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Plant-based drinks for vegetarian or vegan toddlers: Nutritional evaluation of commercial products, and review of health benefits and potential concerns

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ABSTRACT

There is an increasing trend today towards plant-based diets in western society, often resulting in milk restriction. In the case of very young children, the direct substitution of milk by other foods, without proper nutritional advice, may lead to a lack of nutrients and hence to growth and development alterations. This study focuses on the nutritional assessment of various commercially available plant-based drinks, to determine their adequacy as alternatives to ruminant milk, in relation to the nutritional requirements of toddlers (1–3 years old), and to establish whether other sources of nutrient supplementation may be needed, as well as any other possible positive and /or negative health effects associated to their consumption. A sample of 179 commercial plant-based drinks (almond, coconut, hemp, oat, rice, soy, tigernut) were chosen and their nutrient contents were compared to the EFSA nutrient reference values for toddlers. The scientific literature on the presence of bioactive and/or undesirable compounds was reviewed.

None of the plant-based drinks studied should be considered as a milk substitute, since they are different food products with a different composition. However, from the results obtained, the best choice for toddlers who do not consume milk would be to consume at least 250 mL/day of fortified soy drink (for its higher amount and quality of protein, polyunsaturated fatty acids and phytosterols), and always in the context of a carefully-balanced diet. Almond, hemp or oat drinks are other alternatives that can be used in combination or for soy-allergic toddlers.

The key nutrients that should be fortified in plant-based drinks are: vitamins A and B_{12}, calcium, zinc and iodine, as they represent the most significant nutritional differences with milk; vitamin D would also be desirable. Of these, vitamins A, B_{12}, D and calcium, are easily found in many commercial plant-based drinks on the Spanish market (most frequently in soy drinks), unlike iodine and zinc, which were not added to any. Given the fish restriction in vegetarians/vegans and the fact that plant-based drinks provide high amounts of phytates and tannins, which act as antinutrients, a good strategy for the industry would be to fortify plant-based drinks with iodine and zinc to improve the nutritional value of products aimed to vegetarians/vegans.

1. Introduction

Among all the available food options for infants, prolonged breastfeeding is the best choice during the first 1–2 years of life, or even longer (World Health Organization, 2021). During this period a decision may be made to use infant or follow-on formulas, where cow milk and, more recently, goat milk are used as the main protein source (Prosser, 2021; Salazar Quero et al., 2018). During the second year of life food choices start to be more similar to the general population, depending on the habits and preferences of each family. At this time milk and dairy products continue to be basic children's diets, and provide high-value proteins, vitamins, minerals and fats. Two to three servings/day of milk or dairy products are therefore recommended in the food-based dietary guidelines in Spain and other countries (Martínez et al., 2020; Martínez Rubio, 2020).). Most populations opt for ruminant milk (cow, goat or sheep) due to its availability and/or tradition; sources of milk

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such as camel or buffalo milk may be used in other countries.

The concept of vegetarianism/veganism began to spread in various countries in the mid 20th century as a part of a trend to develop and use of animal-free food alternatives for the benefit of animals, humans, and the environment. Vegetarian and vegan culture is mainly driven by cultural ethical, religious, or environmental reasons are the main reasons that move vegetarian and vegan culture (Allès et al., 2017). A vegetarian/vegan diet is based on plant foods, such as fruits, vegetables, nuts, seeds, whole grains and legumes and their derivatives, and excludes the consumption of all types of meat, fish and molluscs or crustaceans. Dairy products, eggs, and honey may be consumed, so that there are several types of vegetarian diets (Agnoli et al., 2017; Baldassarre et al., 2020). Several studies show that vegan and vegetarian populations have increased in recent years. In Europe, it is estimated that between 1 % and 10 % of population follow this type of diet (Baroni et al., 2018), although there are no current data to accurately quantify the number of vegans. In Spain, data from 2011 estimated the number of vegetarians at about 700,000, with a growing number of children born into a vegan family environment (Rosenfeld & Burrow, 2017).

There are several studies on the suitability of vegetarian and vegan diets for health at different stages of life. Some of the results highlight the impact of a vegetarian vegan diet on general health, especially for avoiding or reducing the risk of overweight and obesity, type 2 diabetes, cardiovascular diseases, and certain types of cancer, in addition to improving body mass index (BMI) and hip circumference (Jakse et al., 2019; Miles et al., 2019; Pawlak, 2017; Salvador et al., 2019; Weder et al., 2019). However, these studies sometimes present contradictory results; the differences may be due to the design of the study, especially the population group considered for comparisons, as well as the different models of plant-based or vegan diets.

The Spanish Paediatric Association has confirmed the suitability of plant-based diets for children, although stating that highly restrictive diets require an additional effort to ensure an adequate dietary strategy (Redecilla et al., 2020). Thus, although it is advisable for infants and young children to follow an omnivorous or at least an ovo-lacto-vegetarian diet, it has also been maintained that children following vegetarian diets, may grow and develop normally, provided these diets are well balanced. However, other studies report that there is insufficient evidence to confirm that even with a well-balanced plant-based diet, the growth and/or development of vegetarian and vegan children will not be compromised as there is a lack of data from longitudinal studies that evaluate the nutritional adequacy of these diets on the health of infants, children and adolescents, and particularly the medium and long-term impact of this type of diet on health (Agnoli et al., 2017; Jakse et al., 2019; Kiely, 2021; Miles et al., 2019; Pawlak, 2017; Peretti et al., 2020; Redecilla Ferreiro, Moráis López, & Moreno Villares, 2020; Richter et al., 2016; Salvador, García-Maldonado, Gallego-Narbón, Zapatera, & Vaquero, 2019; Schürmann, Kersting, & Alexy, 2017; Weder, Hoffmann, Becker, Alexy, & Keller, 2019; Sutter and Bender, 2021).

When assessing the adequacy of a particular type of diet, another point to bear in mind is that food restriction is usually accompanied by the substitution with other foods. Milk restriction may be a choice of vegetarians/vegans, but it is also a necessity for people suffering cow milk protein allergy (CMPA) or lactose intolerance. Food-mediated allergic reactions are a growing health problem, especially in children, and require the total avoidance of the allergenic agent. Cow milk proteins are a major allergen in early life, with an estimated prevalence of CMPA in developed countries of up to 3 % at age of one year (Flom & Sicherer, 2019; Seth et al., 2020). Lactose malabsorption/intolerance may be of different types (Ugidos-Rodríguez, Matallana-González & Sánchez-Mata, 2018): those affecting children may be congenital lactase deficiency (a rare genetic condition), developmental lactase deficiency (as a result of premature birth at 28–32 weeks, before lactase production in the gut), or primary hypolactasia (the most frequent type, normally appearing at the age of about 5–7 with the maximum impact in adulthood, and widely variable prevalence depending on the geographic region, from 5 % in Northern Europe to 90 % in Asian countries). All these situations require the exclusion of ruminant milk from the diet (either partially in some lactose intolerant people or totally in the cases of milk allergy). The alternatives are often plant-based beverages, with a similar appearance and uses to milk and a wide variety of products in the market. These plant-based drinks cannot be called milk, as this term is restricted to the product of mammary glands, although the EU allows certain exceptions where the term "milk" refers to this type of products in response to traditional uses. This is the case of "almond milk" in Spain or "coconut milk" in Italy, among others (European Union, 2010).

