wall materials [9], surgical materials [10]**,** paper [11] food and medicine [12]. In addition, hemp seed can be used for producing different products with its sufficient nutrional value but without any illegal compounds.

Hemp seed milk is one of the important seed-based milk products; it is produced from industrial hemp. As previously said, demand for plant-based milk is increasing every day, but due to a lack of information and a generally unfavorable attitude toward discriminating between hemp and other cannabis types, the demand for hemp seed milk is insufficient and limited. The prejudice against hemp products has been eliminated by studies in which THC analyzes hemp products in the market available. In the study conducted by Pisciottanoet al. [13] the THC content of hemp seed milk was determined as <LOQ.

The primary goal of this study is to have a general perspective about hemp seed milk nutrient components and nutritional qualities, compare hemp seed milk characteristics to those of other plant-based milks and cow milk, as well as to discuss the methods and techniques employed in hemp seed milk production as have been explored in the literature. Moreover, to generate a future perspective for this promising product.

MANUFACTURE AND STABILIZATION PROCESS OF HEMP SEED MILK

Plant-based milks are basically produced by extracting different raw materials (cereal, legume, nut, pseudo-cereal and seed) in water followed by homogenization and thermally treated to increase shelf life and to improve stabilization. Hemp seeds are marketed as hulled or whole. Furthermore, its derivatives such as its flour and oil are used worldwide as food and/or food additives [12, 14].

Hemp seed milk is made by homogenizing ground seeds in water (1:5 w/v), and the filtered milk, is generally heated for extended shelf life [15, 16]. Schematic presentation of hemp seed milk production is shown in Fig 1. Commercial stable hemp seed milk production is challenging since hemp seed milk as an oil-in-water (O/W) emulsion is unstable and prone to flocculation, coalescence, and creaming. This will result in a low-quality product with a short shelf life and lower consumer acceptance [15]. Therefore, exogenous emulsifiers and stabilizers are often used to improve the stability of emulsions to get stable hemp seed milk; however, using these additives is not cost-effective because it raises production costs and has some health concerns, such as chronic inflammatory diseases, obesity-related diseases, and metabolic disorders [2]. Therefore, there is a pressing need to produce hemp seed milk free of added chemical substances.

Hemp protein has a low emulsifying capacity since its structure is compact and it has poor water solubility [15], low emulsion stability index, and water-holding capacity [17]. In consequence, there have been many attempts to improve the emulsifying capacity of hemp protein by altering its original structure, such as 1) enzymatic hydrolysis [17] as they have noticed an improvement in the protein solubility of hemp protein after the application of limited enzymatic hydrolysis by trypsin enzyme, but there was a remarkable decrease in the emulsifying activity index [17]; 2) acylation, it has been reported that acetylation treatment improved the emulsifying activity indexes of hemp protein and aided in the formation of more soluble protein aggregate [17]. Further, hemp seed proteins have low heat stability and are affected and started to aggregate when exposed to heat treatment at 80°C or above for 10 min [18]. Since high temperatures induce denaturation and trigger the formation of large insoluble protein aggregate, literature demonstrated that heating causes changing in the molecular structure of proteins, unfolding of the native tertiary structure, exposing of hydrophobic groups, and subsequent aggregation of the denatured molecules. However, many factors affect the occurrence of protein aggregation, including protein concentration and heating conditions [18].

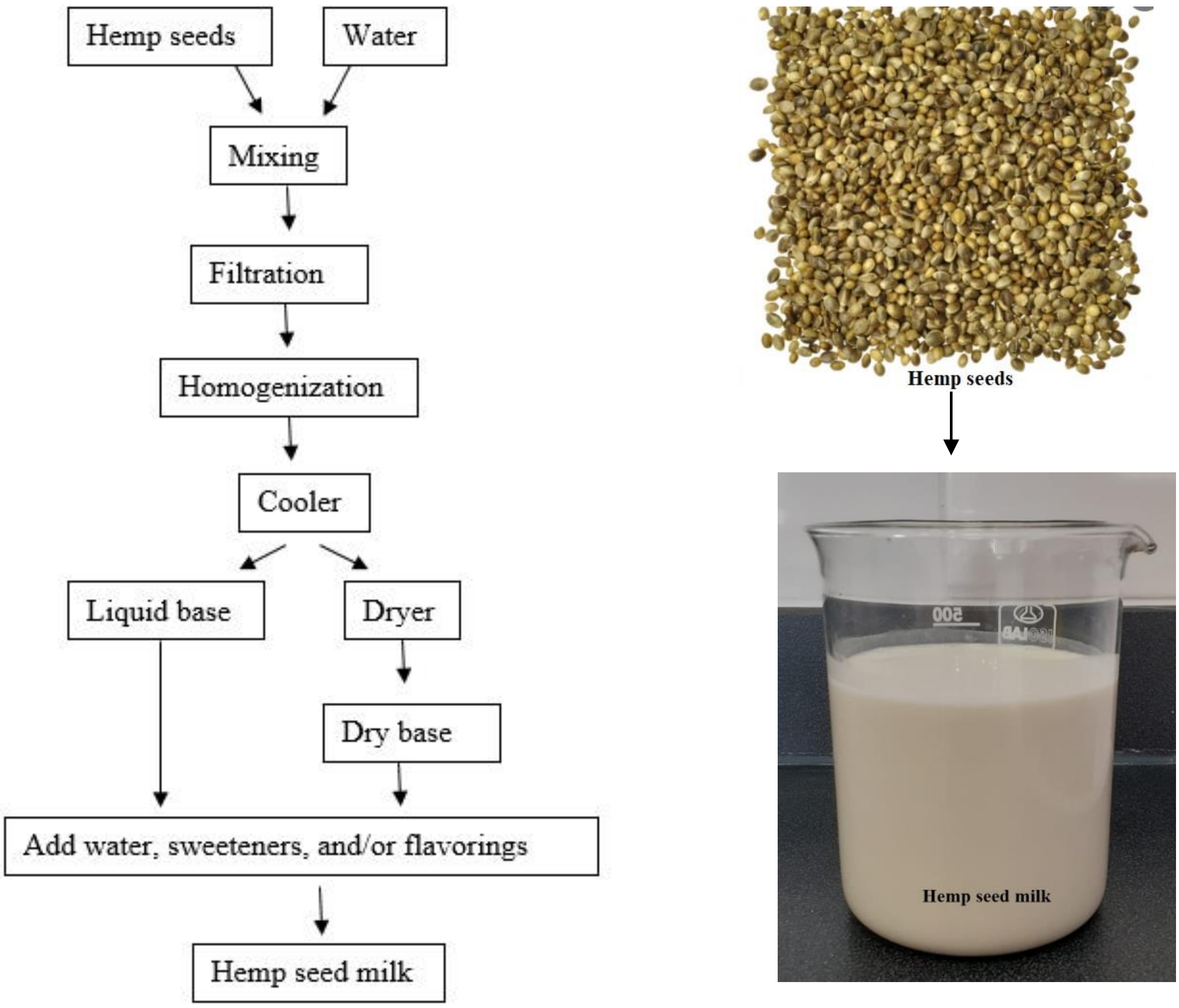

Figure 1. Flow chart of hemp seed milk production [16]

Accordingly, if heat stability and solubility of hemp proteins are to be preserved, heat treatments should ideally be kept below 80°C, according to the findings [18]. Thereupon these poor functional properties of hemp protein, the potential of producing stable commercial hemp seed milk is limited, as hemp seeds have approximately 25% protein of its total content [18].

