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Plant-based beverages as milk alternatives? Nutritional and functional approach through food labelling

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ABSTRACT

Plant-based beverages (PBB) market is largely growing. In this study, 136 beverages made of soy, oat, almond, rice, tigernut, and others (mixtures of various plant materials), from the Spanish market were evaluated through labelling information.

Energy value and fat content were intermediate between skimmed and whole cow milk; while fatty acids profile was quite different. Carbohydrate content was usually higher than cow milk, and highly dependent on the addition of sugars. All products provided some dietary fibre. With the exception of soy-based drinks, samples presented lower protein and calcium content than milk (1/3 samples studied were Ca-fortified), and 23% were vitamin D enriched.

The claim "No added sugars" was in more than 50% samples. A right labelling and nutritional education of consumers is essential to make adequate choices, since the appearing of many claims is not always indicative of a better-quality product.

Plant-based beverages cannot be considered as an alternative to milk, but as a different product, with their own nutritional and functional entity. Their inclusion in a diversified balanced diet can provide interesting functional components, such as soluble fibre or unsaturated fatty acids (mainly soybean and almond drink), which can help improve the health status of the population.

1. Introduction

Nowadays the consumption of plant-based beverages is increasing due to new dietetic trends, with a reduction of animal products intake, and diversification of the commercial offer of food products. These beverages are usually considered as alternatives to milk, being even called as plant-based milks. This denomination is erroneous in Europe, as according to Regulation 1308/2013 of European Union (2013), the term milk means "exclusively the normal mammary secretion obtained from one or more milkings without either addition thereto or extraction therefrom", with only a few minor modifications permitted including normalization of fat content. However, the Commission Decision of European Union (2010) allows some exceptions for using the term "milk" to refer to some non-dairy plant-based beverages, which have been traditionally so-called (e.g. "almond milk" in Spain or "coconut milk" in Portugal, among others. In other countries, the term "mylk" (modified from "milk") is used to refer to plant-based beverages due to pressure from the dairy industry to differentiate the products (Queiroz Silva and Smetana, 2022). Despite the voices against this exclusive denomination of milk, this definition has been confirmed by Judgment of the Court of 14 June 2017 (EU, 2017).

With independence of the terminology, these products are increasingly produced and demanded by consumers. The global dairy alternatives market is estimated to be valued at American dollar (USD) 27.3 billion in 2022 and is projected to reach USD 44.8 billion by 2027 recording a compound annual growth rate of 10.4%, in terms of value (Markets and Markets, 2022). In the European Union (EU), Spain is leader on commercialization of plant-based beverages, with a grown of 14 % from 2018, and 24 million L sold in 2021. In Spain, oat beverages represent 25 % of total market of plant-based beverages, followed by soy and almond drinks (Statista Database, 2022).

To explain this increase in the market, there are several factors that may be considered as reasons for the impulse on the consumption of plant-based beverages. First, the increase on the cases (diagnosed, or just

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suggestive) of lactose intolerance with a prevalence of about 70 % in world population (mainly in adult population), and leading to gastrointestinal symptoms (Ugidos-Rodríguez et al., 2018; Atenodoro, 2019). In addition, allergy to ruminant milk protein presents a high incidence during the first three years of life, with an estimated prevalence in developed countries ranging from 0.5% to 3% at age 1 year (Flom and Sicherer, 2019; Benedé et al., 2022). This situation affect to 11.2 % of Spanish population (half of them under two years old), and provoking from mild symptoms to fatal anaphylaxis (Ojeda et al., 2018). Moreover, there is a tendency to increase the presence of plant foods in the diet for health reasons (to increase the presence of fibre, plant antioxidants or other healthy compounds in the diet). Other motivations include environmental issues, animal welfare concerns, ethics, religion, etc, that leads sometimes to vegetarian / vegan diets, in which non-dairy beverages becomes a basic food.

Nowadays 37–43 % of European and Spanish population affirm being consumers of plant-based beverages (Smart Protein Project, 2021). Considering the high variability in raw material, technological processes, and fortifying substances used in this products formulation, it is essential to know if the substitution of ruminant milk by these plant products may be adequate, especially for vulnerable groups of population such as children or elderly people. Some previous studies (Escobar-Sáez et al., 2022) assess the adequacy of substituting ruminant milk by different plant-based beverages for toddlers, finding than some nutrients (such as iodine) may be lacking and would need fortification or be provided by other food sources.

One of the main factors conditioning the nutritional composition of non-dairy plant-based beverages is the ingredient used. Prime maters may be grains such as cereals (rice, oat), pseudo-cereals (quinoa), pulses (soybean), nuts (almonds, hazelnuts, walnuts), other seeds (sesame, coconut), or even tubers (tigernut). These plant materials are usually macerated in water in a widely variable proportion (2–15 %). For that reason, nutritional properties of each beverage depend on the nature and amount of the main ingredient as well as the addition of fortifying substances (e.g., calcium, vitamin D) or other possible ingredients (McClements et al. 2019).

However, the presentation of these plant-based beverages as milk alternatives, with appearance and used similar to animal milk, may lead to the perception that they are equivalent. Nowadays consumers are informed about the characteristics of a certain food product through food labelling and publicity under the EU Regulation 1169/2011, and especially through nutrition and health claims included on it (Regulation 1924/2006 on nutrition and health claims made on foods). Although they are not mandatory information in food labelling, when appearing, they should be clear, accurate and based on scientific evidence. Currently, consumers perceive that products with these types of claims in the label are healthier than those with no claims, and often attributes them more nutritional and /or functional benefits than those indicated in the label.

As many consumers nowadays decide to substitute cow milk by plant-based alternatives, the present study is focus on the assessing the nutritional and functional characteristics of plant-based non-dairy beverages available in the Spanish market, as compared to cow milk, through information provided by labelling and the current scientific evidence. This knowledge may be used as a tool to make right choices, with the objective of improving the nutritional status of consumers.

2. Material and methods

2.1. Plant-based beverages

Sampling has been performed through a survey on different Spanish markets and supermarkets, including stores and websites. A criterion of inclusion was the fact that labelling was according to EU Regulation 1169/2011 regarding nutritional information, which means that they should have all the mandatory mentions (energy value, fat, saturated fatty acids, carbohydrates, sugars, proteins and salt), all of them in the same visual camp, and expressed per 100 g or 100 mL. This mandatory information may be optionally completed with mono and poly-unsaturated fatty acids, polyols, starch, fibre, vitamins and/or minerals (these only in case that the amount provided by the products is more than a significant amount, as 7.5 % of Nutrient Reference Values, as defined in EU Regulations).

In the case on websites, when the complete labelling did not clearly appear in the package, products were excluded. With these criteria, a total number of 136 samples were recorded, belonging to the following categories: 27 samples of soybean beverage (19.9 %), 25 samples of oat beverage (18.4 %), 22 samples of almond beverage (16.2 %), 21 samples of rice beverage (15.4 %), 18 samples of tigernut beverage (13.2 %) and 17 % of products were grouped as “others”. The products grouped as “others” included beverages less represented and usually marketed as a mixture of several ingredients, such as coconut, hazelnut, birdseed, walnut, quinoa, cashew drinks. Tigernut beverage deserves a special mention and was included for being a very particular product in Spanish market: it is made from ancient times and used as refreshment called “horchata”. This term was used in old Spanish to refer to a beverage made of different seeds and other plant materials crushed and macerated with water, as it is in fact the elaboration procedure of plant-based beverages. Nowadays, besides this traditional use, tigernut drink is marketed among other plant-based beverages.