Previous studies analysing the nutritional composition of various plant-based drinks have demonstrated that these options would in no case replace milk, although they may serve as possible alternatives in the case of dietary milk restriction. This is a nutritional challenge, and nutritional intervention should be considered in order to ensure adequate energy and nutrient contributions to safeguard patient health, especially in children at critical stages of growth and development (Clegg et al., 2021; Mennini et al., 2020; Paul et al., 2020; Protudjer & Mikkelsen, 2020; Schiano et al., 2020; Singhal et al., 2017; Vitoria, 2017; Wright & Smith 2020). Although concern focuses on the nutrients that are supplied in significant proportions by ruminant milk, attention should also be paid to the child's overall diet, since -for example- lactose intolerance or milk protein allergy entails merely restricting milk and dairy products, whereas for a vegetarian/vegan child other animal products are also restricted, and thus other alternative sources of nutrients of animal origin are unavailable. In other cases, toddlers may still be breastfed (as reccommended by public health programmes advising prolonged breastfeeding), so in these cases, the risk of deficiencies is lower due to the nutrients supplied by human milk. For all these reasons, the choice of foods for vegetarian/vegan toddlers should be specifically and carefully planned to avoid nutrient deficiencies, with a particular emphasis on proteins, since milk is a major source of proteins of high nutritional quality, and micronutrients. Besides, proteins, essential micronutrients include vitamin A, as the provitamin A provided by plants has a lower efficiency of bioconversion to retinol (Soares et al., 2019); vitamins B_{12} and D, which are absent from plant-based foods (Bailey et al., 2018; Gallego-Narbon et al., 2019 Hovinen et al., 2021; Rudloff et al., 2019); and iodine, which plays an important role in growth and development in the first three years of life, and whose main sources in the diet are sea foods and dairy products (Yeliosof & Silverman, 2018). Other important minerals are calcium (crucial during the development of bone mass, in early life) and zinc (a structural component of many proteins and involved in several important functions in the human body such as metabolism and immune functions). Both are present in seeds and other plant foods, but with lower bioavailability due to the chemical forms present and the possibility of binding to some antinutritional compounds such as phytic acid or tannins in foods of plant origin (Faster et al., 2013; Heaney et al., 2000; Weaver et al., 1999). Ruminant milk significantly contributes to the dietary intake of these nutrients, and thus its replacement in the diet of vegan toddlers should be accompanied by their substitution with alternative food sources or by nutrient supplementation to avoid deficiencies in vulnerable people (Menal-Puey, Martinez-Biarge & Marques-López, 2019).

To assess the suitability of plant-based drinks as milk alternatives, require accurate knowledge of their nutritional composition. However, Food Composition Databases (FCDs) present a wide variability in the composition data for different plant-based drinks. This has been corroborated in a search carried out in eight national and international FCDs: Moreiras Tuni et al., 2018 (Spain); AUSNUT, 2011-2013; Canadian Nutrient Archive, 2015; McCance and Widdowson, 2015 (UK); BEDCA, 2022 (Spain); USDA, 2022; FAO/INFOODS, 2022. Heterogeneity of data is due to the fact that they do not always specify whether they come from fortified or unfortified drinks, the amount of the main ingredient, the presence of added sugar, and other factors affecting the final composition of the product. In other cases, the information is scarce (e.g. hemp drink) or refers to products that may not be equivalent (e.g. some values described for “coconut drink” refer to the canned product, which is sometimes different from the commercial products labelled as “ coconut drink”).

With this background, the main aim of this study is to assess the nutritional composition of various commercial plant-based drinks (in the way they are marketed) to determine their adequacy as alternatives to ruminant milk, in terms of the nutritional requirements of toddlers (1–3 years old), and to establish whether other sources of nutrient supplementation may be needed, in addition to other possible positive and /or negative health effects associated to their consumption.

2. Material and methods

A descriptive study was carried out in order to evaluate the composition of various plant-based beverages. Seven types of drinks prepared from different plant foods were chosen: almond (seeds), coconut (seeds), hemp (seeds), oat (grains), rice (grains), soy (seeds) and tigernut (tubers). They were surveyed in different supermarkets and specialized stores in Spain, as well as websites. Tigernut drinks were included because although plant-based drinks are relatively new products for the Spanish population, tigernut drinks (traditionally called “*horchata*”) enjoy a centuries-old tradition in Spain, and so could be an option for people interested in promoting traditional autochthonous products.

A total sample of 179 commercial plant-based drinks was obtained, coded according to the type of drink and brand, with special attention to their nutrition facts and claims. The claims searched were: presence or absence of sugar, light/lite, fortified with nutrients and certified "organic". Information on ingredients and nutritional composition was compiled from labelling. Flavoured drinks and/or mixed drinks were considered for this study because the added ingredients may alter their basic composition.

The European Food Safety Authority (EFSA) Nutrient Reference Values (NRVs) for children between 1 and 3 years old were considered (EFSA, 2017) as scientific support for the need to adapt and ensure the intake of nutrients in this type of diet. In addition to nutritional values, an in-depth review was made of the presence of other bioactive compounds with proven health benefits in the selected plant-based drinks, and the possible presence of undesirable compounds (antinutrients, allergens and/or potentially toxic compounds, either naturally occurring or as contaminants).

The IBM SPSS® version 21 program was used for the statistical analysis of the variables. A descriptive analysis was carried out for the different samples. The data were expressed in number of cases, percentages and frequencies.

3. Results and discussion

3.1. *Study of commercial plant-based drinks and their nutrient contribution to diet.*

Fig. 1 shows the distribution of the sample according to the type of drink, with oat, soybean and almond drinks being the most frequent (26.8 %, 24.6 %, 23.5 %, respectively). The information on the amount of the main ingredient is highly significant, as its percentage will determine the nutritional composition of the product. As can be seen in Fig. 2, most drinks (37.4 %) had 10–15 % of the main ingredient, followed by another group (25.1 %) containing 5–10 %. The most repeated value for the amount of the main ingredient was 14 %. It is important to note that in the highest interval, many cereal drinks (rice and oat) and some soy drinks were significant for having the highest percentage of the main ingredient (15.3 % average), and as much as 20 % in a few samples of rice drink. In contrast, the lowest interval (0–5 %) contains mostly almond beverages, which, together with hemp drinks, presented the lowest values of the main ingredient (3.7 and 3 %, average, respectively). Thus, in terms of the amount of the main ingredient, oat and rice beverages can be considered as being more adequate in providing a higher amount of material from these seeds.

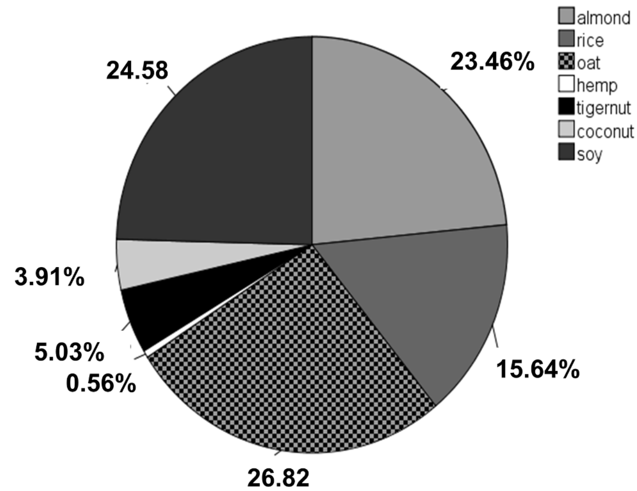

Fig. 1. Distribution of the studied drinks according to the type of the main ingredient.

A claim related to organic certification was observed in 54.2 % of the beverages studied (n = 97). This declaration is voluntary for the food industry and identifies products whose ingredients are organically produced (European Union, 2007).

For the discussion of the results for nutritional value, the tables have been organised as follows. Table 1 shows the nutritional composition of each type of commercial plant-based drink, compared to ruminant milk (cow and goat milk). Based on these data, and in order to evaluate the possible nutritional deficiencies associated with the substitution of cow milk by these types of beverages, the nutrients for which cow milk can be considered as a source in the human diet (based on European Union Regulations 1924/2006 and 1169/2011) were selected and compared with the amounts of nutrients supplied by plant-based beverages. These nutrients were: proteins, vitamins A and $B_{12,}$ calcium, iodine and zinc. These selected vitamins and minerals are shown in Table 2 together with other nutrients of interest (vitamin D, iron and Na/salt), and their contents are expressed as the percentage of DRVs covered with an amount of 250 mL of the plant-based beverages in this study. The amount of 250 mL milk /beverage was selected, as it corresponds to a standard cup or glass (Moreiras Tuni et al., 2018), and also according to the recommendations of several organisms, such as World Health Organization (2008), related to milk intake in complementary feeding and during childhood. Table 3 presents information on the claims in the labelling of the drinks relating to the presence/absence of added salt and sugars (according to European Union Regulation 1924/2006) and fortification with various nutrients, which are detailed in Table 4. Finally, Table 5 shows the different ingredients used for calcium fortification in the plant-based drinks analysed.

