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Comprehensive Analysis of Nutritional, Organoleptic, and Functional Aspects of Cow's Milk and Plant-Based Milk Alternatives in the Colombian Market

Análisis integral de los aspectos nutricionales, organolépticos y funcionales de la leche de vaca y las alternativas de leche de origen vegetal en el mercado colombiano

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ABSTRACT

Background: Plant-based beverages, also known as plant-based milk alternatives, are often considered nutritional replacements for conventional cow's milk, as they can serve similar organoleptic and gastronomic purposes. They are increasingly preferred by consumers who have transitioned from conventional milk for various reasons, including lactose intolerance, health concerns, and ethical considerations related to animal welfare and environmental sustainability. However, the nutritional differences between plant-based beverages and cow's milk have been well-documented in the literature, highlighting variations in essential nutrients such as protein, sugars, saturated fats, sodium, and calcium. **Objectives:** to analyze the nutritional profile of plant-based milk alternatives available in the Colombian market and cow´s milk, to identify whether they can be considered nutritional alternatives. **Methods:** through the recollection of the data reported in the Nutritional Facts table presented in the labels of the selected products in the supermarkets of the city of Medellín, Colombia, in addition to the launches reported on Mintel Market Research© to cover the national territory, and the nutritional profile of whole and skimmed cow´s milk, a comparative analysis is performed using the Health Star Rating methodology from Australia and New Zealand. **Results:** 96 plant-based milk alternatives were evaluated and categorized by vegetable source. The skimmed milk was ranked best because of its low-fat content, followed by the whole milk. The soy and cashew beverages evaluated were the best ranked of all the available plant-based options. Almond and oat beverages, and those whose source is a combination of two or more vegetable sources, obtained third place, followed by the rice beverages in fourth place, and coconut beverages in last. **Conclusions:** none of the commercially available plant-based alternative milks in Colombia are an adequate nutritional substitute for cow´s milk, mainly due to their protein, added sugars, and calcium contents.

Key words:

Plant-based nutrition, alternative milk products, dietary intakes, functional properties, consumer perception.

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RESUMEN

Antecedentes: las bebidas vegetales no lácteas se consideran como una alternativa de la leche de vaca, debido a su aspecto y textura lechosa, y por esta razón su consumo ha aumentado en ciertas poblaciones que buscan un reemplazo de la leche de vaca, por razones como el veganismo, la intolerancia a la lactosa y la concientización sobre la huella ambiental de su producción. No obstante, se han descrito en la literatura aspectos nutricionales del intercambio entre este tipo de productos y la leche de vaca, identificando la diferencia en el contenido de nutrientes como la proteína, azúcares añadidos, grasas saturadas, sodio y calcio. **Objetivo:** analizar comparativamente el perfil nutricional de las bebidas vegetales disponibles en el mercado colombiano, y la leche de vaca, para identificar si pueden ser consideradas como alternativas nutricionales. **Métodos:** por medio de la recolección de los datos reportados en la tabla nutricional de las etiquetas de los productos seleccionados en los supermercados de la ciudad de Medellín, Colombia, además de los lanzamientos reportados en Mintel Market Research © para cubrir el territorio nacional, y el perfil nutricional de la leche de vaca entera y descremada, se llevó a cabo un análisis comparativo utilizando la metodología de Health Star Rating de Australia y Nueva Zelanda. **Resultados:** se evaluaron 96 referencias del mercado y fueron categorizadas por fuente vegetal. La leche de vaca descremada fue la mejor puntuada por su bajo contenido de grasa saturada, seguida de la leche entera. Las bebidas de soya y marañón fueron las mejor puntuadas de todas las bebidas vegetales evaluadas, seguidas de las opciones de almendra y avena. Adicionalmente, las opciones con combinación de fuentes vegetales y las bebidas de arroz; y en último lugar, las bebidas de coco. **Conclusiones:** ninguna de las bebidas vegetales disponibles en el mercado colombiano evaluadas son una alternativa nutricional adecuada de la leche de vaca, debido principalmente a los contenidos de proteína, azúcares y calcio.

Palabras clave: Nutrición basada en plantas, productos alternativos de la leche, ingesta dietética, propiedades funcionales, percepción del consumidor.

INTRODUCTION

Cow´s milk is one of the most consumed beverages in the world because of its complete nutritional value, availability, affordability, and important technological role in the food industry (1). However, it has been identified that this consumption of milk or its derivatives may be limited by different factors or lifestyles, leading an increasingly large group of consumers to seek alternatives to this product category (2).

One of the main reasons for looking for a cow´s milk substitute is the prevalence of lactose intolerance worldwide (3). This medical condition consists of the absence of the lactase enzyme (EC 3.2.1.108), which digests lactose, the carbohydrate in cow´s milk. This condition can be avoided by consuming lactose-free milk and derived products, which are a response from the food and dairy industry to meet an increasing demand from this population that seeks the functionality and nutritional profile of cow´s milk but with previously hydrolyzed lactose.