Mitchell and Shammet [16] invented a novel method for producing commercial hemp seed milk. First, the production is carried out using seeds that have low levels of tetrahydrocannabinol (THC) (less than 0.3%). The hemp seeds have been mixed with water and hydrated into a slurry by absorbing water and being softened. After being waited in the mixing tank for a certain period, the hemp seed slurry is applied to wet milling, and the resulting slurry is recovered and circulated back to the mixing tank over and over for around ten minutes until reaching the desired consistency and maximum yields. Then a filtration step removes the shells, fibers, and other solid materials. After that, the filtered hemp slurry or milky mixture with about 16% solids is homogenized for increasing the stability and resulting white creamy hemp seed milk. To stop the vitamins and oil oxidation, the hemp seed milk temperature was reduced in a cooler to under 10ºC. Water, emulsifiers, stabilizers, sweeteners, and/or flavorings can be added. Finally, to extend the hemp milk's shelf life, aseptic processing involves sterilizing the product using an ultra-high temperature (UHT) treatment followed by sterile packaging. The advantage of the current invention is that it provides milk that is liquid, white, and high in essential fatty acids Omega 3 and 6, low in carbohydrate, and has a good flavor [19].

Berghofer et al. [20] hold a patent for the manufacturing of hemp seed milk. According to their method, to obtain hemp seed milk that has a stable color (never becomes grey), is free of bitter taste, and can be pasteurized and sterilized, the whole hemp seeds in a ratio of 15-25% are soaked for 5-12h in water at a temperature between 5-35°C. Then, water is used for the extraction, and the resulting raw hemp seed milk is separated from the remained solids of the hemp seeds [20]. A lot more plainly, hemp seed milk has been produced in two different ways, 1) the hemp seeds are immersed in water for 5-12h and then grounded around 15 minutes. Afterward, milk extraction is carried out at a temperature below 80°C, or 2°C). Hemp seeds are crushed at temperatures ranging from 0°C to 80°C. After the extraction, obtained milk for 3-4 hours, additional cold extraction at a temperature between 0-10°C has been carried out. Latterly, the obtained extracted hemp seed milk is separated into peeling part which contains proteins and other hemp seeds particles, and raw hemp seed milk which can be sold directly to consumers or processed further, like applying homogenization, the addition of emulsifiers and flavors, pasteurization (60-93°C), or sterilization at a temperature above 100°C [20]. However, it is established that when performing mashing and extraction of milk at temperatures of 80°C and above, the coagulated proteins during the process do not extrude from the beginning; however, they are separated at the end of the line with other divided solid substances [20].

Recently, another novel processing method for producing non-thermally hemp seed milk without emulsifiers or stabilizers has been discussed in the literature. Wang et al. [15] applied the pH treatment combined with the high-pressure homogenization (HPH) process for producing hemp seed milk with high oxidative stability. This process disrupts the tertiary structure and generates a molten globule conformation with unique surface properties [2, 19]. Hence, this modifying method has been successfully applied before to improve different plant isolated proteins, such as soy protein [21], which demonstrated enhancement in the emulsifying activity and emulsion stability and pea protein [22].

In recent years, to produce stable O/W food emulsions, high-pressure homogenization (HPH) has been introduced [15]. The main principle of HPH is mechanically reducing the size of oil droplets, providing a uniform size distribution, and increasing the surface area, which all result in improved stability. Jiang et al. [22] examined the efficiency of combining pH arrangement and HPH techniques under 70 MPa high pressure to prepare pea protein-sunflower oil emulsions, and data showed an optimum physical and oxidative stability [22]. On the other hand, ultrasonic treatment has improved the extraction of phenolic and flavonoids from defatted hemp. The results indicated a two-fold increase in polyphenol extraction yield and antioxidant capacity compared to the traditional extraction approach. As a result, this technology helps industries reduce chemical consumption and extraction time while also extending the shelf life of hemp seed milk [23].

NUTRITION PROFILE OF HEMP SEED MILK

In recent years, hemp seeds' nutritional content and minimal allergenicity have led to an upsurge in hemp product consumption. Hemp seed milk has been produced from the whole grain to get maximum nutritional value. Table 1 shows the composition of hemp seed and hemp seed milk. Hemp seeds contain all essential amino acids and are high in polyunsaturated fatty acids such as a-linolenic acid and linoleic acid, making them one of the best sources. Further, hemp seeds are mainly composed of lipids (25-35%), proteins (20–25%), carbohydrates (20–30%), insoluble fibers (10–15%), vitamin E (90 mg/100 gm) and minerals (sodium, phosphorus, potassium, magnesium, calcium, sulfur, iron, and zinc) [2]. The amount of B vitamins in hemp seeds is similar to that of other grains, but the quality and content of protein and fatty acids distinguish them [7].

Hemp seed milk contains around 0.83- 4% protein, 1.25-3% fat, and 2.5- 20% carbohydrate [19]. However, hemp seed milk's total saturated and polyunsaturated fatty acids are 0.428% and 4.173%, respectively [2].

Hemp seed protein is made of 65% high-quality edestin (globulin) protein, which is known as the most efficient plant-derived protein, with albumin protein and essential amino acids accounting for the other 35% [7]. All nine essential amino acids exist in hemp seeds, with a high abundance of sulfur-containing amino acids such as cysteine and methionine, which are often lacking in vegetable proteins. Further, the 3:1 omega-6 to omega-3 fatty acid (FA) ratio in hemp is nearly ideal for health and a good choice for vegans who don't eat animal products. Though linoleic acid and a-linolenic acid are the most abundant fatty acids (80–90 g/100g of their total fatty acids) [2] hemp also contains both polyunsaturated gamma-linolenic acid (GLA; omega 6) and stearidonic acid (omega-3). As well as, it's worth mentioning that hemp seed is mercury-free [7].