3.1.1. *Energy and proximal composition of commercial plant-based drinks*

Cow and goat milk provide an energy value of 157–194 kcal per 250 mL serving. Plant-based drinks had a lower energy value than ruminant milk, except for tigernut drink, which had a similar value. Six commercial soy drink samples presented the nutritional claim of being “light”; however, soy drink is not necessarily more energetic than other drinks; the explanation for this may be because these drinks are more widespread than the others, and consumers may demand low energy products.

The higher energy value of tigernut drinks is due to the frequent addition of sugars; as it can be seen in Table 1, tigernut drinks have an average content of up to 26.4 g of total carbohydrates/250 mL, of which

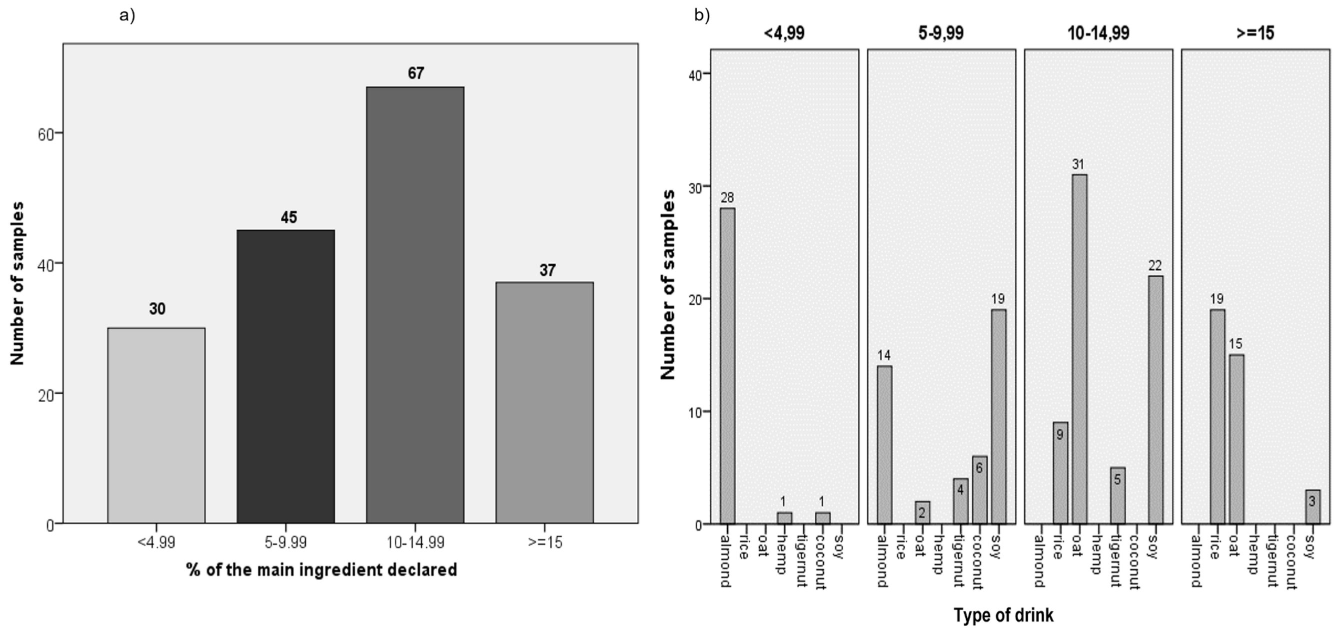

Fig. 2. Distribution of the studied drinks according to the percentage of the main ingredient declared on the label (a = Global distribution; b = Distribution of the different types of beverages grouped by percentage of main ingredient).

-according to the labelling- 20.9 g corresponds to sugars (although the amount of added sugar is not shown on the label, so this content would include the naturally occurring and the added sugars).

Compared to other beverages, tubers (tigernut) and cereals (rice and oat) drinks had a higher carbohydrates content (all with an average content of 18–26 %), as expected, mainly due to the greater presence of starch as a reserve compound in grains and tubers. However although carbohydrates are naturally high in these products, as it can be seen in Table 3, only 4–7 % of oat and rice drinks (respectively) presented added sugars (78–83 % with claims of about added sugars), whereas the opposite occurs for the tigernut drinks: 89 % listed added sugars in the ingredients list, and only 1 of 9 claimed to have no added sugars.

Other plant-based drinks may also have added sugars for sensorial reasons. Soy and almond drinks frequently had added sugars, (57 and 43 % of the samples, respectively), with high variability in the final amount declared (0–9 g/100 g). It should be noted that a declaration of a value of 0 in the labelling does not necessarily mean total absence, but close to 0; in the case of almond drinks, this is due to the low amount of almond seed sometimes used to prepared the drink (sometimes less than 5 % as mentioned above).

From the whole sample studied, 59 % of the commercial drinks claimed to have low sugar content (“sugar-free”, “no added sugar”, “zero sugars”), while 73 of 179 beverages made no claims relating to sugar (Table 3). Of these, 56 samples listed sugar in their ingredient list (31 %), while 17 samples (9 %) had no added sugar and made no sugar-related claim. Only two samples included sweeteners other than sugar in their composition.

According to World Health Organization (2015), the free sugar intake in the diet should not exceed 10 % of the total energy intake. Also Fidler Mis et al. (2017) recommended a maximum intake of 15–16 g of free sugar/day recommended for 2–4 year old children. A serving of 250 mL of many commercial tigernut drinks and some rice and oat drinks would surpass this level. For that reason, plant-based drinks with added sugars should not therefore be recommended as a staple food; although they can sporadically be consumed within the context of a balanced diet; similarly to tigernut drink traditionally consumed in Spain as an occasional sweet cold refreshment.

The total amount of dietary fibre is improved in plant-based drinks *vs*. ruminant milk. All the plant-based drinks studied provide average values between 0.9 g fibre in rice drink samples and 1.5 g fibre in oat drinks, per 250 mL serving (Table 1); oat drinks had the maximum values as expected. These contents would contribute to fibre intake in toddlers, although it should be taken into account that plant-based diets already provide high amounts of fibre, and thus the fibre content of plant drinks is not essential (Kahleova, Levin and Barnard, 2017; Miles et al., 2019; Müller, 2020; Redecilla Ferreiro, Moráis López & Moreno Villares 2020).

As expected, the fat content is lower in the plant-based drinks (2.0–7.2 g/250 mL serving) than in ruminant milk which may present values from 8.5 to 12.0 g/250 mL serving (see Table 1). The various drinks responded to the profile to be expected from their composition, so coconut milk presented about 90 % saturated from total fatty acids (4.4 g/250 mL) compared to other plant-based drinks, close to ruminant milk; while almond milk had a high percentage of monounsaturated fatty acids (3.4 g/250 mL, being about 76 % of total fatty acids), and soybean drink were notable with almost 60 % of polyunsaturated fatty acids (2.6 g/250 mL). Many of these fatty acids may have interesting functional properties, as discussed in subsection 3.1.1.

Hemp drinks had a higher fat content compared to the other plant-based drinks, due to the high presence of fat in these seeds and to the addition of hemp oil. In this study it was observed that sunflower oil was added to 53 of 179 beverages: rice (n = 25 of 28; 89.3%), oat (n = 24 of 48; 50.0%) and almonds (n = 4 of 42; 9.5%). In view of this, the use of olive oil, golden flax or canola oil could improve the fatty acid profile of these beverages. Oil addition, as well as other ingredients may modify the palatability of these products. A variety of different oils can be added to plant-based beverages (coconut, corn, flaxseed, olive, palm, soybean, sunflower or other edible oils) in order to be dispersed in the water phase to form a low viscosity emulsion with some of the sensory attributes of bovine milk, providing thicker mouth feeling (Scholz-Ahrens et al., 2020; McClements, Newman, & McClements, 2019). Regarding the addition of oils in plant-based beverages, supplementation with EPA + DHA, as indicated by EFSA (2017) would also be a good strategy for vegan/vegetarian toddlers since they are often excluding fish which are major dietary sources of these fatty acids with very important functions in early development; some other dietary sources such as seaweeds may be used as sources of these fatty acids for supplementation of these drinks of other food products.

Table 1

Values of energy and nutrients (average ± standard deviation) in 250 mL (equivalent to one serving) of the drinks studied, including both fortified and non-fortified drinks.