Apart from nutritional information, the presence of nutritional (NC) and/or health (HC) claims was surveyed as well as other mentions such as organic certified as defined by EU Regulation 834/2007 (European Union, 2007).

Nutritional values of the studied plant-based drinks were compared with the composition of whole and skimmed cow milk, using data from the Spanish Food Composition Database BEDCA (2022). Some functional aspects of beverages raw materials were obtained through the revision of recent literature.

2.2. Statistical analysis

Statistical analysis was made through SPSS version 25.0 (Armonk, NY, USA: IBM Corp), with a significance level of $p < 0,05$. Shapiro-Wilk was used to check if the distribution of data was normal. The variables were expressed as average (interquartile range). To analyse the differences on energy and nutritional contents between all the types of beverages, the non-parametric test Bonferroni of Kruskal-Wallis for independent samples was used, with DUNN test applied for multiple comparison.

To better explore variability among plant-based drink types regarding their nutritional composition, a Principal Component Analysis (PCA) was performed, using Statgraphics Plus 5.1 software, (Warrenton, VA, USA).

3. Results and discussion

3.1. Nutrient profile through mandatory food information

A wide variety of products from different raw material, mixtures of ingredients, elaboration process and brands were found in the Spanish market of plant-based beverages. This leads to a quite different nutrient profile. Table 1 shows the mandatory nutritional parameters indicated by the Council Regulation (EU) no. 1169/2011 (European Union, 2011) and found in labels of all plant-based drink types and groups studied (energy value; fat and saturated fatty acids; carbohydrates and sugars; proteins and salt). Figs. 1 and 2 present box and whisker plots built from the results of energy values, total fat, saturated fat, carbohydrates, sugars and proteins for the studied beverages. These plots show the spread and centres of each data set; boxes show the interquartile range and the median (as a line in the centre of the box); whiskers show maximum and minimum values, and outliers are represented as

Table 1
Descriptive statistical results as average (standard deviation) of mandatory nutrition facts from the labelling of different plant-based beverages. n = number of samples.

	n	Energy value (Kcal/100 mL)	Fat (g/100 mL)	Saturated fatty acids (g/100 mL)	Carbohydrates (g/100 mL)	Sugars (g/100 mL)	Proteins (g/100 mL)	Salt (g/100 mL)
Soybean	27	38.2 (6.9)^{b}	1.8 (0.35)^{bc}	0.31 (0.09)^{b}	2.6 (2.9)^{a}	1.7 (1.0)^{a}	3.1 (0.78)^{d}	0.09 (0.03)^{bc}
Rice	21	55.5 (8.4)^{d}	1.0 (0.20)^{a}	0.12 (0.06)^{a}	11.2 (1.8)^{c}	6.0 (1.6)^{c}	0.36 (0.20)^{a}	0.09 (0.02)^{abc}
Oat	25	46.5 (4.0)^{c}	0.90 (0.26)^{a}	0.15 (0.06)^{a}	8.3 (1.1)^{b}	5.3 (1.5)^{bc}	1.04 (0.32)^{c}	0.07 (0.03)^{a}
Almond	22	28.9 (15.3)^{a}	2.0 (0.85)^{c}	0.23 (0.12)^{ab}	1.9 (2.3)^{a}	1.5 (2.1)^{a}	0.76 (0.35)^{b}	0.10 (0.04)^{c}
Tigernut	18	78.8 (20.8)^{e}	2.7 (0.57)^{d}	0.61 (0.19)^{d}	12.7 (4.1)^{c}	10.6 (3.4)^{d}	0.67 (0.18)^{b}	0.08 (0.04)^{ab}
"Others"	23	49.9 (18.0)^{cd}	1.6 (0.81)^{b}	0.46 (0.43)^{c}	8.0 (4.2)^{b}	4.2 (2.3)^{b}	0.64 (0.47)^{b}	0.10 (0.04)^{bc}

For each column, different letters indicate statistically significant differences ($p < 0.05$).

individual points (with sampling codes used). Values of cow whole and skimmed milk (data obtained from BEDCA, 2022), are included in the Figures, as thick (whole cow milk = WCM) and thin (skimmed cow milk = SCM) lines, for comparison purposes, as these products are often used as substitutes of ruminant milk in the diet.

As it can be seen, the average energy content of the analysed plant-based drinks was highly variable 48.2 (13.0—134.8) kcal/100 mL (Fig. 1a). It was observed that about half of the studied products presented intermediate values of energy, between skimmed (34 kcal/100 mL) and whole cow milk (65 kcal/100 mL), both presenting quite stable values. Furthermore, 23.5 % provided less energy values than skimmed cow milk (including 88.9 % of almond beverages) and 22.8 % of the samples higher than whole cow milk (including 68.2 % of tigernut beverages). Almond drinks showed the lowest energy values (28.9 kcal/100 mL), followed by soybean (38 kcal/100 mL), and on the other hand, higher average value of energy was declared in those drinks made of tigernut (78.8 kcal/100 mL).

In the case of tigernut drinks, high energy values are due to its high lipid content (2.7 g/100 mL, as average), total carbohydrates and sugars contents (12.7 and 10.6 g/100 mL, respectively). However, for almond and soybean drinks, although lipid content was 1.8–2.0 g/100 mL for each one, sugars and other carbohydrates were the lowest (below 3.0 g/100 mL), which explains their lower energy value. Furthermore, soybean drinks stood up for their remarkable higher protein content 3.1 (0.3–3.9) g/100 mL. Salt content was widely variable ranging between 0.03 and 0.25 g/100 mL.

In a more detailed analysis of fat content, Fig. 1b shows that almost all samples presented intermediate values of fat, between skimmed and whole milk, being higher in tigernut, almond and soybean drinks, and lower in cereal grain drinks (rice and oat). This is not directly related to the fat contents of the main ingredients, since almonds present about 45.2 g/100 g of fat, tigernuts 23.7 g/100 g and soybeans 18.6 g/100 g (BEDCA, 2022), and may be also related to the amount of plant material in the beverage. In a previous survey made in the context of this research group, amounts of the main ingredients in plant-based beverages marketed in Spain were recorded, being very low in almond beverages (around 3.7% averages), higher in tigernut and soybean beverages (10.7% and 11.3 % respectively), and the highest for oat and rice (13.4% and 15.1. % respectively) (Escobar-Sáez et al., 2022). This agree with the results obtained in the present study, where almond drinks, despite higher fat content of the seeds, present values generally between 1 and 2.5 g/100 mL, due to the low presence of seeds. In fact, as raw materials, almond seeds presented higher fat content than tigernut tubers; however the beverages studied showed an inverse trend: tigernut drinks had the highest amount of fat (around 2.5 g per 100 mL), even higher than almond drinks. This fact could be related to a higher plant material content (tigernut) compared to other beverages analysed. Related to this fact, outlier values, reaching almost 5 g fat/100 mL, were found in both types of drinks, with high variability depending on the amount of raw material used. Contrarily, oat and rice, which present poor fat contents (6.9 and 0.9 g per 100 g, respectively, according to BEDCA, 2022), are present in higher amount in the final beverage, and thus the fat content is quite stable and around 1 g per 100 mL.

