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Review
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COMPARISON OF THE NUTRITIONAL VALUE OF COW'S MILK AND PLANT-BASED MILKS

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Abstract: Malnutrition and micronutrient deficiencies are observed among people in many developing countries. The high cost of cow's milk and poverty make it difficult for people to access nutritious food. For this reason, low-cost foods that can be an alternative to cow's milk are important. In addition, the fact that cow's milk causes lactose intolerance, high cholesterol, constipation and bloating in some individuals has led people to other alternatives. Apart from these, alternatives for vegan individuals have begun to be considered. All these reasons have increased the demand for alternative milk of plant origin worldwide. Plant-based milks have been the subject of research with different names in the literature. For example: vegetable milk, non-dairy milk, imitation milk, dairy substitute. This review is focused on comparing nutrient composition of cow's milk and plant-based milk alternatives.

Keywords: Cow's milk, Plant-based milk, Vegetable milk, Non-dairy milk

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1. Introduction

Cow's milk is a complete food that contains all its essential components, such as fat and carbohydrates, as well as being a good source of protein (Padma et al., 2022). Cow's milk, which has high nutritional value, is used as a staple food in many diets. Cow's milk has a wide range of uses. Although milk is consumed as a beverage, it is also added to various beverages like coffee, smoothie. In addition, many dairy products such as ice cream, yogurt, cheese and butter are produced from cow's milk (Bocker and Silva, 2021). But, due to problems such as lactose intolerance and milk allergy caused by cow's milk consumption, the demand for alternative milk of plant-based has increased worldwide (Vanga and Raghavan, 2018). Milk alternatives are water extracts of plants (Tangyu et al., 2019). Although there are many varieties of plant-based milk, the most common are rice milk, soy milk and coconut milk (Rasika et al., 2021). Known for its lactose-free, animal protein-free and cholesterol-free properties, plant-based milks are known as an important food for individuals with sensitivity to the specified properties (Bernat et al., 2014). There are also some disadvantages of plant-based milks. Among these disadvantages are that they are nutritionally unbalanced and their taste profiles are difficult to accept. Fermentation is recommended to produce more valuable and delicious products (Tangyu et al., 2019). Fermented plant-based milk ice cream can be a good alternative that can be used as a new functional food (Aboulfazli et al., 2016). Existence of soy milk in ice creams was reported as a significant improvement in probiotic tolerance against gastrointestinal conditions (Aboulfazli and Baba, 2015). In general, plant-based milk alternatives have lower protein content, calcium availability, and higher GI values, than cow's milk (Chalupa-Krebzdak et al., 2018). However, these milks are rich in phenolic compounds, unsaturated fatty acids and bioactive compounds (Aydar et al., 2020). There are many methods for producing plant-based milk substitutes. Because they have many common steps, one flowchart is prepared for general plant-based milk substitute production in this study (Figure 1) (Makinen et al., 2016). However, there is very little research in the literature to understand the nutritional effects of consuming these plant-based milk drinks, which are popularly promoted as healthy, in the short and long term (Vanga and Raghavan, 2018).

Nutritional comparison of cow's milk and some plant-based milks will be made by using the literature. Although there are many plant-based milks, only rice milk, soy milk, coconut milk, almond milk, tigernut milk, peanut milk and cashew nut milk were the subject of this study. The compared milk types are shown in Figure 2.

1.1 Animal-Based Milk

1.1.1. Cow's milk

Milk is an important food. The four components that predominate in the content of milk are water, fat, protein and lactose. Minerals, enzymes, vitamins and dissolved gases are minor components of milk (Guetouache et al., 2014).