Type of drink	Energy (Kcal)	Carbohydrates (g)	Sugars (g)	Fibre (g)	Total Fat (g)	Saturated Fatty Acids (g)	Monounsaturated Fatty Acids (g)	Polyunsaturated Fatty Acids (g)	Proteins (g)	Vitamin A *(μg)	Vitamin D* (μg)	Vitamin B12* (μg)	Calcium * (mg)	Iron* (mg)	Sodium * (mg)	Iodine * (μg)	Zinc* (mg)
Almond	73	5.47	4.02	1.16	4.45	0.55	3.39	1.35	1.97	300	2.00	0.84	273	5.25	114.3	–	–
(n = 42)	±30	±5.90	±5.68	±0.69	±1.32	±0.26	±0.69	±0.51	±1.06	±101	±1.06	±0.35	±145		±46.1		
Coconut	71	4.19	1.14	1.25	4.86	4.38	–	–	0.53	–	1.88	0.95	280	–	85.6	–	–
(n==7)	±38	±2.98	±1.73		±1.85	±1.76			±0.46				±27		±22.3		
Hemp (n = 1)	100	5.50	0.75	1.30	7.25	0.75	–	–	2.50	–	–	–	–	–	40.0	–	–
Oat	117	19.78	11.79	1.54	2.55	0.51	0.87	1.12	2.33	225	2.27	0.95	288	–	90.2	–	–
(n = 48)	±13.3	±4.01	±4.53	±0.96	±0.81	±0.29	±0.40	±0.54	±0.85	±48	±1.17	±0.19	±148		±66.6		
Rice	135	26.50	14.59	0.89	2.66	0.37	0.76	1.40	0.82	–	1.88	0.96	283	–	85.6	–	–
(n = 28)	±19	±5.54	±4.36	±0.86	±0.72	±0.22	±0.30	±0.55	±0.55		±0.83	±0.34	147		±14.8		
Soy	101	6.39	4.77	1.16	4.40	0.81	0.96	2.58	7.83	300	1.88	0.99	300	–	90.7	–	–
(n = 44)	±21	±4.33	±3.61	±0.49	±1.46	±0.28	±0.44	±1.18	±1.72	±125	±0.89	±0.040	±150		±41.4		
Tigernut	161	26.43	20.89	1.21	5.94	1.64	–	–	1.42	–	–	–	–	–	108.2	–	–
(n = 9)	±43	±11.83	±9.97	±0.58	±0.66	±0.45			±0.17						±61.7		
Cow milk **	160	12.08	12.08	–	9.00	5.30	2.51	0.28	8.22	106	0.13	0.99	303	0.24	119.2	25.2	1.09
	±2.5	±0.58	±0.58		±0.50	±0.44	±0.22	±0.05	±0.55	±0.17	±0.10	±0.42	±	±0.01	±6.29	±3.9	±0.43
Goat milk **	179.17	11.5	11.50	–	10.75	6.92	2.84	0.4	8.92	98.33	0.18	0.2	324.1	0.27	116.7	10.0	1.07
	±24	±0.66	±0.66		±2.18	+0.99	±0.71	±0.33	±0.72	±2.89	±0.06	±0.00	±64	±0.03	±19.1	±14.1	±0.16

When standard deviation does not appear, means that only one value was found; when a line appears, means that any value was found in the labelling for this parameter.

[*] Values only for drinks claiming fortification (non-fortified drinks are not obliged to present vitamins and minerals content in labeling).

[**] Whole cow and goat milk, non-fortified. Data obtained from Moreiras Tuni et al. (2018), BEDCA (2022),FAO/INFOODS (2022).

Table 2
Percentage of reference values covered with a portion of 250 mL of the studied commercial plant-based drinks, compared to ruminant milk, using minimum and maximum values composition data declared in the label.

Nutrient	DRV**	Ruminant milk*		Almond Drink		Coconut Drink		Hemp Drink		Oat Drink		Rice Drink		Soy Drink		Tigernut Drink	
		Cow	Goat	F	NF	F	NF	F	NF	F	NF	F	NF	F	NF	F	NF
Proteins	**12 g**†	63.7–72.9	70.8–81.2	7.5–22.9	10.4–33.3	0 – 4.2	4.2–10.4	–	20.8	4.2–20.2	3.5–20.2	20.8	2.1–10.4	35.9–104.2	29.2–81.2	18.2	10.41–14.58
Vitamin A (RE)	**250 µg**	38.4–46.0	38.0–40.0	80–120	12	–	–	–	–	120	–	–	–	120 -	–	–	
Vitamin D	**15 µg**	0.5–1.7	1–1.6	6.3–33.3	–	12.5	–	–	–	6.3–12.7	–	12.5–12.6	–	12.5–12.7	–	6.3	–
Vitamin B_{12}	**1.5 µg**	50,0–98.7	16.6	50.6–66.7	–	63.3	–	–	–	63.3	–	63.3–66.7	–	58.3–70.9	–	–	–
Calcium	**450 mg**	66.1–68.9	61.1–88.3	33.3–88.9		55.5–66.7		–	–	33.3–66.7		33.3–66.7	–	33.3–88.9	66.67	–	–
Iodine	**90 µg**	25–31.1	22.2	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Zinc	**4.3 mg**	17.4–36.3	22.1–29.1	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Iron	**7 mg**	8.0–8.9	8.9–10.7	75.0	–	–	–	–	–	–	–	–	–	–	–	–	–
Sodium	**less than2g**††	5.6–6.2	5.0–6.9	0.4–15	2–6	5	0.5–20	3–6	0.5–10	1.6–12.6							

F: fortified in the expressed nutrient; NF = non-fortified in the expressed nutrient; RE = retinol equivalents; when a line appears, means that any value was found in the labelling for this parameter.
* Whole cow and goat milk, non-fortified. Data obtained from Moreiras Tuni et al. (2018), BEDCA (2022),FAO/INFOODS (2022).
** Population Reference Intake (PRIs) for proteins, vitamin A, Ca and Zn; Adequate Intakes (AIs) for vitamins D, B12 and iodine; all of them per day(EFSA, 2017).
† Obtained by applying the average protein intake recommended by EFSA for this age range, and considering the mean weight (average 11.7Kg) for 1–3 year, boys and girls, p50 (WHO data in: https://www.who.int/toolkits/child-growth-standards/standards/weight-for-length-height) and.
†† Daily Maximum level according to WHO recommendations. None of the plant-based drinks studied presented salt fortification, but salt may be used as an ingredient in technological process.,

Table 3
Presence of information related to sugars, salt or nutrient fortification in labelling of studied plant-based drinks, expressed as frequency (Percentage).

Type of drink	Claims related to sugar content(“Zero sugars” / “No added sugars”)	Added sugars in the ingredient list	Added salt in the ingredient list	Claims regarding any nutrient fortification
Almond (n = 42)	22 (52.4 %)	18 (42.9 %)	31 (73.8 %)	19 (45.2 %)
Coconut (n = 7)	6 (85 %)	1 (14.3 %)	7 (100 %)	4 (57.1 %)
Hemp (n = 1)	1 (100 %)	0	0	0
Oat (n = 48)	40 (83.3 %)	2 (4.2 %)	25 (52.1 %)	22 (45.8 %)
Rice (n = 28)	22 (78.6 %)	2 (7.1 %)	24 (85.7 %)	12 (42.9 %)
Soy (n = 44)	14 (31.8 %)	25 (56.8 %)	28 (63.6 %)	29 (65.9 %)
Tigernut (n = 9)	1 (11.1 %)	8 (88.9 %)	1 (11.1 %)	0
Total	106 (59.2 %)	56 (31.3 %)	116 (64.8 %)	86 (48.0 %)

Table 4
Fortification with proteins, vitamin A, D and B12, calcium and iron, in the studied plant-based drinks, expressed as frequency (percentage).