Nonetheless, lactose-free products are not a suitable option for everyone looking for an alternative, for example, the vegan/vegetarian consumers, who, depending on their specific lifestyle, avoid and forbid the consumption of any kind of animal product, including food, textiles, and cosmetics. This consumption trend has increased significantly in the past decades. It needs more commercial options and alternatives that are not only palatable and affordable but also provide adequate nutritional content to meet their special needs of critical nutrients. These critical nutrients are protein, calcium, and some vitamins, which are more available from animal products and not as easy to obtain from a vegan diet (4).

On the other hand, awareness of the environmental impact of industrial processes has modified the consumption trends, especially of agribusiness and animal food products, because of their known relationship with the carbon footprint (5). The increase of consumers changing the purchase decision process based on the impact that products have on the environment is an additional reason for the industry to provide non-animal alternatives.

Vegetable sources such as almond, oat, rice, and coconut, amongst others, have gained popularity in their beverage form due to their creamy and milk-like texture. They are commonly known as "plant-based milk alternatives" referencing the similarity to cow´s milk and implying that they are interchangeable foods (6). However, it has been described by previous studies around the world that the nutritional content of the commercially available plant-based milk alternatives is not the same as cow´s milk, and not even comparable for them to be classified as nutritional alternatives (7–11).

These differences are based on the protein, calcium, vitamin A, and vitamin D contents, which are in higher levels and greater bioavailability in cow´s milk vs the plant-based milk alternatives (8,11,12). Due to the lack of legislation and regulation of these products, both nationally and internationally, there's no standard for the content of nutrients they must meet, nor are there specific ingredients in the formula to receive the name of milk alternative.

Similar studies around the world have analyzed the nutritional profile of plant-based milk alternatives versus the nutritional profile of cow´s milk. Still, no known studies make this comparison based on the Colombian market. Thus, this work aimed to comparatively analyze the commercially available plant-based milk alternative options and whole and skimmed cow´s milk by nutritional content in order to determine whether they can be considered adequate nutritional alternatives.

MATERIALS AND METHODS

The nutritional content of the evaluated references was identified in the Nutrition Facts table on the label of the commercially available plant-based milk alternatives in the main supermarkets of Medellín, Colombia, in three months (July–September) of 2022. Data were collected in the same period from the market intelligence platform Mintel Market Research© (Mintel Group Ltd, London, UK) to ensure nationwide coverage. The selection criteria were the milk-like aspect, the milk-free or dairy-free certification, and the vegetable source (almond, soy, coconut, rice, oat, cashew, and those that combine two or more vegetable sources). On the other side, for the whole and skimmed milk nutritional contents, the data were collected from the Table of Composition of Colombian Foodstuffs of the Colombian Institute of Family Welfare (13).

The specific nutrient data collected for each reference was selected according with mandatory nutrient declaration (according to Resolution 333 of 2011 of Health Ministry of Colombia, in effect at the time of the data collection, subsequently modified by Resolution 810 de 2021 and 2492 de 2022) (by 100 mL): calories (kcal and kJ), total fat, saturated fat, cholesterol, total carbohydrates, dietary fiber, sugars, protein, calcium, vitamin A, and vitamin C (14).

The comparative analysis was carried out using Australia and New Zealand´s Commonwealth methodology for front-of-pack labeling, the Health Star Rating, using the HSR Calculator 4.2 version, available free of charge on the official website (15). Additionally, a coding system was used to ensure the confidentiality of commercial brands or manufacturer names, avoiding a conflict of interest. Approval from an ethics committee does not apply to the methodology of this study.

RESULTS

A total of 96 different samples were evaluated, of which the most common was the almond drink (*n* = 46; 47.9%), followed by coconut drink (*n* = 17; 17.7%), then drinks representing a combination of vegetable sources (*n* = 11; 11.5%), followed by soy drinks (*n* = 8; 8.3%), oat (*n* = 8; 8.3%), rice (*n* = 3; 3.1%) and cashew (*n* = 3; 3.1%), represented by figure 1. By identifying the manufacturer's address on the packaging, the country of origin was determined and distributed as shown in figure 2.

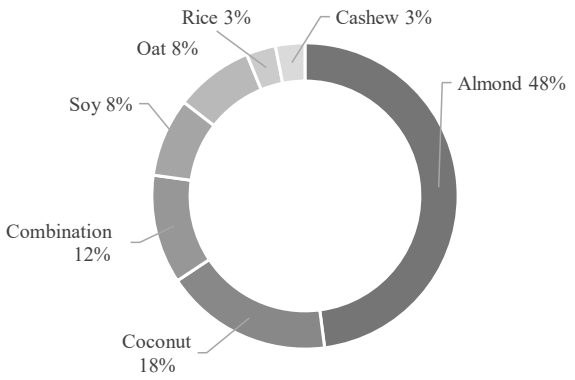

Figure 1. Distribution of the evaluated references by vegetable source.