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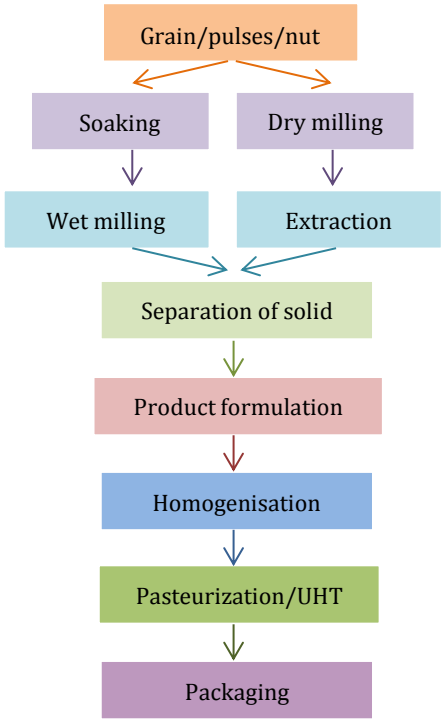

Figure 1. The general manufacturing process of vegetable milk alternatives (Makinen et al., 2016).

1.2 Plant-based Milk Types

There are many types of plant-based milk. The most common plant-based milks are soy and rice milk. In this review, data in the literature on soy, rice, coconut, almond, tiger nut, peanut and cashew nut milk varieties will be examined. A brief literature information about these milk types is written below.

1.2.1. Rice milk

Rice milk is not an adequate source of protein (Mori et al., 2015). However, it has been the subject of many different studies. Rice milk is a milk alternative beverage that can be used in kefir production (Sulistyaningtyas et al., 2019). In addition, lactic acid bacteria contribute to rice milk fermentation and these bacteria produce products such as yoghurt and cheese. It is thought that rice yogurt can be used as a supplementary to colon anticancer therapy (Fawzi et al., 2022).

1.2.2. Soy milk

Soy milk is a traditional beverage popular in Asia (Ng and Loh, 2018). Soy milk, a plant-based beverage, is a rich source of nutrients. But soy milk contains several harmful compounds, including allergens, anti-nutritional factors, and biogenic amines (Mollakhalili-Meybodi et al., 2022). Soy milk substitute in cake production has increased the overall nutritional composition of the products, and besides milk it is a good source of protein (Erfanian and Rasti, 2019).

1.2.3. Coconut milk

Coconut milk is an oil-in-water emulsion extracted from coconut (Chiewchan et al., 2006). Coconut milk is a dairy alternative source rich in various nutrients. Low-fat coconut milk is an alternative to cow's milk in the production of kefir-based beverages (Abadl et al., 2022). Coconut milk contains negligible levels of cholesterol. This situation makes coconut milk suitable for a group of populations suffering from lactose intolerance and heart disease (Tulashie et al., 2022).

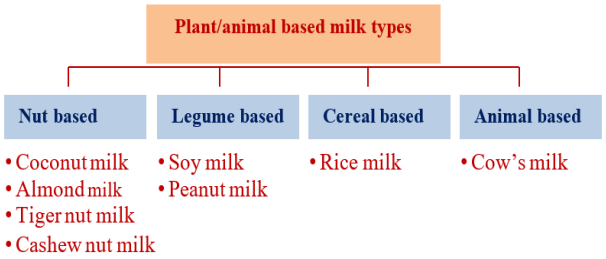

Figure 2. Milk types.

1.2.4. Almond milk

Almond milk is a nutrient-dense milk that is lower in calories than cow's milk. This milk is an important beverage for gastrointestinal and cardiovascular health (Alozie Yetunde and Udofia, 2015). Probiotic yoghurts produced by adding almond milk to dairy products compensate the expectations of consumers who demand food products with high nutritional value (Yılmaz-Ersan and Topcuoglu, 2022).

1.2.5. Tiger nut milk

Tiger nut milk is a widely produced and consumed beverage also called "kunun aya" in Nigeria (Opeyemi and Obuneme, 2020). Tiger nut milk is a nutrient-rich beverage. Tiger nut milk is a perishable beverage. Therefore, extending the shelf life of commercialized tiger nut milk is an important topic (Codina-Torrella et al., 2018; Costa Neto et al., 2019). It has been determined that microencapsulation application increases the shelf life of tiger nut milk (Costa Neto et al., 2019). In addition, in many studies, tiger nut milk is also referred to as "chufa milk".

1.2.6. Peanut milk

The use of peanut milk will provide an alternative to animal milk and will also help to overcome malnutrition (Yadav et al., 2010). Peanut milk has higher fat, protein content and calorific value than cow's milk (Gamlı and Atasoy, 2018). In addition, in many studies, peanut milk is also referred to as "groundnut milk, bambara groundnut milk".