Type of drink	Proteins	Vitamin A	Vitamin D	Vitamin B_{12}	Calcium	Iron
Almond (n = 42)	2 (4.8 %)	6 (14.3 %)	10 (23.8 %)	8 (19.0 %)	19 (45.2 %)	1 (2.4%)
Coconut (n = 7)	0	0	1 (14.3 %)	1 (14.3 %)	4 (57.1 %)	0
Hemp (n = 1)	0	0	0	0	0	0
Oat (n = 48)	1 (2.1 %)	2 (4.2 %)	10 (20.8 %)	2 (4.2 %)	26 (54.2 %)	0
Rice (n = 28)	0	0	7 (25.0 %)	3 (10.7 %)	12 (42.9 %)	0
Soy (n = 44)	0	10 (22.7 %)	15 (34.1 %)	9 (20.4 %)	28 (63.6 %)	0
Tigernut (n = 9)	2 (22.2 %)	0	1 (11.1 %)	0	0	0
Total	5 (2.8 %)	18 (10.0 %)	44 (24.6 %)	23 (12.8 %)	89 (49.7 %)	1 (0.5 %)

Table 5
Distribution of samples in terms of ingredients used for calcium fortification.

Type of drink	Type of fortificacion	Frequency	Percentage
Almond (n = 42)	Calcium salts	13	31.0
	Seaweeds	6	14.3
	Total fortified samples	19	45.2
Coconut (n = 7)	Calcium salts	1	14.3
	Seaweeds	2	28.6
	Calcium salts + seaweeds	1	14.3
	Total fortified samples	4	57.1
Oat (n = 48)	Calcium salts	10	20.8
	Seaweeds	11	22.9
	Total fortified samples	21	43.8
Rice (n = 28)	Calcium salts	7	25.0
	Seaweeds	5	17.9
	Total fortified samples	12	42.9
Soy (n = 44)	Calcium salts	21	47.7
	Seaweeds	7	15.9
	Calcium salts + seaweeds	1	2.3
	Total fortified samples	29	65.9

Hemp drink does not appear in the table, because the sample found was not calcium fortified.

Besides the modification of the lipid fraction, other technological strategies, such as fermentation, can contribute to greater palatability (Tangyu et al., 2019). Although this study does not include drinks with added flavourings, they may be useful in the transition process of introducing these products into the diet. Likewise, the use of plant-based drinks made from a combination of two or more base materials can contribute to a better sensorial experience.

The drinks with the closest protein content to the ruminant milk (7.7–8.5 g/250 mL) were soy drink (7.83 g/250 mL on average). As can be seen in Table 2, commercial soy drinks usually provide better coverage of proteins DRVs for toddlers (29.2–81.2%), followed by hemp (20.8 %), oat (4.1–20.2 %) and almond (7.5–35.8 %) respectively. In comparison, ruminant milk supplies over 63 %, only exceeded by some soy drink samples with very high amounts of plant material (more than 15 %), probably formulated to provide 100 % of protein DRVs.

These values should not only be interpreted quantitatively, but also in terms of protein quality. In this aspect, it should be noted that almond, coconut and rice have lower levels of total essential aminoacids than cow milk (about 40 % or less), with the lowest amount corresponding to methionine, lysine and tryptophan. Soy protein is considered to be one of the best plant protein sources. It provides about 11 % fewer essential aminoacids than cow milk, and a proportion of essential aminoacids closer to cow milk in terms of Digestible Indispensable Aminoacid Scores (DIAAS), although methionine is a limiting aminoacid (Sousa & Kopf-Boland, 2017). Studies on hemp protein have shown that with the exception of lysine and sulphur-containing aminoacids, other essential aminoacids are found in suitable levels. They present values similar to pulses in terms of Protein Digestibility-Corrected Amino Acid Scores (PDCAAS), being of about 50 % of casein as reference protein (100 %); this value was 92 % for soy protein and 23 % for almond protein (Gorissen et al., 2018; House et al., 2010; Wang et al., 2008). However, it should be noted that most of these studies focus on the quality of the whole protein in the plant material, while in plant-based drinks not all the protein in the plan matrix is likely to remain in the final filtered product, so the proportion of essential aminoacids will differ from the raw material.

The low lysine or methionine content of some of these proteins can be offset by ingesting 2–4 times more protein and combining different protein sources such as hemp or rice (low in lysine) with soy or pea (low in methionine) in a 50/50 ratio, resulting in a better amino acid composition (Gorissen et al., 2018; House et al., 2010). It was also observed that 2.8 % of the commercial plant-based drinks surveyed (namely samples of tigernut, almond and oat drinks) declared the addition of plant protein. Thus, supplementation with leguminous plant proteins (soy and/or pea) has been reported as a useful strategy to improve the protein profile of beverages such as coconut, almond, oat or rice (Lu et al., 2020).

3.1.2. Vitamins in commercial plant-based drinks

A vegan/vegetarian diet may be adequate in many nutritional aspects, but vitamin B_{12} deficiency (Aguirre et al., 2019; Gallego-Narbón et al., 2019), may occur, especially in vegan diets. Therefore, when substituting ruminant milk with plant-based beverages, particularly in children, this nutrient should supplemented either by fortifying the beverage or by taking a separate dietary supplement. Vitamins D and B_{12} are not naturally present in plants (although vitamin D can be partially obtained through exposure to UV light), and vitamin A activity may be present as provitamin A carotenoids, with less activity than retinol, so their supplementation should also be considered.

As it can be seen in Table 3, the “fortification” claim was present on the labelling of 86 drinks (48%), and Table 4 shows that the main fortifying substances added were: proteins, vitamins A, D, B_{12}, and calcium. Soy and oat drinks were more frequently fortified than other drinks (61 and 50 %, respectively), as they are probably the most widespread varieties. According to European Union Regulations 1924/2006 and 1169/2011, the fortification claim is not mandatory foods; however, if any such claim appears (including the term “source of” or “high amount in”), it is mandatory to display the vitamin and mineral amounts in the nutrition information on the label. In this context, Table 1 shows the vitamin A, B_{12} and D content of commercial plant-based drinks that claim to be fortified with these nutrients, since the content of these vitamins was not declared in the nutrition facts for the other samples.

Vitamins in commercial hemp and tigernut drinks were not fortified nor declared (Tables 2 and 4). For other samples, vitamin A content was only mentioned in fortified almond, oat and soy drinks, providing more than 80 % of DRVs for vitamin A (Table 2). Vitamin D was provided at a maximum level of 33 % of DRVs in fortified almond drinks, and in amounts of 6.3–12 % DRV in fortified coconut, oat, rice and soy drinks. Vitamin B_{12} was present at over 50 % DRVs in fortified almond, coconut, oat and rice drinks, and up to 70 % in soy drink. The values of these vitamins in these fortified plant-based beverages were often higher than those present in non-fortified ruminant milk, especially in the case of vitamin D. Given than the diets of vegetarian/vegan toddlers usually exclude animal foods that are rich sources of both vitamins, supplementation in either the drinks consumed or as specific food supplements would be highly recommended. As shown in Table 4, vitamin D has the highest frequency of fortification in commercial plant-based drinks (24.6 %), while only 12.8 % of the products studied were enriched with vitamin B_{12}, and 10 % with vitamin A (less necessary than others, since plant products may provide provitamin A). Soy drinks are notable for presenting the highest frequency of fortification with these three vitamins.

3.1.3. Calcium in commercial plant-based drinks

Calcium bioavailability depends on several factors, such as individual conditions, the form in which it is present in the food, and the presence of components that enhance or decreasing its absorption. Ruminant milk has a high content of calcium that is highly bioavailable under the conditions in the gastrointestinal tract, among other reasons, due to the adequate ratio calcium/phosphorus, close to one; in plant foods, phytates and oxalates forms complexes with calcium, that are not solubilized and ionized even at the low pH encountered during gastric transit, and this fact limits calcium absorption (Shkembi & Huppertz, 2021).

Some of the raw plant materials used to produce the drinks in this study are rich in calcium, such as for example, almonds (BEDCA, 2022); however, in the final drink these levels will depend on the proportions of the ingredient used and the production process. Non-fortified drinks did not indicate the amount of calcium, since it is not mandatory; in fortified almond, coconut, oat, rice or soy drinks, the amount of calcium added, represented between 33 and 88 % of DRVs per 250 mL serving, while ruminant milk would cover about 60–88 % (Table 2). In hemp and tigernut beverages, neither the content nor the fortification with this mineral was declared.