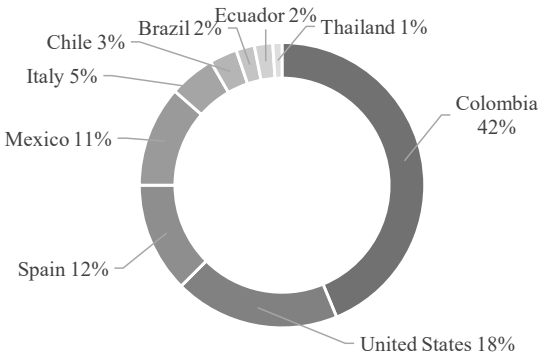

Figure 2. Distribution of the evaluated references by country of origin.

The nutritional information of each reference was evaluated per 100 mL of product (Appendix A.), yielding the following results: the total caloric content varies from 9.0 to 72.0 kcal/100 mL, with the following macronutrient distribution: total fat content varies from 0.4 to 5.3 g/100 mL, protein from 0.0 to 3.75 g/100 mL, and carbohydrate content from 0.0 to 14.2 g/100 mL.

The beverage with the highest caloric content was a soy reference, and the one with the lowest was from an almond source, which claims to be a sugar-

free version. On the other hand, the beverage with the highest protein content (3.75 g/100 mL) had a caloric content of 33 kcal per 100 mL, and its source was cashew. Several beverages (*n* = 15) reported zero protein content (0.0 g/100 mL), and their sources were almonds (*n* = 7), coconut (*n* = 6) and combination of vegetable sources (*n* = 2).

The sugar content varied widely, ranging from 0.0 to 10.4 g/100 mL. One of the nutrients with a lower presence in general was fiber, with 41 of all the references contributing 0.0 g per 100 mL. The beverage with the highest sugar content was rice, and its fiber content was nil. In contrast, the beverage with the highest fiber content was a combination of vegetable sources, and its sugar content was 3.0 g per 100 ml of product.

Rice beverages had the highest sugar content with an average of 7.63 g/100 mL (SE ± 1.90), followed by the average contribution of oat beverages (4.22 g/100 mL; ± 0.93), vegetable source combination drinks (3.54 g/100 mL; ± 0.79), soy (3.24 g/100 mL; ± 0.90), almonds (2.15 g/100 mL; ± 0.31) and, finally, cashew (0.51 g/100 mL; ± 0.38).

Regarding micronutrients, Colombian regulations (Resolution 333 of 2011 of the Ministry of Health and Social Protection, in force at the time of the study) require the declaration of vitamins A and C in the nutritional table, and the minerals are calcium and iron. Vitamin C was absent in all references evaluated (0.0% of the recommended daily value), while vitamin A was reported in 65,6% (*n* = 63) of the total assessed references.

The highest reported vitamin A content was 195.0 µg Retinol equivalents (ER) in an almond beverage. However, on average, cashew beverages provide the highest content of this vitamin (31.48 µg ER/100 mL; ± 24.26) compared to other sources such as oat (20.83 µg ER/100 mL; ± 11.69), coconut (48.74 µg ER/100 mL; ± 10.19), almond (42.51 µg ER/100 mL; ± 5.80), and soy (39.73 µg ER/100 mL; ± 5.89). In contrast, rice and vegetable combination drinks have no detectable vitamin A content (0.0 µg ER/100 mL).

The calcium content varies from 1.7 mg to 500 mg per 100 mL of product, with the soy and coconut references occupying the first place, with contributions of 450 mg and 500 mg of calcium per 100 mL of product, respectively. The iron content was generally very low with respect to the Reference Daily Intake (RDI) of this mineral (20 mg), not exceeding levels of 4 g per 100 mL of product and an average of 0.22 g/100 mL.

When evaluating the nutritional profile of cow's milk, the following values were identified per 100 mL of product: 55 kcal, 3.2 grams of protein, 3.2 grams of lipids (of which 1.9 g correspond to saturated fat), 3.4 grams of carbohydrates, which, being all from lactose, are considered the same value for total sugars, and no dietary fiber content. For micronutrients, cow's milk contributes 39 µg ER of vitamin A, 120 mg of calcium, 0.0 mg of iron, and 0.0 mg of vitamin C, in the same amount, 100 mL.