1.2.7. Cashew nut milk

Cashew nut milk is promoted in rural communities where the availability and cost of animal milk poses great challenges to people. Cashew nut milk can be preferred as a milk substitute due to it's reduce the cost of diary milk and its high nutritional content (Tamuno and Monday, 2019).

2. Comparison of Plant-Based Milks and Cow's Milk

In this review article protein, fat, carbohydrate, sugar contents and energy values of cow's milk and plant-based milk will be compared (Figure 3).

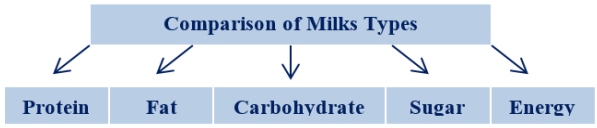

Figure 3. Comparison of plant-based milks and cow's milk.

2.1 Content of Protein

Proteins are one of the essential nutrient for healthy life, growth and cell reparation. However, with the increasing world population, protein sources are decreasing day by day and this situation causes an increase in the demand for new alternative protein sources. Plants, which are low cost compared to animal protein sources and preferred by special consumer groups such as vegan and vegetarian, are a good alternative protein source (Çetiner and Ersus Bilek, 2018). Encouraging the use of protein-rich foods can reduce the problem of malnutrition (in terms of protein and energy) (Oyeyinka et al., 2019).

In general, plant-based milk alternatives have lower protein content than cow's milk (Chalupa-Krebzdak et al., 2018).

Table 1 show the protein contents of milk samples. Soy milk and peanut milk have similar protein content as cow's milk. Compared to cow's milk, rice milk, almond milk, tigernut milk, cashew nut milk contains less protein.

2.2 Content of Fat

Fat content is one of the important parameters in determining food quality in many food products (Guthausen et al., 2004). Fats from plant-based sources have shown positive alterations in gut microbiota biodiversity studies (Muralidharan et al., 2019). Table 2 show the fat contents of milk samples. With the literature review, it was concluded that the fat content of coconut milk is higher than other plant-based milks and cow's milk. Rice milk, soy milk, tigernut milk and cashew nut milk have lower fat content than cow's milk.

Table 1. Protein content of milk types

Reference	Protein (%)	Reference	Protein (%)
Cow's Milk		Almond Milk	
(Jemaa et al., 2021)	3.32	(Vanga and Raghavan, 2018)	1
(Asres et al., 2022)	3.40	(Maghsoudlou et al., 2016)	1.06
(Abou-Dobara et al., 2016)	3.65	(Kundu et al., 2018)	1.3
Rice Milk		Tigernut Milk	
(Vanga and Raghavan, 2018)	1	(Wakil et al., 2014)	1.66
(Silva et al., 2023)	1.48	(Abdulfatai et al., 2013)	2.24
(Abou-Dobara et al., 2016)	1.62	(Neto et al., 2017)	2.6
Soy Milk		Peanut Milk	
(Makinen et al., 2014)	2.95	(Isanga and Zhang, 2009)	3.71
(Kundu et al., 2018)	3.17	(Jain et al., 2013)	3.8
(Abou-Dobara et al., 2016)	3.54	(Abou-Dobara et al., 2016)	3.91
Coconut Milk		Cashew nut Milk	
(Tulashie et al., 2022)	2.22	(Cardello et al., 2022)	0.4
(Ayah et al., 2022)	2.30	(USDA, 2019)	0.42
(Szparaga et al., 2019)	3.23	(Drewnowski, 2022)	0.87