Other studies on calcium content in plant-based drinks, such as that of Alozie and Udofia (2015) found lower values of calcium in almond drink (32.8 mg/250 mL), but higher that in other plant-based beverages such as soy drinks (9.8 mg/250 mL). Moraleja García-Saavedra (2017) also reported higher calcium content in almond drinks (500 mg/250 mL), compared to oat or rice drinks (300 mg/250 mL). Chalupa-Krebzdack et al. (2018) reported calcium content of 100–473.7 mg/250 mL in almond drink, in agreement with Siqueira Silva et al. (2020) who found 370.5 mg/250 mL, and 282 mg/250 mL in soy drink. These high values exceed those expected from the natural calcium present in the plant material, taking into account the usual proportions of the main ingredient as indicated in FCDs (BEDCA, 2022), coming from fortification of the drinks to approach levels of cow milk (300–325 mg/250 mL). This agrees with Astolfi et al. (2020), who studied mineral content in different plant beverages and concluded than Calcium content in fortified soy drink is about 300 mg/250 mL, much higher than in non-fortified rice, oat and spelt drinks (10–43.5 mg/250 mL); non-fortified hemp drinks have been reported to contain about 30 mg calcium/250 mL.

In this study, calcium was found to be the nutrient most frequently added to plant-based drinks, as this is one of the most important dietary contributions of milk. From all the commercial samples studied, 89 samples (about 48 % of the total) were calcium-fortified, with over 42 % of each category studied, with the exception of hemp and tigernut. All the soy, oat and almond drinks claiming fortification were fortified in calcium, independently of other nutrients that might also be added (Table 4).

Calcium fortification strategies for foods should consider that factors such as calcium load or chemical form might condition its bioavalability. Shkembi & Huppertz (2021) observed that calcium absorption in soy drinks fortified with calcium carbonate was similar to that of bovine milk, and both were significantly higher than for soy drinks fortified with tricalcium phosphate, with the same calcium load. As seen in Table 5, 64 % of the total calcium-fortified samples contained calcium salts (calcium carbonate, calcium phosphates or calcium citrate); in 30 samples (33 %) calcium came from seaweeds, while two of the 85 drinks (coconut and soy) contained a combination of both. Fortification with calcium from seaweeds (*Lithothamnium calcareum*) is a current trend today, however, although there is as yet insufficient evidence to support the suitability of the use of calcium from seaweeds in humans, one study revealed a similar bioavailability to calcium carbonate ($CaCO_3$) in piglets (Schlegel & Gutzwiller, 2017).

Due to the importance of calcium in childhood, fortification with this nutrient in any plant-based drink chosen to feed for toddlers is highly recommended, to levels of 300 mg per 250 mL (similar to milk). Related to calcium/phosphorus ratio, it has been reported around 5 in soy drink, according to results of Lacerda Sanches et al. (2020); for that reason, phosphorus fortification may be also explored, not only to better contribute to the intake of this mineral, but also to equilibrate calcium/phosphorus ratio and contribute to calcium absorption. Otherwise other calcium food sources, such as breast milk, vegetables or nuts (taking into account the drawback of oxalates and phytates) or food supplements should be used, to achieve a DRV of 450 mg/day.

3.1.4. Other minerals in commercial plant-based drinks

Iodine and zinc were not fortified (nor declared) in any of the drinks studied (Table 2). Seeds and other plant foods are known to be good dietary sources of zinc, although, as mentioned above, its bioavailability is limited by the presence of tannins and phytates (Alonso-Esteban et al., 2022; Dahdou et al., 2019; Souci, Fachmann & Kraut, 2008). It should also be noted that -as with other minerals-, not all the zinc content in the plant material would be found in the filtered drink, since a portion will be bound to the polymer matrix. Astolfi et al. (2020) reported values of 0.5, 0.12, 0.1, 0.15 mg zinc/250 mL respectively for soy, rice, oat and spelt drinks, compared to values of about 1 mg/250 mL found in FCDs for ruminant milk; and Lacerda Sanches et al. (2020) reported lower bioaccesibility of zinc and phosphorus (as it is in a high extent as phytate compounds) in soy drink compared to cow milk. It is therefore advisable in the diet of children who do not consume ruminant milk to increase the presence of foods providing high amounts of zinc (such as whole cereals and nuts), breast milk and/or food supplements to reach the DRV of 4.3 mg zinc per day.

Iodine is essential in children's early development and its main sources are sea foods and dairy products. The intake of this nutrient may therefore be adequate they consume fish (e.g. those who are allergic to cow milk or lactose intolerant); however, vegetarian/vegan toddlers are at higher risk of iodine deficiency (Brantsæter et al., 2018; Karcz, Królak-Olejnik & Paluszyńska, 2019; Vila et al., 2020; Yeliosof & Silverman, 2018). Other sources such as seaweeds are not usually consumed in sufficient amounts to provide iodine DRVs; and are not so advisable for the paediatric population due to the possible presence of contaminants such as Cd, As, Pb, Sn (Desideri et al., 2016; Peñalver et al., 2020). To the authors' knowledge there are no data in the literature on the presence iodine in plant-based drinks, since these products are not expected sources of this mineral. Given that 250 mL of cow milk can provide about 26 % of iodine DRV for toddlers (Table 1), and plant-based drinks are not assumed to provide significant amounts of this mineral unless they are fortified, supplementation with about 90 µg of iodine per day is recommended for children for whom other iodine sources in their diet are restricted, and for the mothers of breastfed toddlers.

Iron is present in low amounts in ruminant milk, and also in some plant foods, although its bioavailability is not high; it has therefore not been considered as a nutrient for comparison with plant-based drinks. It is however noteworthy that one sample of commercial almond drink was fortified with iron at levels of 5.3 mg/250 mL.

A reduction in salt consumption is a current nutritional goal for the global population, according to WHO recommendations (World Health Organization, 2020). Plant foods usually present low amounts of sodium than animal products; however, many industrialized products, which include plant-based contain added salt as an ingredient, presumably for technological and sensorial reasons. All the drinks in this study declare salt in their nutrition labelling, as it is mandatory to state the amount of sodium as "salt" on the food label, even in the case of sodium naturally occurring in foods (European Union Regulation 1924/2006). The plant-based drinks studied declared an average amount of 0.2 g of salt/250 mL, which makes a range of sodium of 24 to 150 mg of/250 mL (Table 2); this high variability is explained by the fact that in 45.2 % it was naturally present sodium, while in 116 drinks (64.8 %) salt was indicated as an added ingredient, (Table 3) in variable amounts. With the exception of tigernut drinks, salt was added to more than 50 % of the commercial plant drinks in all the categories, and 100 % of the commercial coconut drinks. r.

Given these results, it seems appropriate to raise the possibility of adding iodized salt, providing 60 ppm of iodine, in plant-based drinks.; according to the results of this study, would mean at maximum, 1.49 µg iodine/250 mL. The use of iodized salt in the regular diet should also be recommended for vegetarian/vegan toddlers (García-Ascaso, Ares-Segura & Ros-Pérez, 2018). Despite the possibility of introducing iodine through the addition of salt, this ingredient should be reduced to a minimum to avoid the excessive sodium intake in the diet, in early life.

3.2. Influence of studied plant-based beverages on human health: Fatty acids profile, bioactive compounds, antinutrients, potentially toxic compounds and/or allergens.

The health impact of foods comes not only from nutrients, but also from the effects of the different phytochemicals that provide health benefits, and from the negative effect of antinutrients, allergens or potentially toxic compounds, either naturally occurring or contaminants.

3.2.1. Fatty acid profile and phytosterols in plant-based drinks

Polyunsaturated and monounsaturated fatty (PUFAs and MUFAs, respectively), as well as phytosterols present in seeds and other plant foods may play a role in lowering total and LDL cholesterol and preventing cardiovascular diseases (Marangoni & Poli, 2010); these effects are often associated with the consumption of almonds and soybeans, among other seeds.

Almonds are rich in MUFAs and phytochemical components such as phytosterols and other antioxidants (Paul et al., 2019; Toro-Funes et al., 2010). Paul et al. (2019) found values for MUFAs of around 31–35 g/100 g, lower than other authors including Martínez-Padilla et al. (2020) and Manzoor et al. (2020) who reported 59.1 and 66.2 g/100 g respectively. However, all agree that oleic acid (18:2) is the main MUFA in almond seeds. An average value of 3.39 g of MUFAs/250 mL was found in the commercial almond drinks reviewed in this study, higher than any of the other plant-based drinks. Beta-sitosterol, campesterol and stigmasterol are predominant phytosterols found in almond drink. Aydar et al. (2020) pointed out that almond drink contain 174.7 mg/L of these compounds *vs* 22.1 mg/L found by Toro-Funes et al. (2010), but both authors agree that beta sitosterol is the main phytosterol present.