For its part, 100 mL of skimmed cow's milk has values of 34 kcal, 3.3 g of protein, 0.1 g of total lipids, equivalent to saturated fat, and 4.9 g of sugars (the same as carbohydrates). In terms of micronutrients, it contains 1 µg ER of vitamin A, 127 mg of calcium, 0.0 mg of iron, and vitamin C.

For their classification using the HSR methodology, cow's milk, in its skimmed version, obtains the highest score (5 stars), considering its contribution of protein and its low content of saturated fat. Whole cow's milk obtained the second highest score (4 ½ stars), the only difference with the skimmed version being the saturated fat content.

The classification of the references with the HSR system yielded diverse results, represented by the average of each category in Table 1 and exact values for all the references evaluated in Appendix A. For example, the lowest scores were for two coconut references, with 2 stars, followed by another coconut beverage and one oat beverage, with 2 ½ stars. With a score of 3 stars, the references are varied: almond (*n* = 1), oat (*n* = 1), rice (*n* = 1) and coconut (*n* = 1); and for 3 ½ stars there are a total of 33 drinks, distributed as follows: almond (*n* = 14), coconut (*n* = 13), combination of vegetable sources (*n* = 4) and oat (*n* = 2). For a score of 4 stars, 42 beverages, of which the majority are almond (*n* = 30), followed by vegetable source combination beverages (*n* = 5), oat (*n* = 3), cashew (*n* = 2), soy (*n* = 1) and, finally, rice (*n* = 1).

The highest scores were 4 ½ and 5 stars, with only 8 beverages obtaining 4 ½, distributed as follows: soy (n = 5) and one reference each for almond, oat, and combination of vegetable sources; and 3 beverages obtained the highest score of 5 stars, two of them soy and one cashew.

From the averages obtained from the category's almonds, coconut, combination of vegetable sources, soybeans, oats, rice and cashew, the scores are classified as follows: soybeans and cashew 4 ½ stars, almonds, oats, and those of combinations of

vegetable sources 4 stars, rice 3 ½ stars and, finally, coconut with 3 stars. Table 1 results also include the standard deviation of the data, where a wide dispersion of the data within the groups is evident.

For adding points in the (HSR) methodology, the contents of 'concentrated fruits and vegetables' and 'FVNL' (fruits, vegetables, nuts, and legumes) are considered 0.0%. This assumption is based on the fact that it is not possible to determine these contents from the nutritional table or the ingredient list provided on the product labels. Furthermore, given the typical composition of these types of beverages, it can be inferred that such concentrates are generally not used; likewise, for whole and skimmed cow's milk, these values were taken at 0.0%. For this reason, these results were not included in Table 1.

Table 1. Energy and nutrient values (average and standard error[1]) in 100 mL of vegetable beverages available in the Colombian market and milk, and their classification according to the HSR system.

Type of drink	Energy (kJ)	Saturated fat (g)	Total sugars (g)	Sodium (mg)	Fiber (g)	Protein (g)	Calcium[2] (mg)	Health Star Rating
Whole milk[3]	230.12	1.90	3.40	42.00	-	3.20	120.00	****✧
Skimmed milk[4]	142.25	0.10	4.90	43.00	-	3.30	127.00	*****
Almond (*n* = 46)	108.6 ± 6.99	0.21 ± 0.05	2.15 ± 0.31	60.11 ± 5.03	0.37 ± 0.07	0.53 ± 0.06	109.21 ± 9.60	****
Coconut (*n* = 17)	112.58 ± 12.87	2.09 ± 0.26	1.09 ± 0.40	34.63 ± 5.83	0.66 ± 0.13	0.23 ± 0.08	115.74 ± 28.10	***
Combination (*n* = 11)	200.51 ± 18.86	0.86 ± 0.11	3.54 ± 0.79	45.67 ± 11.25	1.05 ± 0.39	0.78 ± 0.27	27.84 ± 15.26	****
Soy (*n* = 8)	182.46 ± 20.61	0.14 ± 0.05	3.24 ± 0.90	50.95 ± 9.95	0.37 ± 0.14	2.65 ± 0.33	152.75 ± 47.79	****✧
Oat (*n* = 8)	186.96 ± 21.79	0.16 ± 0.06	4.22 ± 0.93	85.62 ± 27.01	0.54 ± 0.19	0.86 ± 0.23	121.01 ± 17.41	****
Rice (*n* = 3)	252.43 ± 19.38	0.17 ± 0.03	7.63 ± 1.90	90.00 ± 10.00	0.03 ± 0.03	0.33 ± 0.09	-	***✧
Cashew (*n* = 3)	105.89 ± 20.26	0.51 ± 0.06	0.51 ± 0.38	32.83 ± 10.94	0.12 ± 0.12	1.67 ± 1.05	70.01 ± 34.16	****✧

When the standard error does not appear, only one value was found; when a line appears, it means that the value found was 0.