Table 2. Fat content of milk types

Reference	Fat (%)	Reference	Fat (%)
Cow's Milk		Almond Milk	
(Ceballos et al., 2009)	3.42	(Maria and Victoria, 2018)	1.6
(Isanga and Zhang, 2009)	3.54	(Angelino et al., 2020)	2.3
(Abou-Dobara et al., 2016)	3.6	(Vanga and Raghavan, 2018)	2.5
Rice Milk		Tigernut Milk	
(Drewnowski, 2022)	1.21	(Abdulfatai et al., 2013)	1.23
(Lalić et al., 2014)	2.4	(Amponsah et al., 2017)	1.81
(Vanga and Raghavan, 2018)	2.5	(Muhammad et al., 2019)	2.84
Soy Milk		Peanut Milk	
(George and Awopetu, 2017)	1.83	(Bucker et al., 1979)	4.4
(Angelino et al., 2020)	2	(Abou-Dobara et al., 2016)	4.5
(Kundu et al., 2018)	2.35	(Elsamani, 2016)	5.0
Coconut Milk		Cashew nut Milk	
(Azlin-Hashim et al., 2019)	11.02	(Cardello et al., 2022)	1.4
(Tulashie et al., 2022)	14.12	(Sumner and Burbridge, 2020)	2
(Masia et al., 2020)	17.67	(Drewnowski, 2022)	2.26

2.3 Content of Carbohydrate

Carbohydrates are important in foods as a major source of energy (Jebb, 2015; Campos et al., 2022). Carbohydrates form a significant component of a healthy and balanced diet. Carbohydrates, which provide 50-70% of energy intake, are divided into three main groups in human nutrition. These are sugars, starch and non-starch polysaccharides (Lunn and Buttriss, 2007). Table 3 show the carbohydrates contents of milk samples. With the literature review, it was concluded that the carbohydrate content of rice milk and tigernut milk is higher than other plant-based milks and cow's milk. Other plant-based milks have similar carbohydrate content as cow's milk.

2.4 Content of Total Sugar

Total sugars are described as the total of all free monosaccharides and disaccharides (such as glucose, fructose, lactose, and sucrose) (BeMiller, 2010). Table 4 show the sugar contents of milk samples. With the literature review, it was concluded that the sugar content of rice milk is higher than other plant-based milks and cow's milk. Soy milk, coconut milk, almond milk, peanut milk and cashew nut milk have lower sugar content than cow's milk.

2.5 Energy Value

The risk of obesity and cardiometabolic disease increases with calories from any food (Stanhope et al., 2018). The dietary energy of cow's milk varies based on the fat content of the milk. Most of the energy in milk alternatives consists of carbohydrates and sugars. These alternatives drinks relatively raise the glycemic index (Chalupa-Krebzdak et al., 2018). Table 5 show the energy value of milk samples. With the literature review, it was concluded that the energy value of coconut milk and peanut milk is higher than other plant-based milks and cow's milk. Almond milk and cashew nut milk have lower fat content than other plant-based milks and cow's milk. Rice milk and soy milk have similar energy value as cow's milk.

Table 3. Carbohydrate content of milk types

Reference	Carbohydrate (%)	Reference	Carbohydrate (%)
Cow's Milk		Almond Milk	
(Asres et al., 2022)	4.32	(Devnani et al., 2020)	2.3
(Gamlı and Atasoy, 2018)	4.61	(Ceylan and Özer, 2020)	2.44
(Mohamed et al., 2019)	4.96	(Maria and Victoria, 2018)	2.71
Rice Milk		Tigernut Milk	
(Atwaa et al., 2019)	10.27	(Costa Neto et al., 2019)	7.61
(Silva et al., 2023)	11.33	(Wakil et al., 2014)	8.34
(Angelino et al., 2020)	12	(Abdulfatai et al., 2013)	10.73
Soy Milk		Peanut Milk	
(USDA, 2021b)	3	(Pahane et al., 2017)	4.2
(Al and Oladimeji, 2008)	3.49	(Gamlı and Atasoy, 2018)	4.24
(Vanga and Raghavan, 2018)	4	(Singh et al., 2018)	4.7
Coconut Milk		Cashew nut Milk	
(Clegg et al., 2021)	3.70	(Craig and Brothers, 2021)	3
(Mepba et al., 2006)	3.84	(Oyeyinka et al., 2019)	5.17
(USDA, 1984)	5.54	(Tamuno and Monday, 2019)	5.95