PUFAs are the principal fraction in soybeans, followed by MUFAs (Aydar et al., 2020; Chalupa-Krebzdak et al., 2018; Han et al., 2021; Martínez-Padilla et al., 2020; Serrano et al., 2017). According to these authors, linoleic acid represents about 55 % of total fatty acids in soy drinks, and is the main PUFA; linolenic acid is also noteworthy, and is present in significant amounts in soybeans (about 7 % of total fatty acids), compared to other seeds. Oleic acid is the main MUFA, representing about 22 % of total fatty acids. Soy drinks also contain interesting levels of phytosterols. Toro-Funes et al. (2010) and Aydar et al. (2020) found 190.8 and 96.9 mg/L respectively in their studies and both show the main phytosterol present in coconut drink to be beta-sitosterol, with values of up to 94.1 mg/L (Toro-Funes et al., 2010).

The fatty acid profile of hemp drinks shows some similarities to soy drinks, in this case, with a predominance of linoleic and linolenic (about 56 and 16 % of total fatty acids) (Aydar et al., 2020; Martínez-Padilla et al., 2020). Chalupa-Krebzdak et al. (2018) reported a content of 0.4 g/100 mL of n-3 fatty acids in hemp drink. Many seeds present interesting values of n-3 PUFAs; however, it should be noted that n-3 fatty acids of plant origin are not long chain PUFAs such as eicosapentaenoic (EPA) and docosahexaenoic (DHA) acids, which are the most important for visual function and development at different levels in early childhood. Toddlers must obtain these fatty acids from other suitable food sources, such as sea foods. As previously indicated, these fatty acids may also be obtained from seaweed; however, as mentioned earlier the evidence is not clear on the use of seaweed for the paediatric population and the possible presence of contaminants in seaweed should be taken into account (Desideri et al., 2016; Peñalver et al., 2020). Supplementation of plant-based drinks with EPA/DHA could therefore be considered for toddlers whose diet does not include fish, as a good alternative source of these important nutrients.

In contrast, coconut drinks are the plant-based beverages with the highest SFA content (Aydar et al., 2020; Belewu and Belewu, 2007; Chalupa-Krebzdak et al., 2018; Martínez-Padilla et al., 2020; Paul et al., 2019), with lauric acid (12:0) being a major SFA, as reported by authors such as Aydar et al. (2020) with values of 50 % of total fatty acids content. Although, this fact is traditionally associated with a lower health quality, coconut drinks contain medium chain triglycerides, for which a large body of scientific evidences supports a range of beneficial effects on HDL and LDL cholesterol, CVD/CHD risk, cognitive function body mass, waist circumference, insulin sensitivity, energy expenditure, and overall adiposity (Cardoso et al., 2015; Hewlings, 2020).

Even though other plant-based drinks made from cereals like oat or rice have very low amount of fat, Martínez-Padilla et al. (2020) studied fatty acid profiles in oat drinks, and concluded they had a high PUFA content (43 % of total fatty acids) with a predominance of linoleic acid the major one. Other authors (Aydar et al., 2020) found similar results. The same authors obtained 28.76 mg/100 mL of beta sitosterol, lower than other plant-based beverages such as soy drinks.

3.2.2. Fibre and phenolics as bioactive compounds in plant based drinks

The fibre fraction has important bioactivities for the normal functioning of the human body, particularly related to gut health. As mentioned previously, oat drinks are particularly worth highlighting due to their content of β-glucan at levels of 0.51 g/100 g (Önning et al., 1999). This is a soluble and viscous fibre recognized for its importance for cardiovascular health since it reduces cardiovascular risk (Shen et al., 2016). The mechanism of action of β-glucan occurs in the space between the wall of the intestine and the lumen, which acts as a physical barrier to glucose and fat uptake in intestinal epithelial cells. The consumption of oat beta-glucan is related to a reduction in the risk of diabetes and obesity, as it decreases the glycaemic response and the serum level of low-density lipoproteins (Abbasi et al., 2016).

Other compounds of interest in plant-based drinks are phenolics, which act through different mechanisms as antioxidants in either the preservation of foods, or the body. Their physiological effects are related to the maintenance of oxidative equilibrium in the organism, which influence cardiovascular health, cell proliferation or immune function among others (Martins, Barros & Ferreira, 2016). This is a wide family of compounds, and their nature vary depending of the seed used as prime matter for the plant-based beverage. The isoflavons genistein, daidzein, and glycitein have been found in soy beverages (Aydar et al., 2020). Siqueira Silva et al. (2020) found that coconut drink presented values of phenolics of about around 7 mg GAE/L, higher than other products such as almond, soybean, rice or oat drink, comprising mainly flavonoids, isoflavones, phenolic acids and others. Manzoor et al. (2020) also reported the presence of condensed tannin in almond drink. All these compounds have shown antioxidant activity, contributing to a better health status on the organism.

3.2.3. Antinutrients in plant-based drinks

In addition to the beneficial antioxidant properties of phenolics, some of them -as it is the case of tannins- may also have antinutritional potential, impairing the bioavailability of certains nutrients such as minerals and proteins. As previously mentioned, phytic acid and phytates are present in cereals (such as oat) and nuts. This family of compounds behaves as antinutrients, reducing iron, zinc and calcium bioavailability. To avoid this harmful effect, higher levels of minerals such as iron, zinc or calcium should be taken when a food with high phytates content is consumed regularly.

Many seeds are rich in phytates; pulses may contain about 0.34–2.2 g/100 g (dry matter); cereals, about 0.2–2.6 g/100 g (dry matter), and hemp has been reported to have 2.6–3.1 g/100 g (Alonso-Esteban et al., 2022; Castro-Alba et al., 2019). The level of phytic acid in soy drinks reported by Burgos Luján and Tong (2015) was 1.41 mmol/L, higher than for other plant beverages such as oat drink; which limits mineral bioavailability.

Saponins are glucosides that could be considered as antinutrients, because they impact the digestion of proteins, especially soy proteins, by creating insoluble saponin–protein complexes that are resistant to digestion. They may also exert some hemolytic activity, but on the other hand, nowadays these family of compounds have been regarded as beneficial suggesting positive effects on blood lipids and glucose. Different seeds such as soybean and oat present different saponins, although during technological process of some plant-based beverages (as it is the case of soy drink), the thermal treatment applied may reduce the content of these compounds (Barakat, Reim & Rohn, 2015; Francis et al., 2002; Potter et al., 1993).

The previously mentioned compounds may be common to many types of plant-based drinks. However, some compounds with potential toxicity or allergenicity may be specific to, or specifically accumulated in certain species. Each individual type of drink in the study is discussed below, grouping the main health benefits and concerns that should be taken into account when using them as milk substitutes for toddlers.

3.2.4. Almond drink

This product has a long tradition of use in Spain for cases of milk dietary restriction. As previously indicated, almond drinks have high calcium content (although dependent on the amount of almonds present in the drinks, which is usually low, as mentioned previously). These drinks also have a healthy fatty acid and phytosterol profiles that make it a good choice for a better cardiovascular health.

On the other hand, caution should b.e taken to detect cases of almond allergy. Amandin is a main protein responsible for the almond allergy. Devnani et al. (2020) and Dhakal et al. (2014) studied thermal and high-pressure treatments in almond drinks and they found that proteins, including amandin are lower after both treatments. However, other studies show the presence of other heat-stable allergens in almonds (Mandalari & Mackie, 2018), so almond-allergic toddlers should not ingest this type of drink. Many food allergies appear with the first exposure to the allergenic substance, so toddlers' first exposure to almonds or almond-derived foods should always be made in low amounts and under supervision, to confirm the tolerance of this nut.

3.2.5. *Coconut drink*

As mentioned above, coconut drink stands out by its SFA content, specially lauric acid, which is traditionally related with cardiovascular disorders, but currently, associated with beneficial effects on health. Some studies show the antimicrobial properties of the glycerides derived from lauric acid and other short chain fatty acids, such as monocaprin and monolaurin from coconut (Davidson, et al., 2020; Rouse, 2005).