[1]The standard error represents the variability of the sample mean, indicating how precisely the sample estimates the population mean.

[2]Calcium is not a value required by the HSR methodology; it is included to better illustrate the most relevant nutrients for the present study.

[3-4]Whole and skimmed milk, pasteurized. Data was obtained from the Table of Composition of Colombian Foodstuffs of the Colombian Institute of Family Welfare (ICBF, 2018).

DISCUSSION

The supply of plant-based milk alternatives available in the Colombian market represents one of the consumption trends of a growing population that seeks to substitute cow´s milk. Still, it is important to evaluate the nutritional quality of this substitution. Even though plant-based milk alternatives have several benefits per se, such as the contribution of isoflavones and vitamins, and their cholesterol-free nature (8), the typical consumer generally only considers the milky appearance and flavor to consider them as a counterpart of cow´s milk, also associating them to factors such as sustainability, health benefits and cost (16).

ANALYSIS BY NUTRIENTS

The comparative analysis results indicate that none of the commercial plant-based milk alternative options available in the Colombian market currently meet the nutritional characteristics to be considered a nutritional alternative to cow´s milk.

These results are consistent with similar studies conducted in other countries, where it is determined that regardless of the vegetable source used, the nutritional characteristics of plant-based milk alternatives are different and inferior in some aspects, especially in factors such as protein content, bioavailability of micronutrients such as calcium,

and the presence of anti-nutritional factors, when compared with cow´s milk (7,9–12).

Protein

The protein content of the references evaluated in the present study turned out to be lower than that of the content of cow´s milk, with soy beverages being the most comparable in this aspect, as concluded by Astolfi and collaborators (2020) (7), who present as one of their main points that the levels of nutrients in soy beverages, especially protein, are an important option for lactose-intolerant people.

None of the other plant-based milk alternative categories evaluated, on average, meet at least half of the protein provided by cow´s milk, except for cashew. And in addition to the protein content, it is important to evaluate the bioavailability of the protein, and its variations according to the source, since it has been reported that the PDCAAS (Protein Digestibility Index) score of vegetable proteins can vary from 30% to 70% (17), which means that their absorption is limited to these levels. In comparison, the cow´s milk score is 100%, the "ideal" level of digestibility (18).

Calcium

The level of calcium, according to Chalupa-Krebzdak et al. (2018) (9), is highly variable within the plant-based milk alternatives options evaluated in their study, in agreement with the results of the present study, where some of the categories according to the vegetable source, report a null calcium content, as are the rice references on average; and in other cases, a higher content than reported by the cow´s milk, such as the total average of the soy references. However, it is important to consider not only the amount, but also the bioavailability of calcium as it can be affected by reasons such as the source of calcium fortification, which usually has a lower absorption rate than calcium from cow´s milk and has a higher possibility of sedimentation in some beverages due to its solubility when fortified from different synthetic sources (9).

Total sugars

Regarding total sugars, the rice-based beverages studied had a higher total sugar content than any other source, and milk, therefore, a higher caloric content, resulting in a lower HSR classification, probably due to their low protein and fiber content. Similar limitations of plant-based beverages in lactation and infancy were evaluated by Vitoria (2017) (17), where it is further specified that the sugar source of the beverage does matter, for example, the benefits provided by cow´s milk sugars (lactose) as prebiotic effects and improved calcium absorption when its consumed as recommended, whereas the sugar content of the plant based milk alternatives its usually of added sugars.

Other categories evaluated with higher amounts of sugars than cow´s milk are oat and soy beverages. However, the latter has been related to improving cardiovascular risk indicators, lipid alterations, and anthropometric markers of inflammation, mainly due to its isoflavone content (19). Oat beverages are associated with β-glucan content, whose consumption has been related to reducing total cholesterol, triglycerides, and blood glucose (20).

Saturated fat

Cow´s milk and its derivatives are considered significant contributors to dietary saturated fat (21), and whole milk obtained a higher content than the samples evaluated in the present study, except for the coconut beverage average category. However, skimmed cow´s milk obtained the highest score in the HSR classification due to its absence of saturated fat, which this system recognizes as one of the healthiest foods.

The coconut beverage category had the highest saturated fat content and scored lowest in the HSR classification system. Nevertheless, the composition of coconut saturated fat is mostly medium-chain fatty acids. These are used by the human body as energy more efficiently than long-chain fatty acids, giving them important health benefits (22), a consideration not taken into account by the HSR classification system, since it does not discriminate by the type of saturated fat.

Study limitations

The present study presents various limitations in terms of data collection and analysis; however, the results can generate recommendations for the food industry that manufactures these types of beverages in terms of fortification of micronutrients such as calcium, vitamin A, and vitamin D, as well as for the final consumer in terms of substituting cow´s milk for this type of beverage and the implications of this dietary variation.