Another difference from cow milk is that all samples presented much lower saturated fat than whole cow milk (Fig. 1c), but higher than skimmed milk (which contains negligible amount of fat) again with rice and oat drinks as those presenting the lowest contents. This was expected, since plant materials used as main ingredient for the elaboration of the studied samples presented a fatty acid profile with high proportion of polyunsaturated fatty acids. Some samples in the category of "others" stood out for their highest saturated fat content, corresponding to coconut beverages, since these seeds present around 90 % saturated fatty acids (BEDCA, 2022).

Carbohydrates in plant-based beverages deserve a special mention. Whole and skimmed cow milk present similar amount of carbohydrates (around 4.6 g lactose per 100 mL). From the present survey it was seen that 38.2 % of plant-based beverages in the Spanish market presented lower carbohydrates contents, standing up soybean and almond beverages; on the other hand, rice, oat and specially tigernut beverages always presented significant higher contents of total available carbohydrates with values of 7.8 to 14.5 g/100 mL (Fig. 2a, 2b). Seeds and tubers are plant structures accumulating storage substances for the development of the new plant, such as starch. While oily seeds (such as almond or soybean) present high amount of lipid content, and thus lower carbohydrate percent when compared to starchy products. Besides the naturally occurring carbohydrates in the seeds, many plant-based beverages are added with sugars, and this would condition the final carbohydrate and specially sugars amount. Free sugar content in tigernut beverage was the highest, as sugar is traditionally added in its elaboration (this product is used as a sweet refreshment); rice and oat beverages were in slightly higher levels as cow milk, and soybean and almond beverages had the lowest carbohydrates contents, with more than 75 % of the studied samples presenting lower amount of either total carbohydrates and sugars than cow milk. For these reasons, sugars and total carbohydrates content was highly variable among marketed plant-based beverages, ranging from 0 to 14.5 g sugars/100 mL and 0.2–22.4 g carbohydrates/100 mL, depending on amount and type of plant material and addition of sugars for sensorial reasons.

Except for soybean beverages, with protein values similar to cow milk (approximately 3.2 g/100 mL as average, BEDCA, 2022), 85.3 % of plant-based studied beverages presented significantly lower protein amounts than cow milk (most values below 1.5 g/100 mL), as it can be clearly observed in Fig. 2c. It was also observed that some commercial samples use a combination of various ingredients to improve protein content, as for example, one sample in the group "Others" was made of oat and walnuts, with higher values of proteins compared to simple oat drinks.

From a nutritional point of view, protein quality is conditioned by several factors, including digestibility and aminoacid profile adequacy. Digestible Indispensable Amino Acid Score (DIAAS) is a method to estimate the nutritional quality of a protein, based on amino acid digestibility values obtained in adult humans or animal models. This information cannot be obtained from labels. Based on literature, cow milk proteins present higher values for DIIAS than the plant-based beverages studied, except for soybean drink, with values close to cow milk (Fructuoso et al., 2021). Singhal et al. (2017) established that soybean drinks as well as cow milk proteins had a DIIAS value over 100 % for most essential aminoacids, while this value is below 100 % for the

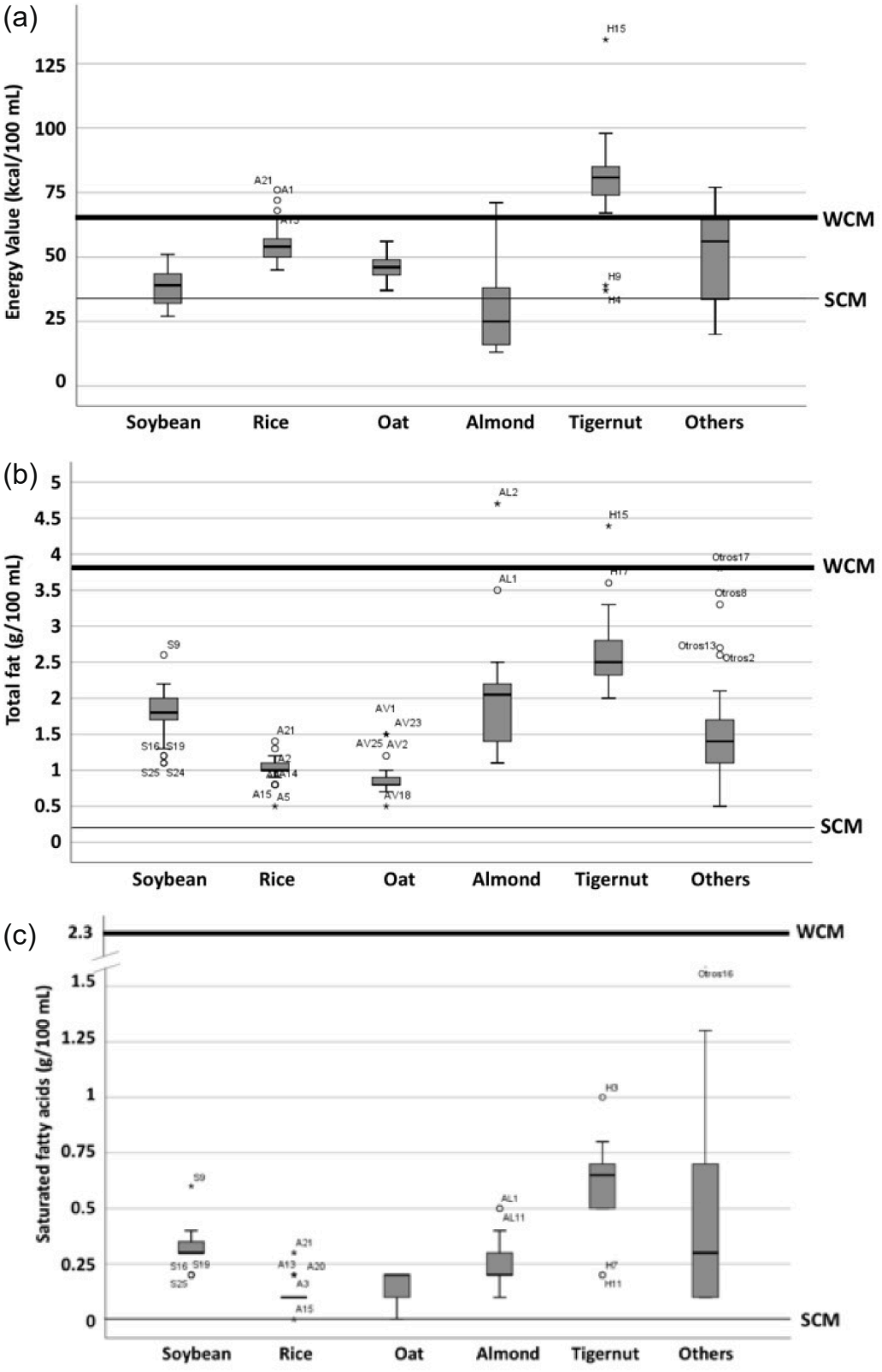

Fig. 1. Box and whiskers plots for energy value (a), total fat (b) and saturated fatty acids (c) contents. Figures show: interquartile range, median (line in the centre of the box), maximum, minimum and outliers values (sampling codes: letters indicate the type of beverage and numbers indicate the brand). Horizontal lines represent the contents in WCM = whole cow milk (thick line), and SCM = skimmed cow milk (thin line).