This drink has a great acceptance due to its sensorial properties, as it is creamy, with dense and homogeneous texture, and very good flavour and odour. Moreover, coconut drink extraction keeps antioxidant components as tocopherols, tocotrienols and polyphenols, which are lost in coconut oil obtention (Navarro et al., 2007). From the author's knowledge, there are no references about antinutrients or toxic compounds in coconut drink. Only Azlin-Hasim et al. (2019) reported adulterations with water and carbohydrates and other authors reported arsenic contamination in coconut-rice drinks (Ruzik & Jakubowska, 2022).

3.2.6. *Hemp drink*

Data on the composition of hemp drinks are scarce, due to the novelty of this product, although there are some recent studies on their protein quality and functional effects attributed to the aforementioned unsaturated lipid profile of hemp seeds; some studies have also been carried out on their on their prebiotic effects (Nissen et al., 2019; Nissen, di Carlo & Gianotti, 2020).

Apart from their phytate content, the main health concern related to the consumption of hemp drinks by toddlers is the presence of cannabinoids. Some of the literature describes the intoxication of children with various hemp food products (Richards et al., 2017), provoking symptoms such as lethargy or ataxy. However, although there have been several classifications of hemp varieties, cultivars devoted to food uses (*Cannabis sativa* subsp. *sativa*), usually present negligible or very low amounts of cannabinoids, in contrast to other varieties (*C. sativa* subsp. *indi*ca), that are richer in cannabinoids, and used in medicine or as a recreational drug (Barcaccia et al., 2020; Small, 2015). Cannabinoids are present in the flower trichomes but not in the seeds, so as hemp is the only part of the plant authorised by the EU for food uses, any cannabinoids detected in hemp foods must come from contamination by other parts of the plant, and will only be present at trace levels. This has been confirmed by the study of di Marco Pisciottano et al. (2021), who analysed cannabinoids in hemp drinks samples by LC-MS/MS and found levels below the analytical quantification limit (0.002 mg/L) and always lower than other hemp food products.

3.2.7. *Oat drink*

As mentioned above, this type of drink is notable for the presence of β-glucan soluble fibre and other specific bioactive compounds, such as avenacosides A and B in oat drinks; these are steroid glycosides (saponins) mainly characterized by their antimicrobial effects (Paul et al., 2019; Yang et al., 2016).

In regard to idiosyncratic adverse reactions to food components, coeliac toddlers should be cautious with the consumption of oat drink due to the presence of avenin protein (Malalgoda & Simsek, 2017). Only oat drinks "gluten-free" certified should be selected in these cases.

3.2.8. *Rice drink*

The main concern relating to the consumption of rice drinks is the possible presence of high levels of arsenic in the rice grains used to prepare them. Rice grains can accumulate arsenic from soil, rock and groundwater, in a tenfold concentration compared to other cereals (Davis et al., 2017); levels vary, depending on the genotype and growing conditions, and on the technological process applied (e.g., husked rice retains more inorganic arsenic as a part of the bran layer than white rice). Even though most rice samples fall within the maximum levels established by European regulations (European Union, 2015), major consumers of rice products could be at risk. Rice drinks have been reported to contain mean values of inorganic arsenic between 4.8 and 34 μg/kg (Guillod-Magnin et al., 2018).

The scientific report of Arcella et al. (2021) pointed out that infants, toddlers and other children are the population groups with the highest levels of exposure levels to dietary inorganic arsenic, with the main contributors to this exposure, being rice and rice-based products, together with drinking water, among others. The study of Guillod-Magnin et al. (2018), analysed arsenic exposure via different rice-based products for toddlers in Switzerland, at different levels and consumption scenarios, and identified rice drinks as one of the main contributors to the arsenic intake of the toddlers in the group designed as "only consumers" (including coeliac children, cows' drink allergic, vegans or Asian ethnic group), as a specific group at higher risk of arsenic exposure.

Rice-based beverages should therefore not be used solely as a milk substitute, but in combination with other drinks, either animal-derived or plant-based beverages made from grains others than rice, to avoid an excessive arsenic intake in this population group.

3.2.9. *Soy drink*

Soy drink is a good choice because of its lipid profile, with a higher amount of the n-3 linolenic acid, phytosterol and isoflavons content. This product may have the inconvenience of phytates acting as antinutrients; but it has also the advantage of providing the highest amount and best quality of proteins of all the plant-based drinks, and is therefore probably one of the best options for its nutritional value and bioactive compounds.

The only concern would be, the possibility of a soy allergy, mainly caused by major seed storage proteins such as 11S glycinin or 7S ß-conglycinin (Gly m 5), among others, which are associated with severe allergic reactions (Kern et al., 2019). Therefore, as in the case of almond drinks, it should only be used for toddlers that have shown a good tolerance of these seeds; and should be first introduced under supervision to detect any potential adverse reaction.

3.2.10. *Tigernut drink*

Most of the articles about tigernut products refer to "horchata", the traditional Spanish tigernut drink. Valero-Vello et al. (2021) indicated that tigernut products offer large proportions of vitamins and minerals (such as vitamins C and E), lipids and oleic acid, which are beneficial for several functions in the human body, including cardiovascular health. Furthermore, the presence of vitamin E is significant as it is an important antioxidant for its ability to scavenge free radicals, which reduces the risk of cancer and prevents the progression of pre-cancerous lesions.

The study by Sebastià et al. (2010) found aflatoxin A in tigernut drinks, as a contaminant that may be present in many seeds and other foods, and it is under the control of EU regulations. No other data have been found in the literature regarding the presence of mycotoxins in the other plant-based drinks studied.

4. Conclusions

None of the plant-based drinks in this study are ruminant milk substitutes since they are different food products with a different composition. However, the best option for a plant-based drink for vegetarian/vegan children aged 1 to 3 years who do not consume ruminant milk, would be the regular consumption of at least 250 mL/day of fortified soy drink, always in the context of a carefully-balanced diet. This drink provides a higher content of better quality protein than the other drinks, and has a healthy fatty acid profile and phytosterols. Other good alternatives to use in combination or for soy-allergic toddlers are almond drinks (MUFAs), hemp drink (PUFAs) or oat drink (higher fibre content and presence of β-glucan soluble fibre). Coconut and tigernut drinks may be consumed occasionally, as well as rice drinks.

One selection criterion is to seek out a product with a high amount of the main ingredient, and a lower amount of other ingredients such as sugars, salt or additives.

The key nutrients that should be sought as fortification in plant-based drinks are: vitamins A and B_{12}; calcium (and phosphorus to a ratio close to one), zinc and iodine, as they represent the most significant nutritional differences with ruminant milk; vitamin D, as well as DHA and EPA would also be desirable for vegetarian/vegan toddlers since it is not provided in sufficient quantities by other foods in their diet. Of these, Ca and vitamins A, B_{12}, and D, are readily found in this type of foods; 63 % commercial soy drinks in Spain are calcium-fortified, and between 20 and 34 % are fortified in these three vitamins. In contrast, there are no commercial plant-based drinks on the Spanish market fortified with iodine and/or zinc. A good strategy for the industry would be to fortify plant-based drinks with iodine and zinc in order to improve the nutritional value of products aimed at vegetarians/vegans.

In regard to overall nutritional recommendations, the situation of vegetarian/vegan toddlers varies widely depending on their food restriction. As plant-based drinks provide high amounts of phytates and tannins, which act as antinutrients, an increased intake of zinc, iron and calcium in their diet is advised, either through fortification of plant-based drinks, or obtained from other food sources (whole grains, nuts, vegetables); and/or food supplements. Iodine supplements are recommended in the case of fish restriction since plant-based drinks are not usually fortified with this nutrient.

CRediT authorship contribution statement

D. Escobar-Sáez: Conceptualization, Methodology, Investigation, Data curation, Writing – original draft, Writing – review & editing. **L. Montero-Jiménez:** Conceptualization, Methodology, Investigation, Writing – original draft, Writing – review & editing. **P. García-Herrera:** Conceptualization, Methodology, Validation, Investigation, Writing – original draft, Writing – review & editing. **M.C. Sánchez-Mata:** Conceptualization, Methodology, Validation, Data curation, Writing – review & editing, Supervision.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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