Table 4. Sugar content of milk types

Reference	Sugar (%)	Reference	Sugar (%)
Cow's Milk		Almond Milk	
(Coyle et al., 2019)	4.4	(Sumner and Burbridge, 2020)	2.4
(Sumner and Burbridge, 2020)	4.7	(Drewnowski, 2022)	2.58
(Cardello et al., 2022)	4.8	(Angelino et al., 2020)	3.0
Rice Milk		Tigernut Milk	
(Drewnowski, 2022)	5.05	(Neto et al., 2017)	3.70
(Cardello et al., 2022)	5.8	(Okyere and Odamtten, 2014)	6.00
(Angelino et al., 2020)	6.2	(Costa Neto et al., 2019)	6.20
Soy Milk		Peanut Milk	
(Awasthi and Singh, 2020)	2.2	(Naliapara and Cholera, 2017)	0.08
(Angelino et al., 2020)	2.6	(Elgazouly et al., 2018)	0.41
(Vanga and Raghavan, 2018)	3	(Hardy and Jideani, 2018)	0.5
Coconut Milk		Cashewnut Milk	
(Sumner and Burbridge, 2020)	1.9	(Craig and Brothers, 2021)	0
(Drewnowski, 2022)	2.12	(Drewnowski, 2022)	1.88
(Clegg et al., 2021)	2.28	(Sumner and Burbridge, 2020)	2

Table 5. Energy value of milk types

Reference	Energy value (kcal/100 g)	Reference	Energy value (kcal/100 g)
Cow's Milk		Almond Milk	
(Gamlı and Atasoy, 2018)	58.27	(USDA, 2021a)	19
(Şahan and Say, 2001)	62.13	(Vanga and Raghavan, 2018)	35
(Bhat et al., 2022)	65.72	(Angelino et al., 2020)	38
Rice Milk		Tigernut Milk	
(Cardello et al., 2022)	50.87	(Abdulfatai et al., 2013)	62.97
(Silva et al., 2023)	52.03	(Ntukidem et al., 2019)	69.41
(Drewnowski, 2022)	53	(Aly et al., 2022)	74
Soy Milk		Peanut Milk	
(Awasthi and Singh, 2020)	50	(Singh et al., 2018)	72
(Alozie Yetunde and Udofia, 2015)	57.36	(Isanga and Zhang, 2009)	86.32
(Mepba et al., 2006)	62.65	(Gamlı and Atasoy, 2018)	90.52
Coconut Milk		Cashew nut Milk	
(Awasthi and Singh, 2020)	70	(Cardello et al., 2022)	17.43
(Mauro et al., 2022)	77.48	(Oyeyinka et al., 2019)	20.25
(Drewnowski, 2022)	95	(Drewnowski, 2022)	36

3. Conclusion

Cow's milk is a good source of fat, protein and micronutrients. But plant-based milks also have a rich protein content similar to cow's milk and are good non-dairy alternatives. For these reasons, there has recently been an interest in milk alternatives derived from plant-based sources. With this study, we wanted to compare the nutritional contents of some plant-based milks as well as knowing that cow's milk is a valuable food. The following conclusions were reached with the literature review.

- Soy milk and peanut milk have similar protein content as cow's milk.
- Coconut milk has a higher fat content than other plant-based milks and cow's milk.
- Rice milk and tigernut milk have higher carbohydrate content than other plant-based milks and cow's milk.
- Peanut milk and cashew nut milk have lower sugar content than other plant-based milks and cow's milk.
- Coconut and peanut milk have higher energy value than other plant-based milks and cow's milk.

There is no doubt that cow's milk is beneficial for the health of individuals who are not allergic. However, plant-based milk is recommended for individuals who do not consume cow's milk due to various reasons such as lactose intolerance and vegan diet. Although the nutritional content of each plant-based milk is not the same, these alternatives are thought to be beneficial for human health.

Author Contributions

The percentage of the author contributions is presented below. The author reviewed and approved the final version of the manuscript.

	R.T.M.
C	100
D	100
S	100
DCP	100
DAI	100
L	100
W	100
CR	100
SR	100

C=Concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision.

Conflict of Interest

The author declare that there is no conflict of interest.

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