Hemp seed milk is unsweetened and unflavored and has roughly 60 calories per serving, which is less than cow's milk [24]. On the other hand, one cup (244 gram) of cow milk contains 12 g of carbohydrate from the naturally occurring sugar lactose [24]. However, hemp seed milk's general characteristics have a thick and creamy structure, a nuttier taste or flavor, which is similar to the taste of soy or rice milk. Besides, hemp seed milk is free of soy, gluten, cholesterol, trans fat and lactose and is low in sodium [7]. Hemp seeds have been used for human nutrition in various ways, such as hemp seeds products (oil, flour, milk, bakery products, chocolate, beer, etc.).

COMPARISON OF HEMP SEED MILK WITH OTHER PLANT MILK TYPES

Plant-based milks are naturally lactose-free, cholesterol-free and animal protein-free, making them a good alternative for people fed with some special diet. In addition, thanks to the bioactive components, antioxidants, monounsaturated and polyunsaturated fats components they contain, they are considered functionally valuable products as well as nutritional value. Contrary to all these positive features, they reduce the nutritional value of foods because of anti-nutritional factors included. They are enhanced with vitamins and minerals because of low vitamin and mineral content [25]. Although they are called milk because they often resemble cow's milk in appearance, plant-based milks may have different nutritional content in cow's milk depending on the type of raw material from which they are derived, the method of production and whether they are enriched or not. For this reason, plant-based milk should not be considered as a cow's milk alternative without proving its nutritional quality and bioavailability [26].

Table.1. Composition of hemp seed and hemp seed milk [2, 19]

		Hemp seed	Hemp seed milk			Hemp seed	Hemp seed milk
Composition (%)	Ash	6.99	0.47	Amino acids (g/100 g protein)	Alanine	4.26	5.20
	Protein	25	0.83-4		Arginine	13.93	13.56
	Carbohydrate	20	0.3-20		Cysteine	6.15	n.d.*
	Fat	30	1.25-4.61		Glutamic acid	14.68	16.49
	Crude fiber	8.3	0.4		Glycine	4.4	4.74
	Moisture content	6.0	91.6		Histidine	3.89	3.62
	Energy value Kcal/100g	456.84	19-53.09		Isoleucine	3.85	4.07
Vitamins,(mg/g)	E	30.1	0.42		Leucine	6.78	6.46
	C	14.4	2.1		Lysine	3.31	3.62
	B_1	9.3	1.1		Methionine	6.7	5.42
	B_2	10.7	0.8		Phenylalanine	3.96	4.07
	B_3	25.1	2.4		Proline	3.96	4.97
	B_6	3.1	0.03		Serine	3.65	3.84
Fatty acid composition (%fat)	Palmitic (C 16:0)	6.2	6.5		Threonine	2.84	3.39
	Stearic (C 18:0)	2.5	2.4		Tyrosine	2.94	3.62
	Oleic (C 18: 1)	9.9	10.2		Valine	4.43	5.65
	Linoleic (C 18:2)	55.2	57.1	Heavy metals, (mg/kg)	Cu	15.75	0.09
	Gammalinolenic (C 18:3 n-6)	2.8	2.1		Cd	0.12	0.01
	Alfalinolenic (C1 18: 3 n-3)	21.3	19.8		Pb	1.50	0.02
	Stearidonic (C 18:4 n-3)	1.2	1.2		Zn	55.35	5.96
	Arachidic (C 20:0)	0.6	0.4		Hg	0.02	0.01
	Eicosenoic (C 20: 1)	0.3	0.25				

*n.d.: Not detected.

With the increasing interest in hemp, hemp products are also being researched. In addition to representing a food on its own, plant-based milk may have more potential to be purchased than other product types since it is used as a basic raw ingredient in the manufacture of many foods (coffee, tea, smoothies, ice cream, yogurt, cheese, butter, cake, desserts). Since plant-based milk are enriched with different components, it is not easy to compare the nutritional composition. This study has been tried to create a general point of view by giving the minimum and maximum values obtained by some studies in the tables.

Proteins are essential structures for cells and play an important role in the progress of life by participating in the structure of enzymes, hormones, nucleic acids, and many other molecules. Compared to cow's milk, soy milk and hemp seed milk are the closest to cow's milk in terms of protein ratio (Table 2). Oat milk has the highest average protein content among plant-based milk.

Singhal et al. [26] compared the nutrient content of non-dairy beverages to that of cow's milk according to the recommended dietary allowance (RDA) or adequate intake for toddlers (1–3 years) and young children (4–6 years). While one serving (240 mL) of cow's milk provides protein equivalent to 59% of the RDA in toddlers (1-3 years) and 40.4% of the RDA in young children (4-8 years), soy milk, which is closest to cow's milk, ensures protein equivalent to 53% and 36.8% of RDA in toddlers and young children, respectively. Hemp seed milk provides protein equivalent to 15% of the RDA in toddlers and 10.5% of the RDA in young children.

The nutritional importance of proteins is measured by their quality, which depends on the amino acid composition, digestibility, and bioavailability. PDCAAS (protein digestibility-corrected amino acid score) and DIAAS (digestible indispensable amino acid score) introduced by WHO in 1998 and by FAO in 2013, respectively, are used to assess protein quality based on *in vivo* experiments. While the PDCAAS and DIAAS value closest to cow protein is in soy protein, the DIAAS value of de-hulled hemp seed protein has been reported as 66.5%. Materials with a DIAAS value of 75 are qualified as a "good protein source," while those with a value above 100 are considered an “excellent source of protein” by the FAO [34]. While cow’s milk has >100% DIAAS values, plant-based milk is likely to have a low PDCAAS or DIAAS due to the limiting amino acid contents of methionine, cysteine, and/or lysine [34]. Hemp seed protein has lower PDCAAS values than soy milk but higher than almond and oat milk (Table 3).

Table 2. General composition of plant-based milks

	Hemp seed milk	Oat milk	Soy milk	Almond milk	Quinoa milk	Cow milk
Protein, %	0.83-6.96	0.78- 17.30	2.6-3.98	0.42-2.50	0.49-2.9	2.9-3.32
Fat, %	1.25-18.02	0.28-12.40	1.47-13.92	1.04-8.26	0.91-2.40	3.40-6.40
Total carbohydrate %	0.3-30.21	4.44-50.01	4.14-5.06	0.58-9.38	3.5-12	3.20-5.40
Ash, %	0.47	0.48	0.71-0.87	3.04	0.11-0.22	0.67-1.9
Energy (kcal)	19-53.09	66-607.10	43-95	15-55.90	29-62	63-118
Total sugar, %	2.5	1.27	3.65	0	9.7	3.38
Total Fiber, %	0-0.4	0.8-20.07	0.2-0.74	0-1.35	0.5	0

Data from Paul et al. [2], Rasika et al. [27], Reyes-Jurado et al. [4], Chichowska et al. [19], Aydar et al. [28], McClements et al. [29], Kanberoglu [30], Martinez-Padilla et al. [31], Pineli et al. [32], Makinen et al. [33], Reyes-Jurado et al. [4].