One of the main limitations of the present study is based on the data collection, which was concentrated in a time range of 3 months and did

not consider other commercial references that may have been launched on the market subsequently. Similarly, in the period taken for data collection, the Colombian food labeling regulations were still in force, Resolution 333 of 2011, which is currently repealed by Resolution 810 of 2021 (modified by Resolution 2492 of 2022) of the Ministry of Health and Social Protection. This regulation does not consider aspects that would generate important points of comparison, such as the declaration of added sugars in the nutritional table, and the exact content of micronutrients instead of the Daily Value percentage (%).

Additionally, other important factors determine the quality of plant-based milk alternatives, and it is impossible to decide on them from the information provided by the nutritional table or the declaration of ingredients. Some of these are the so-called anti-nutritional factors, which are named for their effect on the nutritional content of some foods, reducing their bioavailability by competing for intestinal absorption sites with some micronutrients such as iron or calcium (23). Phytic acid, tannins, and protease inhibitors are examples of anti-nutritional factors, which, moreover, are not regulated by standards, and their content or presence is not generally evaluated in commercial brands of beverages.

Regarding the deficiency of regulations on this type of beverage, or on the requirements that a food must meet to be considered a nutritional alternative to another, the food industry has given the impression through marketing and advertising strategies that this type of beverage is nutritionally comparable to its dairy counterpart, without having the obligation to make statements to the contrary.

The FDA (Food and Drug Administration of the United States) has heeded the warnings about this problem, by publishing in 2023 a draft of a "Guidance for the labeling of plant-based milk alternatives and voluntary nutrient declarations for the food industry", where it is recommended that this type of beverages must comply with the condition of specifying that the nutritional content is different from cow´s milk to declare the word "milk" (for example: "Soy Milk") on its label (24).

Another regulatory body with a definition and specifications for this type of beverage is Australia and New Zealand, through the Food Standards Code (25), where it is specified by factors such as calcium content, protein, and type of vegetable source, as well as the quality and classification of plant-based dairy alternatives (26).

It is important to consider new emerging technologies in the manufacturing of plant-based milk alternatives, such as high-pressure processing, ultraviolet radiation, high-intensity ultrasound, and even, artificial intelligence (27), which can not only improve the nutritional quality of the product, but also expand its shelf life by improving its stability, according to Broker & Silva (2021) (28). Even though this analysis was not the aim of this study, it is considered necessary to be mentioned since the production process directly influences the overall quality of the product, and is information that is not often available to the public or mentioned in the label.

CONCLUSIONS

The results obtained in this study, supported by several similar studies around the world, allow us to conclude that some plant-based beverages available in the Colombian market today are not an adequate nutritional alternative to cow's milk, especially in terms of their content of macronutrients such as protein, sugars, and saturated fats and micronutrients such as calcium.

The comparative analysis using the Health Star Rating system of Australia and New Zealand made it possible to evaluate determinants of the nutritional profile of both vegetable drinks and whole and skimmed cow's milk. According to this classification, skimmed cow's milk was rated with the highest nutritional quality, with the highest possible score, and whole cow's milk got the second-best score, as well as the average of soy and cashew beverages. In third place were almond, oat, and vegetable-source combination beverages, followed by rice beverages, with the lowest score, the average of coconut beverages.

From this information, it was possible to identify some recommendations for nutrient fortification to the manufacturers of this type of beverages in the food industry, indicating that these also have health benefits, and an adequate fortification process in the critical nutrients would increase the nutritional value of the beverage, making it a valid nutritional alternative to cow's milk. Some of these recommendations are based on the bioavailability of nutrients, such as calcium, which requires a source with a sufficient absorption rate, or protein, which needs to be accompanied by a homogenization

process for a milky texture, and the combination of vegetable sources of protein to increase its digestibility.

The absence of national and international regulations generates a gap in compliance with standards that the category must meet to be considered a viable alternative. The issue is further aggravated by limited access to consistent and personalized guidance from health professionals.

With these considerations in mind, this study hopes to guide the consumer considering replacing cow's milk with vegetable drinks by highlighting critical determinants, including individual nutritional needs based on lifestyle or life stage, medical background, spending capacity, sensory preferences, and environmental impact, as determinants of purchasing decisions.

CONFLICT OF INTEREST

There are no conflicts of interest to report in the present study.

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Appendix A. Energy and nutrient values in 100 mL of vegetable beverages and milk available in the Colombian market, and their classification according to the HSR system.