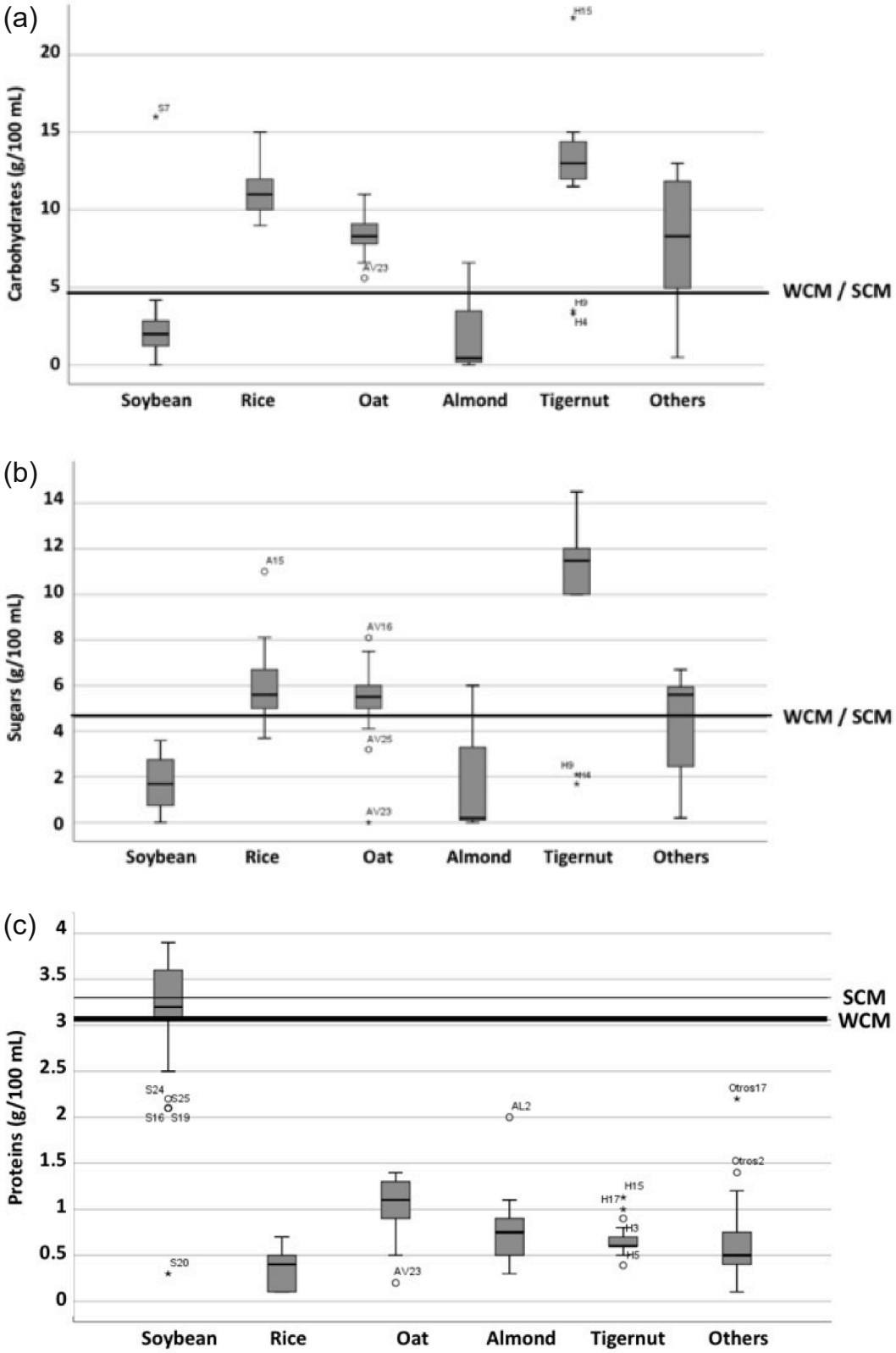

Fig. 2. Box and whiskers plots for carbohydrates (a), sugars (b) and protein (c) contents. Figures show: interquartile range, median (line in the centre of the box), maximum, minimum and outliers values (sampling codes: letters indicate the type of beverage and numbers indicate the brand). Horizontal lines represent the contents in WCM = whole cow milk (thick line), and SCM = skimmed cow milk (thin line).

sulfur aminoacids methionine and cysteine, which are limiting aminoacids in leguminous plants. For that reason, a good strategy to improve protein quality of soybean beverages would be the addition of both aminoacids; however, this practice is only done in infant soybean formulae (as established by European specific regulations), not for conventional soybean drinks addressed for general population. Protein complementation between different prime matters (eg. legumes + cereals) could also be a good alternative to improve protein quality of the final product. As previously pointed out by Paul et al. (2020), legumes appear as a favourite choice due to their rich nutritional profile, but the major limiting factor in the acceptance of legume-derived beverages is their poor sensory profile. In contrast, tigernut-based beverage is an original and pleasant tasty drink that is making a niche in the international market. The presence of the aminoacid L-arginine, the main precursor of nitric oxide (NO), in the fresh product is remarkable as it improves brain function and reduces the risk of vascular and heart diseases (Rubert, et al., 2017).

Market studies have usually the limitation of being circumscribed to a geographical area and type of consumers. In this study the Spanish market was focused; however, the results found about macronutrient composition of plant-based drinks in Spain are in agreement with others made in different European countries. We have to note that Angelino et al. (2020) in the survey of Food Labelling of Italian Products (FLIP), or Sousa & Kopf-Bolanz (2017) who surveyed the Switzerland market, do not include the traditional Spanish tigernut drink. The similarities between studies in different countries may indicate a similar trend in plant-based beverages in terms of ingredients, elaboration process and consumer preference in the European context.

3.2. Functional components through voluntary food information

Besides nutrients, plant-based milk alternatives have a several functional components (fibre, unsaturated fatty acids, phytosterols, isoflavones and other phenolics) that differentiate them from bovine milk and are often correlated to their health-promoting and disease-preventing properties, thus considered as functional components (Chalupa et al., 2022). Some of them may be declared as optional information in food labelling. Among non-mandatory parameters, information about fibre, monounsaturated (MUFA) and polyunsaturated (PUFA) fatty acids, as well as some minerals and vitamins were found in the labels of the studied products (Table 2). As non-mandatory, fibre was only declared in half of the commercial studied samples, while for MUFA, PUFA, minerals and vitamins, information was only present in about 20 % of the studied samples. This information has been related to literature about functional components in raw materials.

Table 2
Descriptive statistical results as average (standard deviation) of non-mandatory nutrition facts from the labelling of different plant-based beverages. n = number of samples presenting the corresponding claim.