Table 3. Comparative overview of the essential amino acid profile of plant-based milk

		Hemp seed milk	Oat milk	Soy milk	Almond milk	Cow milk
Essential amino acid (mg/100g)*	Isoleucine	3.90-4.40	4.15-4.41	1.41-2.47	29.8-39	25-62
	Leucine	6.50-7.10	7.89-9.17	2.94-4-24	83-83.20	90-108
	Lysine	4-4.60	3.79-3.91	0.88-3.92	36.20-57.4	49-96
	Methionine	2.10-2.80	1.73-1.93	0.31-0.85	27.10-27.95	17-27
	Phenylalanine	4.6-4.90	5.46-5.48	1.86-2.79	50.90-50.55	38-56
	Threonine	2.60-3.90	3.25-4.30	0.87-2.09	30.2-43.4	23-41
	Tryptophan	0.70-0.90	3.61-4.09	0.3-0.8	13.9-13.98	N.R.
	Valine	5-5.70	5.34-6.01	1.32-2.59	38.30-73.60	33-53
In vitro based values (%)**	PDCAAS, %	63-66	58-69	86-100	23	100
	DIAAS, %	N.R.	56-67	84-90.6	N.R.	118-120
In vitro protein digestibility (%) ***	Pepsin 1h digestibility	4.70	5.55	5.96	4.82	5.06
	Pancreatin 1h digestibility	17.03	19.39	14.61	20.28	21.37
	Total 2 digestibility	21.73	24.95	20.56	25.19	26.43

Data from *Paul et al. [2], **Chalupa-Krebzdak et al. [34], **Abelilla et al. [35], ***Martinez-Padilla et al. [31]

Martinez-Padilla et al. [31] researched in vitro protein digestibility (IVPD) of selected commercial plant-based milk alternatives. After 1-h incubation with the pepsin enzyme, the IVDP value of soy milk was significantly higher than hemp seed milk. However, IVDP of hemp seed milk is not statistically different from cow's milk. As a result of digestion with pancreatic enzyme after gastric phase, soy milk had the lowest IVDP value followed by hemp drink. That study showed that after pepsin and pancreatin digestion (total 2 hours), the IVDP value of soy drink and hemp drink were the lowest.

Table 4. Fatty acid profiles of commercial plant-based milk alternatives (g/100 g total fatty acids by product)

Compounds	Hemp seed milk	Oat milk	Soy milk	Almond milk	Quinoa milk	Cow milk
SFA	12.32	18.88	14.34	22.64	10.1	68.4
MUFA	13.94	37.26	22.64	59.14	65.48	23.8
PUFA	73.73	43.85	63.02	18.21	24.42	2.21
w-6/w-3	≈ 3.43	≈ 24.64	≈7.52	≈ 133	≈19.34	≈3.43

Data from Martinez-Padilla et al. [31]. SFA: saturated fatty acids; MUFA: monounsaturated fatty acids; PUFA: polyunsaturated fatty acids

Like other members of its group, hemp seed milk is higher fat milk than other plant-based milk (Table 2). Compared to cow's milk, plant-based milk has lower saturated fatty acids but a higher unsaturated fatty acid profile (Table 4). It is reported that a food with a higher ratio of unsaturated fatty acids instead of saturated fatty acids is beneficial for LDL cholesterol. It is known that decreasing blood lipid concentration has a positive effect in treating Alzheimer's disease [28, 34]. Martinez-Padilla et al. [31] conducted a study to determine the fatty acids profile and in vitro protein digestibility (IVPD) score of eight commercially available plant-based milk (almond, coconut, oat, hazelnut, quinoa, rice, soy, and cow milk). Among plant-based milk, hemp seed milk contains high levels of unsaturated fatty acid. Hemp seed milk is characterized by a low content of saturated fats and a good percentage of polyunsaturated fatty acids (PUFA) with a content of 74%. Oleic acid (C18:1, w-9, omega 9) linoleic acid (C18:2, w-6, omega 6) were the greatest source of fatty acids for hemp drinks. Additionally, they reported that hemp drink was the only milk among the analyzed milk that had a source of α-linolenic acid (C18:3, w-3, omega 3) with a content of 16% . Considering the w-6/w-3 ratio (recommended by EFSA in the ranges from 1:1 to 5:1 for a healthy diet), hemp drink was the most similar drink to cow's milk with a ratio of 3.43 (Table 4). Imbalance in the w-6/w-3 ratio can cause some chronic degenerative diseases, such as cardiovascular disease and obesity, mental disease specifically with mood disorders and depression in adults [36, 37]. When examined in terms of fiber content, oat milk has a higher dietary fiber content (especially β-glucan) than other milk [5].

Table 5 shows major minerals of some plant milks. Astolfi et al. [38] had a study in which major, minor, and trace elements were determined in dairy milk and plant-based milk alternatives from an Italian market.

According to their study, soy milk contains the closest major elements to cow's milk. They reported that soy milk for Fe and Cu and hemp milk for Mo had a good contribution to the daily nutrition of consumers in terms of minor elements intake. When hemp seed milk was examined in terms of major elements, element K was found at the highest rate. The closest K ratio to cow's milk was in soy milk, followed by hemp seed milk. In addition, plant-based milk containing the most Mg element after soy milk was hemp seed milk [6]. Additionally, The most common ingredients used for the fortification of hemp seed milk were tricalcium phosphate, vitamin A palmitate, vitamin D2 (Ergocalciferol), vitamin B12 [4]. As can be seen in Table 5, among the plant milks, hemp seed milk can be shown as a good source of calcium. However, when hemp seed milk is to be consumed as an alternative to cow's milk, it should be enriched in minerals, especially major calcium elements [4].