Code	Energy (kj)	Saturated fat (g)	Total sugars (g)	Sodium (mg)	Fiber (g)	Protein (g)	Concentrated fruits & vegetables[1] (%)	FVNL[2] (%)	Health Star Rating
Whole milk, pasteurized[3]	230,12	1,90	3,40	42,00	-	3,20	-	-	****✧
Skimmed milk, pasteurized[4]	142,25	0,10	4,90	43,00	-	3,30	-	-	*****
Almond-based beverages									
AL0101	52,30	-	-	47,92	0,42	0,42	-	-	****
AL0102	139,47	-	5,00	70,83	-	0,42	-	-	****
AL0103	104,60	-	2,92	66,67	-	0,42	-	-	****
AL0104	174,33	-	7,08	91,67	0,41	0,42	-	-	***
AL0105	50,21	-	-	52,00	0,40	0,40	-	-	****
AL0206	79,50	0,40	0,20	46,00	-	0,50	-	-	****
AL0207	121,34	0,40	2,70	46,00	-	0,50	-	-	****
AL0208	167,36	0,50	5,00	10,00	-	-	-	-	****
AL0209	139,47	0,50	4,90	4,70	-	0,80	-	-	****
AL0310	121,34	-	3,20	45,00	-	-	-	-	****
AL0311	62,76	-	-	47,00	-	-	-	-	****
AL0512	104,60	-	2,92	50,00	0,47	0,83	-	-	****
AL0513	104,60	-	2,92	50,00	0,46	0,83	-	-	****
AL0614	43,51	-	-	8,33	-	-	-	-	****
AL0615	209,20	1,25	2,08	8,33	-	0,83	-	-	****
AL0616	226,63	1,25	2,92	8,33	-	0,83	-	-	***✧
AL0717	139,47	-	2,92	87,50	-	1,67	-	-	****✧
AL0718	62,76	-	-	105,00	-	1,50	-	-	***✧
AL0719	156,90	-	5,42	87,50	-	0,16	-	-	***✧
AL0820	100,42	0,20	-	40,00	0,40	0,70	-	-	****
AL0821	163,18	0,20	4,80	16,00	0,30	0,80	-	-	****
AL0822	100,42	0,20	0,10	10,00	0,40	0,70	-	-	****
AL1023	87,86	0,20	-	60,00	0,20	0,60	-	-	****
AL1124	104,60	-	2,00	105,00	-	0,50	-	-	***✧
AL1125	37,66	0,30	-	40,00	-	-	-	-	****
AL1126	104,60	-	6,00	85,00	1,00	1,00	-	-	***✧
AL1327	62,76	-	-	35,50	-	0,50	-	-	****

Code	Energy (kj)	Saturated fat (g)	Total sugars (g)	Sodium (mg)	Fiber (g)	Protein (g)	Concentrated fruits & vegetables[1] (%)	FVNL[2] (%)	Health Star Rating
AL1328	75,31	0,10	0,10	35,50	0,45	0,60	-	-	****
AL1429	43,58	-	-	41,67	1,25	0,41	-	-	****
AL1430	104,60	-	2,92	100,00	0,83	0,50	-	-	***✧
AL1531	121,75	0,21	3,33	62,50	0,83	0,42	-	-	****
AL1632	69,73	0,21	-	87,50	-	0,42	-	-	****
AL1633	156,90	0,83	3,75	91,67	1,25	0,83	-	-	***✧
AL1734	122,03	0,21	-	31,25	-	0,83	-	-	****
AL1935	104,60	0,50	3,00	57,50	0,50	-	-	-	****
AL1936	62,76	0,50	-	52,50	1,00	-	-	-	****
AL1937	133,89	-	4,40	42,00	0,40	1,20	-	-	****
AL2038	104,60	0,60	2,50	84,00	-	0,50	-	-	****
AL2139	104,60	-	2,92	100,00	0,83	-	-	-	***✧
AL2140	139,45	-	3,75	100,00	0,83	-	-	-	***✧
AL2141	43,51	-	-	41,60	1,25	0,41	-	-	****
AL2342	43,56	-	-	100,00	-	0,83	-	-	***✧
AL2343	121,75	-	2,91	87,50	1,25	0,41	-	-	****
AL2444	133,89	0,40	0,30	140,00	-	1,00	-	-	***✧
AL2645	230,12	0,50	6,00	50,00	1,50	0,50	-	-	***✧
AL2746	61,02	-	-	135,71	0,41	0,41	-	-	***✧
Coconut-based beverages									
CO0101	104,60	1,66	2,10	27,00	-	-	-	-	***✧
CO0102	78,45	1,46	-	4,17	0,42	-	-	-	***✧
CO0303	66,94	1,10	-	50,00	-	-	-	-	***✧
CO0604	104,60	1,88	1,25	39,58	1,25	-	-	-	***✧
CO0705	69,73	0,83	0,41	90,83	0,83	1,25	-	-	***✧
CO1106	79,50	2,00	-	50,00	-	0,20	-	-	***✧
CO1107	188,28	4,00	6,00	52,50	1,00	0,50	-	-	**
CO1108	83,68	4,00	-	42,50	-	0,50	-	-	**✧
CO1209	125,52	2,00	2,00	10,00	1,00	-	-	-	***✧
CO1210	41,84	2,00	-	50,00	1,00	-	-	-	***✧
CO1311	276,14	4,60	-	63,00	1,70	0,52	-	-	**
CO1612	122,03	1,04	-	16,67	1,67	0,21	-	-	***✧
CO1913	94,14	1,75	-	40,00	1,00	0,50	-	-	***✧
CO2414	138,49	2,50	0,50	40,00	0,20	0,20	-	-	***
CO2815	78,45	1,46	-	4,16	0,41	-	-	-	***✧
CO2816	122,01	1,66	2,92	4,16	0,41	-	-	-	***✧
CO2817	139,45	1,66	3,33	4,16	0,41	-	-	-	***✧
Vegetable source combination-based beverages.									
MX0401	117,15	0,82	1,10	93,00	-	1,70	-	-	****
MX0402	209,20	1,00	4,60	96,00	-	2,70	-	-	****
MX0803	242,67	0,30	5,00	20,00	0,70	1,80	-	-	****✧
MX0904	301,25	1,60	6,60	100,00	-	0,20	-	-	**✧