	Fibre (g/100 mL)	MUFA (g/100 mL)	PUFA (g/100 mL)	Ca (g/100 mL)	Vit. D (g/100 mL)
n	64	26	26	29	27
Soybean	0.58 (0.27)^{a}	0.31 (0.14)^{a}	0.84 (0.40)^{a}	126 (12.1)^{b}	0.77 (0.05)^{a}
Rice	0.34 (0.25)^{a}	0.32 (0.05)^{ab}	0.65 (0.10)^{a}	108 (26.8)^{ab}	0.76 (0.02)^{a}
Oat	0.50 (0.31)^{a}	0.24 (0.13)^{a}	0.28 (0.16)^{a}	103 (29.3)^{ab}	0.80 (0.31)^{a}
Almond	0.45 (0.32)^{a}	1.03 (0.93)^{c}	0.33 (0.29)^{a}	94.3 (32.0)^{a}	0.97 (0.77)^{a}
Tigernut	0.45 (0.28)^{a}	–	–	–	–
"Others"	0.52 (0.38)^{a}	0.77 (0.41)^{bc}	1.0 (1.2)^{a}	120 (37.9)^{ab}	0.97 (0.71)^{a}

For each column, different letters indicate statistically significant differences ($p < 0.05$).

A remarkable difference from cow milk is the presence of fibre in plant-based beverages. Levels found in labels were close to 0.5 g fibre/100 mL, with only slight differences among them. These products may contribute to dietary intake of fibre since the average fibre consumption in current diets is lower than recommended. However, consumers should be conscious that the contribution of a portion of 250 mL of these drinks would only cover about 5 % of daily recommendations (EFSA, 2017) and a false confidence that when substituting cow milk by plant-based beverages a high intake of fibre is achieved should be avoided. In fact, claims related to fibre content are not made in this type of products, since it would require at least 3 g fibre/100 mL beverage (or 1.5 g fibre per 100 kcal), levels above the contents found in the studied beverages. For that reason, even if plant-based beverages are included in the diet, other fibre sources (as whole grains, legumes, fruits, and vegetables) should be present.

Some fibre components had demonstrated functional properties in gut health or other body functions (Shen et al., 2016); this is the case of oat β-glucan, which is a soluble and viscous fibre with beneficial functions on blood cholesterol and glucose, as EU Regulation 432/2012 has authorized it as a HC. To check the contribution of oat beverage to these benefits, the content of β-glucan, of oat beverage should be assessed, although given the contents of fibre declared on the label (about 0.5 g/100 mL), a daily intake of more than 600 mL of oat beverage should be necessary to achieve the needed amount (3 g β-glucan/day).

As previously commented, a difference between plant-based beverages and cow milk is the profile of saturated/unsaturated fat. Table 2 shows that almond beverages stood out for their MUFAs content (1.55 g/100 mL as average value), in agreement with fatty acid profile of almond seeds given by literature, where oleic appears as the major one (Paul et al., 2020; Martínez-Padilla et al., 2020; Manzoor et al. 2020). On the other hand, soybeans beverages presented the highest PUFA levels (1.0 g/100 mL), since soybeans are a rich source of n-3 linolenic acid (9 % respect to total fatty acids content) compared to most oily seeds (BEDCA, 2022). The individual levels of these compounds are not usually found in the label of food products, while mention to the global amount of SFA is mandatory and mentions about MUFA and PUFA can be optionally made, according to EU Regulation 1169/2011.

It is well known that replacing saturated fats in the diet with unsaturated fats contributes to a better cardiovascular health. For that reason, some claims are authorised regarding MUFA and PUFA in foods. EU Regulation 1924/2006 establish that to use a claim indicating that a food is high in monounsaturated fat, it is required that: at least 45 % of the fatty acids present in the product are monounsaturated fatty acids providing more than 20 % of energy of the product (European Union, 2006). Same requirements are established for claims related to polyunsaturated fat. In this regard, as the studied commercial samples of almond drink indicated fatty acid families in labels, it is remarkable that all of them could be claimed as high in monounsaturated fat (more than 80 % fatty acids were monounsaturated and they provided more than 25 % of energy). Also, all commercial samples of soybean drinks indicating fatty acids in their labels could be claimed as high in polyunsaturated fat (more than 50 % fatty acids were polyunsaturated providing more than 21 % of energy). Even, some products like tigernut drinks, that do not indicate fatty acids in the label, are likely to meet the above cited legal requirements to include the mention "high in monounsaturated fat" as these fatty acids account for 70% −74% of the total lipids in tigernuts and tigernut-based drink, respectively (BEDCA, 2022). It is interesting the presence of phosphatidic acid (PA) in this fresh beverage, unfortunately lost during UHT treatment, as appropriated PA levels in the liver could lead to a novel method for treating Type 2 diabetes and, also, it can play a prominent role in modulating skeletal muscle adaptations to endurance and resistance training, especially relevant for sport practice (Rubert, 2017). In addition, the consumption of this traditional Spanish beverage has been reported as related to prevention of various diseases as heart attacks and thrombosis, decreased colon cancer risk (Clemente-

Villalba et al., 2021), and promotion of gastrointestinal (Bixquert, 2003) and ocular health (Valero-Vello, et al., 2021).

As occurs in the case of fibre, MUFA and PUFA, it is not mandatory to declare amounts of vitamins or minerals in the label of the food products, unless they have any claim regarding these nutrients. Calcium is a key nutrient in either whole or skimmed cow milk; however, in plant-based beverages, the amount of calcium is limited to its presence in the main ingredient, or to fortification. Calcium content in the studied plant-based drinks, was 60–180 mg/100 mL, being most of the samples fortified up to 120 mg/100 mL, which is the average content of calcium in cow milk. The presence of this mineral in significant amounts (60 mg/100 mL), as defined by EU Regulation 1169/2006 (European Union, 2006) would allow the claim "source of calcium", and comes from fortification. This is because, according to Food Composition Database BEDCA (2022), the naturally present calcium amount of the prime matter used in these products hardly would reach the minimum content required by European Regulation to support the nutrition claim "Source of calcium" when used in the proportions technologically adequate to obtain the beverage. This was also corroborated with the mention of calcium salts in the ingredients list of the studied samples. The presence of calcium fortification in the plant-based drinks marketed in Spain agree with the study of Sousa & Kopf-Bolanz (2017) who surveyed the Switzerland market with the observation that 33 % were calcium fortified, very similar to 34 % found in this study. It has been reported that the potential of plant-based drinks in arresting caries depends on their calcium and phosphorus content as the presence of both ions in the oral cavity prevent dissolution of enamel (Rahamat, et al., 2019).

It should also be considered that calcium bioavailability is different in cow milk than in plant-based drinks, due, to the chemical form (usually tricalcium phosphate as fortifying agent), and the absence of vitamin D, as well as the presence of insoluble fibre and the potential presence of phytates, oxalates, lectins, and saponins depending on the prime matter. Phytates are antinutrients that should be taken into account when considering plant-based beverages as calcium sources comparative with cow milk. These compounds are present in different seeds such as pulses, cereals, and nuts, and reduce mineral bioavailability, mainly on iron, zinc and calcium. In this regard, previous studies on plant-based beverages have reported levels of phytic acids of the level of phytic acid in 1.41 mmol/L in soy drinks, higher than for other plant beverages such as oat drink (Burgos-Luján and Tong, 2015). This presence may condition a lower bioavailability of calcium compared to cow milk and would justify the enrichment with high levels of calcium in plant-based beverages.