Table 5. Major minerals of some plant milks (ppm)

Mineral	Hemp seed milk	Oat milk	Soy milk	Almond milk	Quinoa milk	Cow milk
Ca	120-1250	174-856	1200-1230	130.5-202	118.9	1220-1340
K	982-1265.8	394-6710	1000-2150	230-670	224	1490-1810
Mg	121-170.8	60-420	142-150	70-95	32.7	111
Na	130-1400.1	364	22-470	383-710	410	346-580
P	212-639.8	147-8163	311-626	214-750	73.5	481-1210

Data from Astolfi et al. [38], Paul et al. [2], Reyes-Jurado et al. [4]

Color is a feature that should be considered in the formulation development of new plant-based milk. Especially if the product is to be recommended as a cow milk replacer, it should have similar values to cow's milk. The white index calculated using color values (L, a, b) can be used as a good indicator for comparison. While the closest whiteness index value to cow's milk is in quinoa milk, natural pigments in raw materials used are shown as the reason for the difference in other milk types (Table 6) [29].

Table 6. Comparison of physicochemical properties for plant milk types

Properties	Hemp seed milk	Oat milk	Soy milk	Almond milk	Quinoa milk	Cow milk
Viscosity, mPas ($10s^{-1}$)	25	6.77	4.91	13.48	13.20-23.8	3.15
Whiteness Index	68.49	60.21	72.17	67.36	73.52	81.89-89.18
pH	6.81-6.92	7.16	6.8-7.39	5.72-6.92	5.9-6.5	6.42-6.83

Data from McClements et al. [29], Gram [39], Kanberoglu [30], Huang et al. [40], Jeske et al. [41], Makinen et al. [33], Lai et al. [42]

Vaikma et al. [43] investigated the volatile compounds and sensorial characteristics of 90 different plant-derived milk in Estonian markets. Hemp beverage possessed a hay-like odor and astringent taste. With GC-O analysis, the highest alcohols and ketones content were determined in hemp drinks. These compounds may have affected odor by causing hay-like characteristics, as was described by the sensory analysis. Hemp drink also stands out with p-cymene (spicy, phenolic, clove) content, known as phenolic and spicy in odor. This compound may increase astringency and intensify the aftertaste. Furthermore, it was suggested that the specific hemp flavor was caused by different terpenes in that study (Table 7).

Table 7. The number of volatile compounds of plant milks

Compound	Hemp seed milk	Oat milk	Soy milk	Almond milk	Quinoa milk
Acids	0	20	11	3	11
Alcohols	915	134	263	248	26
Aldehydes	359	170	129	3195	124
Ketones	91	44	61	48	8
Esters	9	35	52	57	1
Lactones	0	0	19	39	0
Aromatic/cyclic comp.	48	48	756	342	106
Sulfur compound	2	2	2	1	0

Data from Vaikma et al. [43]

Nissen et al. [6] conducted a study to improve the taste and aroma of hemp seed drinks by fermentation with beneficial lactobacilli and or probiotic bifidobacteria. The aldehyde ratio was found to be highest in unfermented hemp seed milk. While the alcohol, alkane, and ketone ratios increased, the aldehyde ratios decreased with the fermentation process. According to GC-MS analysis 2-heptanol, 2-methyl, 2,4-decadienal, 2-butanone, 3-hydroxy, 2,3-butanedione, 2-methyl, 1-octen-3-ol, cyclohexanol, propanoic acid, caprylic acid and pelargonic acids were detected in hemp seed drink matrices.

No study was found in which antinutritional factors were detected in direct hemp seed milk. However, antinutritional components such as phytic acid, trypsin inhibitors, condensed tannins, cyanogenic glycosides, and saponins have been reported in hemp seeds as in other edible seeds [44]. Table 8 shows the limitation and antinutrients factors of plant-based milk types. Phytic acid is considered as an antinutritional factor in cereal and legume-based milk because it reduces the bioavailability of some minerals (calcium, zinc, iron, magnesium, and copper), creating insoluble complexes. Since lectins prevent glucose absorption and saponins form saponin-protein complexes in foods included, they are also shown as antinutritional factors [34].

Table 8. Limitation factors for plant milk types

	Hemp seed milk	Oat milk	Soy milk	Almond milk	Quinoa milk	Cow milk
Limitations	-Toxicity in high dosage and act against inhibiting inflammatory cytokines production	-Lacks calcium content -Poor emulsion stability due to high starch content -Contain potential allergens -Presence of inhibitors phytates - Lysine is a limiting amino acid -Low calcium content -High amount of lipases that can promote its rancidification	-Formation of hormone-responsive tissues -Reduce testosterone concentration in men -Undesirable beany flavor due to lipoxygenase activity on unsaturated fatty acids -Presence of inhibitors -Methionine and cysteine are limiting amino acids	-Almond allergy -Limited cariogenic properties in the presence of sucrose -Very low protein -Supports growth of pathogenic micro-organism -Presence of proteins with allergenic potential. -Methionine and cysteine are limiting amino acids -Susceptibility to rancidification due to its high concentration of polyunsaturated fatty acids.	-Bitter taste due to the presence of saponins	-Lactose intolerance -Limited availability -Iron, vitamins like folate, and some amino acids deficiency -High price -Presence of pathogens -Cow's milk protein allergy
Antinutrients	-Phytic acid (seed)	-Phytic acid	-Trypsin inhibitor -Phytic acid, -Saponin -Lectin		-Saponin -Phytic acid	

Data from Sethi et al. [5], Paul et al. [2], Silva et al. [45], , Bocker et al. [25], Chalupa-Krebzdak et al. [34]

When considering about the effects of foods on health, this effect is associated with the bioactive components they contain. It is the cannabinoids that stand out as the bioactive component of hemp seeds. However, the number of available research on examining the health benefits of consuming hemp seed milk is very limited and the scientific literature on this milk is hardly available. Table 9 shows bioactive components and health-related substances of plant based milks.

In general, hemp seeds have medicinal properties in four areas: cardiovascular, mental health, dermatological, and the immune system [24]. Besides, hemp seeds have a low glycemic index for diabetics due to their low carbohydrate content. Hemp has many health benefits, the most notable of which are increased energy, cholesterol regulation, improved circulation, immunological and nervous system strengthening, rapid recovery from injuries, reduced stress, and reduced symptoms of atopic dermatitis and allergies [24]. The high hemp content of soluble fiber helps to maintain the digestive tract healthy and clean [16]. Studies also showed that hemp seeds have anti-cancer properties because it contains many plant sterols and antioxidants (useful in reducing the risk of colon, breast, and prostate cancer) [24]. Additionally, hemp has been shown to help prevent illnesses like Parkinson's and Alzheimer's and boost memory. Also, hemp is recommended for the treatment of premenstrual syndrome (Menopause) because of its gamma-linoleic acid content, for Joint diseases, reducing stress because of its magnesium and high-quality proteins. Skin health like treating psoriasis or eczema, etc., further, hemp has been found to be effective in maintaining nervous system homeostasis [24]. Hemp seed milk has the advantage of not containing any milk proteins or the milk sugar lactose, making it suitable for people with cow's milk allergies or intolerances [4]. Chichowska et al. [19] investigated the effect of hemp seed milk consumption on body weight gain, internal organs weight, insulin and thyroid hormones serum concentration and blood lipid indices in rats. The study was carried out on 40 female Wistar rats for 21 days. The findings revealed that consumption hemp seed milk lowers blood triglycerides and cholesterol levels. Furthermore, thyroid hormone levels in experimental rats were found to be much lower [7]. Based on what has been mentioned, hemp and hemp seed milk are thought to be a promise for the future as a nutritious and healthful non-dairy alternative milk. However, more research is still needed and encouraged to understand its positive benefits on human health better.