Code	Energy (kj)	Saturated fat (g)	Total sugars (g)	Sodium (mg)	Fiber (g)	Protein (g)	Concentrated fruits & vegetables[1] (%)	FVNL[2] (%)	Health Star Rating
MX1005	251,04	1,20	0,60	70,00	0,10	0,30	-	-	***✧
MX1406	188,28	1,00	3,00	7,50	3,50	0,50	-	-	****
MX1407	135,98	1,00	1,50	7,50	3,00	0,50	-	-	****
MX1608	174,33	1,04	-	8,33	2,08	0,42	-	-	***✧
MX2209	230,12	0,50	5,50	22,50	1,50	0,50	-	-	***✧
MX2510	104,60	0,50	3,00	40,00	-	-	-	-	****
MX2611	251,04	0,50	8,00	37,50	0,50	-	-	-	***✧
Soy-based beverages									
SO0101	156,90	0,21	-	31,25	0,83	3,33	-	-	*****
SO0102	191,77	0,21	2,08	47,92	0,83	3,33	-	-	*****
SO0103	156,90	0,21	2,92	33,30	0,41	2,50	-	-	****✧
SO0104	301,39	0,42	8,90	38,14	0,85	3,33	-	-	****✧
SO0305	184,10	-	2,50	87,00	-	3,10	-	-	****✧
SO0306	92,05	0,08	2,50	10,00	-	0,60	-	-	****
SO1807	188,28	-	3,50	80,00	-	2,50	-	-	****✧
SO1808	188,28	-	3,50	80,00	-	2,50	-	-	****✧
Oat-based beverages									
AV0102	209,20	0,21	2,92	45,83	-	-	-	-	****
AV0603	69,73	-	-	45,83	1,67	-	-	-	****
AV0904	284,51	-	8,00	80,00	-	0,90	-	-	***✧
AV0905	221,75	0,30	7,70	100,00	-	0,40	-	-	***
AV1006	192,46	0,10	5,40	30,00	0,60	1,40	-	-	***✧
AV1107	209,20	0,50	5,00	45,00	0,56	2,00	-	-	****✧
AV1308	117,15	-	1,82	280,00	0,70	0,90	-	-	**✧
AV2709	191,63	0,21	2,92	58,30	0,83	1,25	-	-	****
Rice-based beverages									
AR0901	255,22	0,20	8,50	100,00	-	0,20	-	-	***
AR0902	284,51	0,20	10,40	100,00	-	0,50	-	-	**✧
AR1003	217,57	0,10	4,00	70,00	0,10	0,30	-	-	****
Cashew-based beverages									
MA0501	139,45	0,41	1,25	50,00	0,35	3,75	-	-	*****
MA0502	69,45	0,63	-	12,50	-	0,41	-	-	****
MA1303	108,78	0,50	0,27	36,00	-	0,85	-	-	****

When a line appears, it means that the value found was 0.

[1]Concentrated fruits and vegetables: a value of 0.0% is taken because it is impossible to determine according to the information presented in the nutritional table or the ingredient list on the required labeling of the products.

[2]FVNL: "Fruits, vegetables, nuts and legumes", a value of 0.0% is taken because it is impossible to determine according to the information presented in the nutritional table or the ingredient list given in the required labeling of the products.

[3- 4 Whole] and skimmed milk, pasteurized. Data obtained from Table of Composition of Colombian Foodstuffs of the Colombian Institute of Family Welfare (ICBF 2018)