For that reason, even if the product is fortified, other calcium sources should be recommended in the diet when plant-based drinks are used to replace cow milk (Fructuoso et al., 2021; Vitoria, 2017). In agreement with Chalupa-Krebzdak, et al. (2018), more research is needed to quantify the effect of anti-nutrients and poor calcium solubilisation more precisely on the total calcium absorption of common plant-based milk alternatives.

While calcium is naturally present in variable amounts in the seeds used as prime matter of plant-based beverages, vitamin D is absent in plant products; for that reason, many of these beverages are also fortified to approach cow milk content. As vitamin D facilitates calcium absorption, both nutrients are often together fortified; however, attention should be paid to avoid excess that create disequilibria in absorption process leading to a reduction in bioavailability of them (Zhou et al., 2021). Vitamin D as an ingredient was present in more samples than declared (74.2 % of the studied drinks), reaching an amount of 0.75 μg of vitamin D per 100 mL of final product. This means contents much higher values than those naturally found in cow milk (0.01–0.03 μg/100 mL).

3.3. Principal component analysis of beverage composition

For a better explanation of the variability in all the studied samples, proximal composition (energy, carbohydrates, sugars, fat, SFA, fibre, proteins, and fat) of the samples included in this study have been subjected to a PCA analysis (Fig. 3). This multivariate analysis was performed providing a two-dimensional map for explaining the observed variance. The two components of the PCA explain 76.82% of the total variance (39.46% first, 37.36% second). It can be observed in Fig. 3, that there are meaningful differences between some of the investigated plant-based drinks, as tigernut *versus* soybean and almond, substantially in terms of their sugars, energy, and carbohydrates content.

The first principal component (39.46% of the total variance) was highly correlated with carbohydrates and sugars, and in lesser degree with salt, fibre, and energy, while it was negatively correlated with proteins, SFA and fat. The second principal component (37.36% of the total variance) was highly correlated with energy, sugars and SFA, and in minor degree with carbohydrates and proteins while it was negatively correlated with fibre content.

A very clear separation was obtained between both whole and skimmed cow milk, appearing in the first quarter, and the different plant-based beverages. Among them, drinks made from oily seeds (soybean and almond) were separated and highly characterized by proteins and fibre content, moreover soybean was more characterized by SFA and fat content than almond drink. Cereal drinks (rice and oat) appeared also separated and characterized by carbohydrates and sugars content, and oat also by fibre content. Tigernut drink is characterized by sugars, energy, and carbohydrates content. This data representation showed significant differences among the composition of different types of beverages depending on the characteristics of the prime matter used for their elaborations and confirm the fact that they cannot be considered as milk replacers, but as different food products to be included in a diversified diet.

3.4. Information to consumers appearing in the studied beverages as nutritional and health claims

Nutritional and specially health claims are used to stand out these functional roles of food products, and are tools used by consumers to perceive when a product has any nutritional or functional benefits. Thus, Table 3 shows the distribution of samples with or without nutritional or other claims appearing in the label of the studied samples. From this study, 119 (87%) products had at least one NC, while only 17 samples had any nutritional claim at all. Among these group the mention "No added sugars" was found in 55% of the total products; 34% had a claim referred to the calcium content ("source of calcium") and 23% to the vitamin D addition "enriched with vitamin D". Considering that products marketed with NC and or HC are usually regarded as healthier by

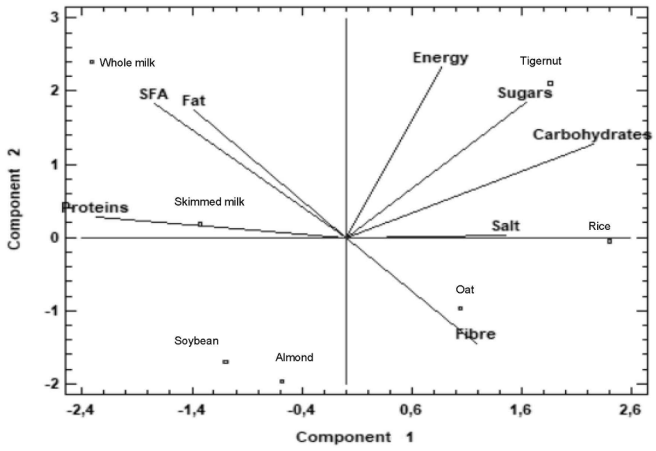

Fig. 3. Principal component analysis (PCA) graph of nutrients from plant-based beverages *versus* milk (whole and skimmed), as a two dimensional map, explaining 76.8% of variability. SFA = saturated fatty acids.

Table 3
Descriptive statistical results as average (standard deviation) of nutrition facts in different plant-based beverages, related with claims in labelling. n = number of samples.

	n	Energy value (Kcal/100 mL)	Fat (g/100 mL)	Saturated fatty acids (g/100 mL)	Carbohydrates (g/100 mL)	Sugars (g/100 mL)	Proteins (g/100 mL)	Salt (g/100 mL)	Ca* (g/100 mL)	Vitamin D* (g/100 mL)
"No added sugars" claim	75	43.2 (15.8)	1.4 (0.6)	0.27 (0.28)	6.5 (4.8)	3.7 (2.9)	1.03 (0.96)	0.09 (0.03)	97.9 (29.7)	0.86 (0.55)
No claim about "No added sugars"	61	54.5 (21.8)	1.9 (0.9)	0.35 (0.22)	7.8 (4.9)	5.7 (3.9)	1.36 (1.16)	0.09 (0.04)	127.2 (16.2)	0.82 (0.20)
Calcium related claim	46	39.7 (14.5)	1.3 (0.4)	0.22 (0.16)	5.3 (4.2)	3.6 (2.5)	1.46 (1.23)	0.1 (0.03)	113.5 (28.6)	0.71 (0.13)
No claim about Ca	90	52.6 (20.4)	1.8 (0.9)	0.35 (0.29)	8.0 (4.9)	5.1 (3.9)	1.03 (0.95)	0.08 (0.04)	110.0 (24.5)	1.32 (0,78)
Vitamin D related claim	31	35.1 (13.0)	1.2 (0.4)	0.2 (0.15)	4.5 (3.6)	3.2 (2.5)	1.22 (1.08)	0.1 (0.04)	108.9 (27.6)	0.82 (0.42)
No claim about vitamin D	105	52.1 (19.5)	1.7 (0.8)	0.34 (0.28)	7.9 (4.9)	5.0 (3.7)	1.16 (1.07)	0.08 (0.04)	118.7 (27.8)	1.01 (0.51)
One or more nutritional claims	121	44.8 (16.2)	1.5 (0.7)	0.28 (0.26)	6.5 (4.5)	4.0 (3.0)	1.21 (1.10)	0.09 (0.04)	112.9 (27.8)	0.82 (0.43)
No nutritional claims	17	72.2 (24.1)	2.5 (1.0)	0.49 (0.2)	11.1 (5.2)	8.9 (4.2)	0.96 (0.75)	0.07 (0.04)	0 (0)	1.50 (0)

*As calcium and vitamin D contents are not mandatory food information in label, table values for samples with no claims about these components come from samples providing this information (6 for calcium and 4 for vitamin D).

consumers, the present study has found that when beverages with or without nutritional claims were compared, those with claims had in general, lower amount of energy, fat, saturated fat, carbohydrates and sugars, while the protein content was higher (Table 3). These data do not agree with those obtained from the study on plant-based beverages in Italian markets (Angelino et al, 2020), where the nutritional profile of beverages with and without NC was quite similar except for a lower content of total fat and saturated fat. However, the Italian survey agree with the present results in the fact that those beverages that showed the nutritional claim "source of Ca" had generally lower amount of energy, fat, carbohydrates, and sugars, while their protein content was higher.