Table 9. Functional properties-Bioactive components of plant milk types

Factors	Hemp seed milk	Oat milk	Soy milk	Almond milk	Quinoa milk	Cow milk
Bioactive components	Linolenic acid, Linoleic acid, γ-tocopherol, Cannabidiolic acid, Lignanamides	Β-glucan, Phytochemicals: Avenanthramides(AVAs), Avenacosides A and B, Phytosterols	Genistein, Daidzein, Glycitein, Isoflavones, Phytosterols, α-tocopherol	Beta-sitosterol, campesterol, stigmasterol folate, vitamin E, niacin, arabinose, flavonoids and phytosterols, alpha-tocopherol		IgG, IgA, Casein, Lactoferricin
Health benefits	-Reduce both motion- and toxin- induced vomiting -Anti-thrombotic, anti-vasoconstrictive, anti-inflammatory, anti-neuro-inflammation activity	-Hypocholesterolaemic -Reduce blood glucose level -Increases solution viscosity and can delay gastric emptying time -Anti-pathogenic effect -Reduction of postprandial glycemic response because of the increasing of gastrointestinal transit -Reduction of total and LDL cholesterol	-Decrease blood pressure level -Hypolipidemic effects -Effective against chronic disease -Recommended against osteoporosis and cardiovascular diseases -Higher bone density and lower rates of fracture -α-galactosidaseactivity -Alleviate menopause symptoms -Decrease the risk of prostate, breast, and colon cancer	-Powerful antioxidant -Low calorie -High in Vit E -Prebiotic properties -Lowers plasma LDL cholesterol level -Decreases plasma LDL level -Decreases lipid peroxidation -Improves gastrointestinal health		-Considered as a wholesome complete food -Antimicrobial activity -Helps in overall growth and maintenance of the body system -Helps in decreasing blood cholesterol levels due to the presence of hypocholesterolemic peptides
Total phenolic content			-8.79 mg GAE/100g (Folin–Ciocalteu) -61.4 mg/100 mL (Folin–Ciocalteu)	1.24 mg GAE/L	4.39 mg GAE/kg	
Antioxidant activity			%17 (DPPH)	%2 (serum retention capacity)	0.34 mM Trolox (DPPH)	

Data from Paul et al. [2], Reyes-Jurado et al. [4], Aydar et al. [28], Sethi et al. [5]

RECENT STUDIES RELATED TO HEMP SEED MILK

Szparaga et al. [46] investigated whether hemp and coconut milk could be a suitable food matrix for probiotic bacteria. They reported that the fermentation process (at 37°C for 6 h) contributed to the increased survival rates of *Lactobacillus casei* subsp. *Rhamnosus* in both coconut and hemp seed milk. After the fermentation process the total count of viable lactic acid bacteria (LAB) cells increase from 11.72 log (cfu/mL) to 13.26 in coconut beverage and from 8.41 log (cfu/mL) to 10.92 log (cfu/mL) in hemp beverage. On day 21 of cold storage (+4°C), the number of viable *Lactobacillus casei* cells in the fermented coconut and hemp seed milk ensured meeting the therapeutic criterion (>6 log (cfu/mL). Zhu et al. [47] examined the effect of heat treatment on the stability and protein structure of hemp seed milk. They showed that with the increase in heat treatment temperature (55–95°C), the nitrogen solubility index (NSI) decreased from 58.55% to 39.81%, the centrifugal precipitation rate increased from 16.58% to 34%, and the average particle size increased from 192.2 nm to 304.6 nm. When they examined the results of FTIR analysis, they understood that the secondary structures of hemp seed milk proteins changed with the increase in heat treatment temperature. Furthermore, they observed the maximum absolute value of zeta potential of 20.57 mV when hemp seed milk was treated at 65°C, accompanied by the best stability and the highest emulsification activity and emulsification stability with emulsifying activity index (EAI) of 0.357 m^2/g and emulsion stability index (ESI) of 43.74%. Lai et al. [42] conducted a process optimization study to produce fermented hemp seed milk. As a result of the research, they suggested the best fermentation conditions as follows: the ratio of *Lactobacillus bulgaricus*: *Streptococcus thermophilus*: *Lactobacillus casei*:

Streptococcus acidophilus was 2:2:1:1.78, the inoculation amount was 6.21%, the fermentation temperature was 39.42°C, and the fermentation time was 7.12 h. At the proposed point, they found that the viable count was 1.9×10 8 CFU/mL, the acidity value was 78 T°, and the sensory score was 8.74. The total sugar and total solid content of fermented hemp seed milk were determined 69.29 mg/mL and 6.08±0.22 g/100 g, respectively. They reported that the contents of flavonoids and the antioxidant activity was significantly improved. While hemp seed milk contains most of the original nutrients, hemp protein is known for its low emulsifying capacity due to its compact structure and poor water solubility. In order to improve this negative feature, Bartkiene et al. [48] produced fermented hemp drinks by fermenting hemp seed paste emulsion with different microorganisms (*Pediococcus acidilactici* LUHS29, *P. pentosaceus* LUHS183, *Lactobacillus casei* LUHS210 and *L. uvarum* LUHS245 strains) and applying ultrasonication at the same time. They proposed that hemp seed beverages, with more stable emulsion and the highest overall acceptability (9.6 points), can be obtained using LUHS245 strain and ultrasonication treatment.