The claim "No added sugars" is one of the most searched by consumers to make a healthier food choice. For that reason, Figs. 4 and 5 show boxplots reflecting the characteristics of nutritional composition of plant-based drinks, according to the presence or absence of this information. For almond and tigernut drinks, when comparing average results, slightly low energy value was found for products labelled as "No added sugars"; however, in general no statistically significant differences were observed, either when comparing all the samples, or between each type of drinks. Similar results were found regarding carbohydrates and sugars content in the samples. As it previously mentioned, almond drinks usually contain less amount of the main ingredient than other plant-based beverages (5 % compared to the general values of 10–15 %), as a result the amount of sugars found in the final product may be more dependent on the amount of added sugar, while for the other products the high amount of sugars present comes from the prime matter. From the presented results, it can be observed that, except for almond drinks, those labelled as "No added sugars" does not necessarily provide less energy, carbohydrates and sugars than those without this claim, and in some cases their amount of sugars is higher than in cow milk. It has also been considered that the presence of the claim "No added sugar" may be an indicator that other types of sweeteners, either natural of synthetic are used thereby increasing consumer acceptance.

Consuming an excess of added sugar has been pointed out as one of the etiologic causes for dental caries and tooth decay as well as other health problems such as obesity and hypercholesterolemia (WHO, 2015; EFSA, 2021). To lessen the burden of chronic illnesses relevant to nutrition WHO (2015) suggested a recommendation that added sugar consumption should stay below 10% of calorie intake and the consumption of foods/drinks that include free sugars should be limited to four times a day (Aydar et al., 2020). In this way, when plant-based beverages are used as staple foods in the diet, those with no added sugar should be preferred. As pointed by Paul (2020), one major advantage of plant-based beverages over conventional milk is that there is an opportunity to manipulate their composition based on demand.

The nutritional claim "source of calcium" appeared in 34 % of the studied products, mainly in soybean (55.6 %), oat (44%) and almond (33.3 %) beverages, while the claim "vitamin D fortified" was found in 22.8 % of the studied samples, being more frequent in soybean (29.6 %), oat (32 %) or almond (36.4 %) beverages. As it is observed in Table 3, there were not statistically significant differences between calcium contents of samples with and without claim about calcium, and the same happen for vitamin D. This is because only a few samples without claims indicated the contents of calcium and vitamin D in labelling (6 for calcium and 4 for vitamin D). According to other authors (Albaladejo, 2022), it has been observed that in some cases a source of calcium or vitamin D is included in ingredient list of some products, but no claim is made about this fact.

Other interesting point observed in this study was the presence of organic certification in vegetable drinks, since it is often considered as an added value for a product in terms of health and sustainability. This issue is especially important in this type of food products, since many consumers of plant-based beverages are vegan or vegetarian population with a motivation for environmental issues. This group of consumers would find attractive claims about organic certification in food products, and thus, this may be a key item for producers of plant-based beverages. However, to make a right choice, consumers should be informed that this claim is related to more environmentally friendly practices in agricultural production of ingredients and not necessarily to a better nutritional quality of the final product. From the present study, 64 % of vegetable drinks had the organic product certification on their label. Interestingly, the drinks that had this certificate usually showed a greater amount of energy and carbohydrates than the drinks without this organic certification. Results obtained are consistent with those for vegetable drinks present in Italian markets (Angelino et al., 2020), indicating that 74 % vegetable drinks in the Italian markets came from organic farming, and do not necessarily show an improvement in the nutritional quality of these products. These results break the idea of the consumer trend in seeking organic drinks as healthier products in terms of nutritional value.

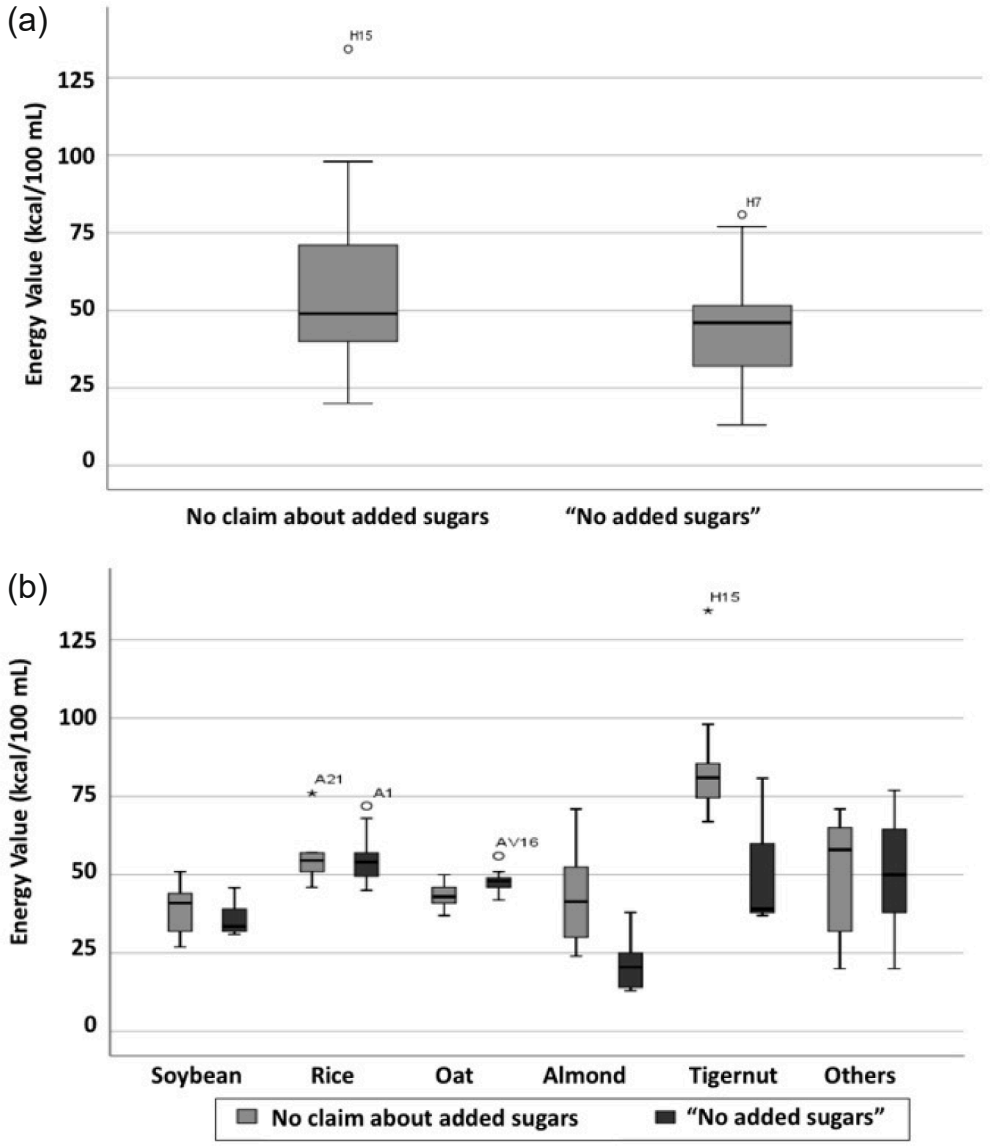

Fig. 4. Box and whiskers plots for energy value of different plant-based beverages with or without the claim "No added sugars". a) all types of beverages; b) different types of beverages. Figures show: interquartile range, median (line in the centre of the box), maximum, minimum and outliers values (with sampling codes).

4. Conclusions

Plant-based beverages cannot be considered as a milk analogue, but a different food product, with their own nutritional profile and functional properties. They present a wide variability in composition, depending on the type and amount of plant material and the addition of other ingredients, mainly sweeteners and enrichment with minerals and vitamins. A limitation of the study done could be the circumscription to Spanish market; however, the trends detected are similar to those reported in other European countries.

Differences with cow milk include intermediate values of energy and fat content between skimmed and whole cow milk and a more unsaturated profile for fatty acids. Carbohydrate content is usually higher than that of cow milk, and it is one of the most variable factors in the final composition.

Soybean and almond drinks significantly differentiate from others, by their lower energy values, carbohydrates and sugars contents, and higher fat content; they could be claimed as high in polyunsaturated and monounsaturated acids respectively. Soybean drinks present the highest protein content, similar to cow milk. On the other hand, oat and rice drinks present low fat and high carbohydrates content. Tigernut drinks stand out with the highest energy value, as well as fat, carbohydrates and sugars, which justifies a sporadic use, for example when an extra source of energy is needed (e.g. sport practice), with the advantage of a healthy fatty acid profile high in monounsaturated acids. Differently to cow milk, all the studied products provided some amount of dietary fibre, although with low contribution to dietary requirements. About one third of the products in the market are calcium enriched to levels similar to cow milk, and 23 % are enriched in vitamin D.

The claim "No added sugars" is present in more than half of the studied samples, reflecting that consumers are receptive to this issue. This claim discriminated better for almond and tigernut beverage than for other products; however, claims related to "No added sugars" or organic certification did not necessarily mean a better nutritional profile, in terms of energy, carbohydrates and sugars than those non-claimed, or than cow milk.

Although plant-based beverages are not considered as cow milk replacers, their inclusion within the context of diversifying a balanced diet

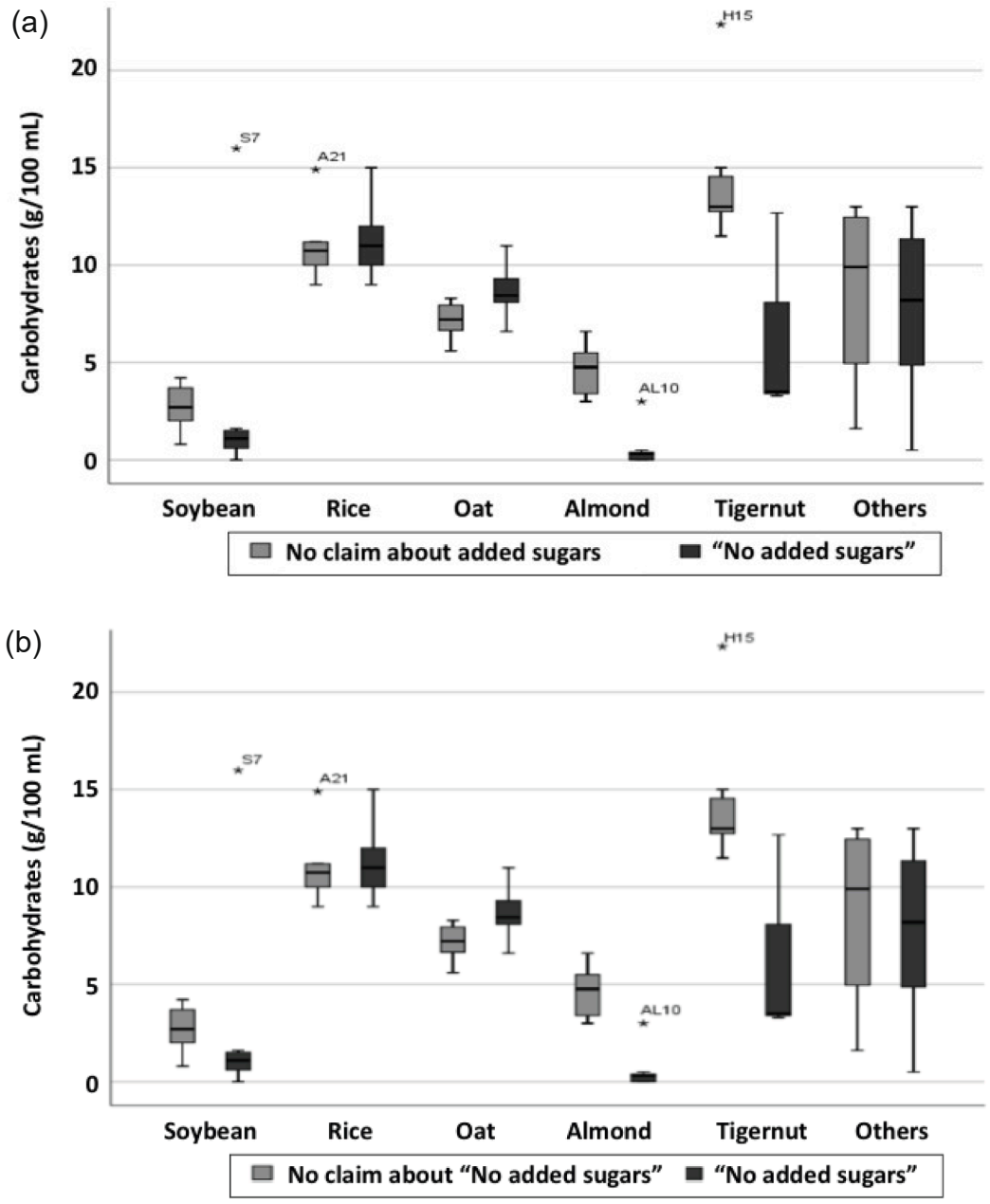

Fig. 5. Box and whiskers plots for carbohydrate contents (a) and sugar contents (b), of different plant-based beverages with or without the claim "No added sugars". Figures show: interquartile range, median (line in the centre of the box), maximum, minimum and outliers values (with sampling codes).

can provide functional components of interest, either if cow milk is consumed or in diets with milk exclusion. However, as many consumers remain using them as milk substitutes, research on new sources of high-quality proteins and more fibre and calcium should be encouraged. Also nutritional education of consumers for a better understanding of food labels is advisable.

CRediT authorship contribution statement

M.L. Pérez-Rodríguez: Conceptualization, Methodology, Investigation, Writing – original draft, Supervision, Project administration, Writing – review & editing. **A. Serrano-Carretero:** Formal analysis, Investigation. **P. García-Herrera:** Writing – original draft, Writing – review & editing. **M. Cámara-Hurtado:** Supervision, Project administration, Writing – review & editing, Funding acquisition. **M.C. Sánchez-Mata:** Writing – original draft, Writing – review & editing.

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.

Data availability

No data was used for the research described in the article.

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