Gram [39] was applied ultrasound and homogenization process to hemp seed milk to prevent or delay the phase separation problem without adding additives. It was reported that the lowest amount of serum separation achieved was found applying homogenization (40 MPa) combined with ultrasonication (20% amplitude for 2 minutes). When it was examined the effects of ultrasound and homogenization process separately, the optimum parameters of the ultrasound process was determined as 50.2% amplitude and 6.40 minutes. Furthermore, it was reported that ultrasound application increased the *L** value of hemp seed milk and decreased the amount of syneresis and serum separation statistically (p<0.05). When homogenization application was evaluated, it was reported that while L* value increased, *a**, *b** value, serum separation (%) (phase separation by gravity force), syneresis (%) (phase separation by centrifuge force), and particle size decreased (p<0.05) also color and physical stability were positively affected. Wang et al. [15] wanted to produce a non-thermally processed, physically and oxidatively stable hemp seed milk. For this purpose, they researched the effects of high-pressure homogenization (HPH) combined with pH shift treatment on hemp seed milk. According to their results, applying pH shift combined with HPH the formation of hydroperoxides and malondialdehyde was delayed and the microbial population was decreased. Nissen et al. [6] produced innovative prebiotic and probiotic plant-based drinks based on hemp seed and fermentation process. In that study, the new formulations of commercial hemp seed-derived drink to be fermented with probiotics (*Lactobacillus fermentum, Lb. plantarum*, and *Bifidobacterium bifidum*). They also blended hemp seed milk with some other plant-based milks (soy and rice milk) to meet the demand for alternative and possibly healthier novel matrices. Zhu et al. [47] investigate the effect of heat treatment (55–95°C) on hemp seed milk's stability and protein structure. It has been reported that as the temperature is increased, the structure of the proteins changes with a decrease of the relative content of α-helix. In addition, as the temperature is increased, the centrifugal precipitation rate and the average particle size increase while the nitrogen solubility index decreases. Although there are studies (but not enough) examining how the technological properties of hemp seed milk change with some processes, there are still very few studies on its bioavailability by human and animal experiments. A study made by Chichowska et al. [19] demonstrated that hemp seed milk leads to a significant decrease in triglycerides and cholesterol blood content of intragastric treated rats.

CONCLUSION

Although soy milk is the most known milk type, the market in question is expanding with new plant-based milk and dairy products day by day. Nowadays, the consumption of animal milk and its market values is decreasing. However, the decrease in question is not the problems in accessing animal milk or the decline in purchasing power but the increase in consumption of plant-based milk. Hemp seed milk is one of the products of this product range and it has become popular with its high nutritional values. Although the presence of the psychoactive substance adversely affects the consumption of hemp seed milk, it is understood over time that the reservation in question is unfounded, as the consumer is informed. Getting more knowledge of hemp seed milk can ensure its enlarged market. New research should have occurred about hemp seed milk and hemp seed milk products from this perspective.

REFERENCES

[1] Future Learn Insights (FLI). https://www.futuremarketinsights.com/reports/sample/rep-gb-13818**.** Access date: 6 March 2022.

[2] 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.

[3] Tangyu, M., Muller, J., Bolten, C.J., Wittmann, C. (2019). Fermentation of plant-based milk alternatives for improved flavour and nutritional value. *Applied Microbiology & Biotechnology*, 103(23-24), 9263-9275.

[4] Reyes-Jurado, F., Soto-Reyes, N., Dávila-Rodríguez, M., Lorenzo-Lea,l A.C., Jiménez-Munguía, M.T., Mani-López, E., Lopez-Malo, A. (2021). Plant-Based Milk Alternatives: Types, Processes, Benefits, and Characteristics. *Food Reviews International*, 1-32.

[5] 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.

[6] Nissen, L., di Carlo, E., Gianotti, A. (2020). Prebiotic potential of hemp blended drinks fermented by probiotics. *Food Research International*, 131:109029.

[7] Vahanvaty, U.S. (2009). Hemp Seed and Hemp Milk. *ICAN: Infant, Child, & Adolescent Nutrition*, 1(4), 232-234.

[8] Cassano, R., Trombino, S., Ferrarelli, T., Nicoletta, F.P., Mauro, M.V., Giraldi, C., Picci, N. (2013). Hemp fiber (Cannabis sativa L.) derivatives with antibacterial and chelating properties. *Cellulose*, 20(1), 547-57.

[9] Gonen, S. (2009). Cannabis sativa L. bitkisinin morfolojisi ve anatomisi üzerine bir araştırma. Master Thesis Ege University.

[10] Gu, L.F. (2006). Surgical sewing free zipper made of antibiotic material hemp fiber. CN Patent Y, 2829641.

[11] Aytaç, S., Ayan, A.K., Arslanoğlu, Ş.F. (2017). Keten-Kendir-Isırgan. Endüstriyel Tip Kenevir Yetiştiriciliği Karadeniz Lif Bitkileri Çalıştayı. Karadeniz Lif Bitkileri Çalıştayı (5-6 Mayıs), Samsun. 27-35.

[12] Kladar, N., Čonić, B.S., Božin, B., Torović, L. (2021). European hemp-based food products – Health concerning cannabinoids exposure assessment. *Food Control*, 129, 108233.

[13] Di Marco Pisciottano, I., Guadagnuolo, G., Soprano, V., Esposito, M., Gallo, P. (2021). A survey of Δ9-THC and relevant cannabinoids in products from the Italian market: A study by LC–MS/MS of food, beverages and feed. *Food Chemistry*, 346, 128898.

[14] King, J.W. (2019). The relationship between cannabis/hemp use in foods and processing methodology. *Current Opinion in Food Science*, 28, 32-40.

[15] Wang, Q., Jiang, J., Xiong, Y.L. (2018). High pressure homogenization combined with pH shift treatment: A process to produce physically and oxidatively stable hemp milk. *Food Research International*, 106, 487-494.

[16] Mitchell, R., Shammet, K.M.(2008). Hemp food product base and processes. Patent No: US20080241339A1.

[17] Yin, S.W., Tang, C.H., Wen, Q.B., Yang, X.Q. (2009). Functional and structural properties andin vitrodigestibility of acylated hemp (Cannabis sativaL.) protein isolates. *International Journal of Food Science & Technology,* 44(12), 2653-2661.

[18] Raikos, V., Duthie, G., Ranawana, V. (2015). Denaturation and oxidative stability of hemp seed (cannabis sativa l.) protein isolate as affected by heat treatment. *Plant Foods for Human Nutrition*, 70(3), 304-309.

[19] Chichowska, J., Kliber, A., Kozowska, J., Biskupski, M., Grygorowicz, Z. (2002). Thyroid hormone and metabolic changes after treated rats with hemp milk. http://www.hempreport.com/pdf/HempMilkStudy%5B1%5D.pdf. Access date: 25 December 2021.

[20] Berghofer, E., Pollmann, K., Traby, M., Frenkenberger, C. (2006). Method for producing hemp milk. Patent No: RU2341093C2.

[21] Jiang, J., Chen, J., Xiong, Y.L. (2009). Structural and emulsifying properties of soy protein isolate subjected to acid and alkaline ph-shifting processes. *Journal of Agricultural and Food Chemistry*, 57(16), 7576–7583.

[22] Jiang, J., Zhu, B., Liu, Y., Xiong, Y. (2014). Interfacial structural role of ph-shifting processed pea protein in the oxidative stability of oil/water emulsions. *Journal of Agricultural and Food Chemistry*, 62(7), 1683-1691.

[23] The, S.S., Birch, E.J. (2014). Effect of ultrasonic treatment on the polyphenol content and antioxidant capacity of extract from defatted hemp, flax and canola seed cakes. *Ultrasonics Sonochemistry*, 21(1), 346-353.

[24] Curl, S., Rivero-Mendoza, D., Dahl, W.J. (2020). Plant-based milks: Hemp. EDIS. 5.

[25] Bocker, R., Silva, E.K. (2022). Innovative technologies for manufacturing plant-based non-dairy alternative milk and their impact on nutritional, sensory and safety aspects. *Future Foods*, 5, 100098.

[26] Singhal, S., Baker, R.D., Baker, S.S. (2017). A Comparison of the nutritional value of cow's milk and nondairy beverages. *Journal of Pediatric Gastroenterology and Nutrition*, 64(5), 799-805.

[27] Rasika, D.M.D., Vidanarachchi, J.K., Rocha, R.S., Balthazar, C.F., Cruz, A.G., Sant'Ana, A.S., Ranadheera, C.S. (2021). Plant-based milk substitutes as emerging probiotic carriers. *Current Opinion in Food Science*, 38, 8-20.

[28] 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.

[29] McClements, D.J., Newman, E., McClements, I.F. (2019). Plant-based milks: A review of the science underpinning their design, fabrication, and performance. *Comprehensive Reviews in Food Science and Food Safety*, 18(6), 2047-2067.

[30] Kanberoglu, B.N. (2021). Use of quinoa beverage and flour as replacement of cow's milk and skimmed milk powder in ice cream production. Master Thesis. Institute of Graduate Studies, Ondokuz Mayis University, Samsun, Turkey (in Turkish).

[31] Martinez-Padilla, E., Li, K., Blok Frandsen, H., Skejovic Joehnke, M., Vargas-Bello-Perez, E., Lykke Petersen, I. (2020). In vitro protein digestibility and fatty acid profile of commercial plant-based milk alternatives. *Foods*, 9(12), 1784.

[32] Pineli, L.D.D., Botelho, R.B.A., Zandonadi, R.P., Solorzano, J.L., de Oliveira, G.T., Reis, C.E.G., Teixeira, D.S. (2015). Low glycemic index and increased protein content in a novel quinoa milk. *Lwt-Food Science and Technology*, 63(2), 1261-1267.

[33] Makinen, O.E., Uniacke-Lowe, T., O'Mahony, J.A., Arendt, E.K. (2015). Physicochemical and acid gelation properties of commercial UHT-treated plant-based milk substitutes and lactose free bovine milk. *Food Chemistry*, 168, 630-638.

[34] 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.

[35] Abelilla, J.J., Liu, Y., Stein, H.H. (2018). Digestible indispensable amino acid score (DIAAS) and protein digestibility corrected amino acid score (PDCAAS) in oat protein concentrate measured in 20- to 30-kilogram pigs. *Journal of the Science of Food and Agriculture*, 98(1), 410-414.

[36] Simopoulos, A.P. (2016). An increase in the omega-6/omega-3 fatty acid ratio increases the risk for obesity. *Nutrients*, 8(3), 128.

[37] Simopoulos, A.P. (2008). The importance of the omega-6/omega-3 fatty acid ratio in cardiovascular disease and other chronic diseases. *Experimental Biology and Medicine*, 233, 6, 684-688.

[38] Astolfi, M.L., Marconi, E., Protano, C., Canepari, S. (2020). Comparative elemental analysis of dairy milk and plant-based milk alternatives. *Food Control*, 116, 107327.

[39] Gram, S. (2021). The effect of ultrasound and homogenization processes on the physicochemical propertieof hemp milk. Master Thesis. Institute of Graduate Studies: Ondokuz Mayıs University, Samsun, Turkey.

[40] Huang, K., Zhang, S., Guan, X., Li, C., Li, S., Liu, Y., Shi, J. (2021). Effect of the oat β-glucan on the development of functional quinoa (Chenopodium quinoa wild) milk. *Food Chemistry*, 349, 129201.

[41] Jeske, S., Zannini, E., Arendt, E.K. (2017). Evaluation of physicochemical and glycaemic properties of commercial plant-based milk substitutes. *Plant Foods for Human Nutrition*, 72(1), 26-33.

[42] Lai, H., Wang, S., Nguyen, Z., Li, B. (2021). Process optimization and antioxidant activity changes of fermented hemp seed milk. *Modern Food Technology*, 37(07), 194-202.

[43] Vaikma, H., Kaleda, A., Rosend, J., Rosenvald, S. (2021). Market mapping of plant-based milk alternatives by using sensory (RATA) and GC analysis. *Future Foods*, 4, 100049.

[44] Farinon, B., Molinari, R., Costantini, L., Merendino, N. (2020). The seed of industrial hemp (Cannabis sativa L.): Nutritional quality and potential functionality for human health and nutrition. *Nutrients*, 12(7), 1935.

[45] Silva, A.R.A., Silva, M.M.N., Ribeiro, B.D. (2020). Health issues and technological aspects of plant-based alternative milk. *Food Research International*, 131, 108972.

[46] Szparaga, A., Tabor, S., Kocira, S., Czerwińska, E., Kuboń, M., Płóciennik, B., Findura, P. (2019). Survivability of probiotic bacteria in model systems of non-fermented and fermented coconut and hemp milks. *Sustainability*, 11(21), 6093.

[47] Zhu, X., Wang, Z., Li, M., Wang, Y., Li, Z., Yang, H., Zhang, N., Sun, B. (2021). Effect of heat treatment on the stability of hemp seed milk and characterization of protein structure. *Food Science and Human Wellness*, 42(7), 68-73.

[48] Bartkiene, E., Zokaityte, E., Lele, V., Sakiene, V., Zavistanaviciute, P., Klupsaite, D., Bendoraitiene, J., Navikaite-Snipaitiene, V., Ruzauskas, M. (2019). Technology and characterisation of whole hemp seed beverages prepared from ultrasonicated and fermented whole seed paste. *International Journal of Food Science & Technology*, 55(1), 406-19.