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# Understanding the marketed plant-based beverages: From ingredients technological function to their nutritional value

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ABSTRACT

Despite the market expansion of plant-based beverages (PBB) there is limited information about what is driven the market and the nutritional status of the existing beverages. The objective was to identify the existing gaps in the PBB market with particular emphasis on their composition and nutritional value. PBB are mainly based on individual flour/powder and blends and sunflower oil is frequently present, besides gellan gum to stabilize the emulsion. In general, PBB are low calorie drinks (10–84 Kcal/ 100 mL), with low amount of saturated fat (0.1–1.90 g/ 100 mL) and fibers, and large variation in proteins (0.1–12 g/ 100 mL). The calcium fortification of PBB is comparable to the calcium levels of whole cow's milk, although the vitamin fortification is low. Analysis reveals that salt and oil reduction, as well as fibers enrichment might drive future innovations.

## 1. Introduction

Plant-based beverages (PBB) is an exponentially growing segment all over the world (Vaikma et al., 2021). The global PBB market was valued at approximately US$9.8 billion in 2017 and it is expected to reach US $19.7 billion by 2023, growing US$10 million in 6 years (Statista, 2022). However, PBB cannot be considered new, as there is a long tradition in Eastern and Western cultures for this type of beverages that are commonly present in the market (Bernat et al., 2014). Among them, *horchata* (Spain, from tiger nuts); *Masvusvu* (Zimbabwean, malted millet); *Boza* (Turkish, fermented millet); *Sikhye* also called *dansul* or *gamju* (South Korea, cooked rice and malt extract); and the most well-known is the *soy milk* from China (Arici & Daglioglu, 2002; Codina et al., 2016; Kim et al., 2012; Mäkinen et al., 2016; Sethi et al., 2016; Zvauya et al., 1997). Initially marketed as an alternative to cow's milk for people with lactose intolerance, the consumption of the soy beverage jumped 50 years ago from the local to global market (Mäkinen et al., 2016). Currently, followers of plant based diets and people concerned about the environment are increasing, and with them, the interest for these PBB (Penha et al., 2021; Sethi et al., 2016; Shori & Al Zahrani, 2022), turning this segment as a great opportunity to create PBB using different plant sources (Sethi et al., 2016).

Plants from different sources have been used for making PBB, including the following groups: i) cereals (rice, oat, corn, spelt, rye, quinoa, kamut); ii) legumes (soy, peanut, lupin, cowpea), iii) nuts (almond, coconut, hazelnut, pistachio, walnut); iv) seeds (sesame, flax, sunflower, pumpkin, hemp); and v) pseudocereals (quinoa, teff, amaranth) (Munekata et al., 2020). Whatever the origin, common processing stages are: wet milling, filtration, sterilization, homogenization, aseptic packaging, and storage (Aydar et al., 2020).

Although dietary restrictions or nutrition are the driving forces of this market, the individuals that enjoy sensory experiences cannot be neglected. Recent scientific literature reports that consumer preferences are dominated by the texture, viscosity, and mouthfeel of PBB (Jaeger & Giacalone, 2021; Moss et al., 2022; Vaikma et al., 2021). To achieve these characteristics is important to form an oil-in-water emulsion, using oils and emulsifiers to modify their stability (McClements, 2015). Nevertheless, much more interest has been focused on the nutritional component and healthy benefits, specifically micronutrient fortification (calcium and vitamins), and bioactive compounds (Ahmad & Ahmed, 2019; Aydar et al., 2020; Silva et al., 2022), although observing high variability in their nutritional composition. In fact, Chalupa-Krebzdak et al. (2018) analyzed 18 beverages based on soy, coconut, rice, hemp, almond and cashew, observing that the protein content ranged between 0.42 and 3.16 g/ 100 mL, while fats varied from 0.83 g/100 mL to 6 g/ 100 mL. Likewise, Vanga & Raghavan, (2018) analyzed 23 beverages

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made from almond, soy, rice or coconut, obtaining similar variability, even in saturated fats (0–5 g/ 100 mL), sugar (0–15.6 g/ 100 mL), and salt (till 0.48 g/ 100 mL). Recently, with the increasing popularity of PPBs, Craig & Fresán, (2021) were able to analyze 148 beverages with new main ingredients (almond, cashew, coconut, hazelnut, macadamia, oat, pea, rice, soy and other -not specify), and authors confirmed previous findings, stating the high variability, and their high content in salt, sugar and saturated fat (composition range in g/ 100 mL: protein 0–8.9, saturated fats 0–4.8; sugar 0–14). However, the market is rapidly growing and with it, the search for alternative plant sources. Therefore, the purpose of the research was to conduct an extensive analysis (benchmarking) of the current market, to identify trends in the composition and nutritional value of PBB, which could help in designing PBB based on scientific knowledge.

## 2. Materials and methods

Data gathering was conducted from May 2022 to August 2022. PBB from the major groceries stores in Europe (El Corte Inglés, Consum, Mercadona, Herbolario Navarro, Eroski in Spain; Tesco in United Kingdom; Edeka in Germany; Auchan, Carrefour, Dia present across Europe) and North America (Walmart in USA and Canada) were included, having samples from private and commercial brands. Data collected included PBB as non-dairy alternatives that are obtained from an aqueous extract of the raw materials and not as a squeezing of the raw material itself, like occurs in juices from vegetables or fruits. Different data processing programs were used throughout the study: Microsoft® Excel 2019 (Version 16.67), Stata/SE (Version 17.0) (College Station, TX, US), and ggplot2 package (Version 3.3.2) (Wickham, 2016) for R (Version 4.0.3) (R core team, 2020). Labels were analyzed for the PBB composition and nutritional facts information. Commercial PBB made from nuts, cereals, seeds, pseudocereal and legumes were considered (including those with cocoa, coffee, fruit, and other flavors), those PBB with missing nutritional information were excluded. Ingredients were recorded and classified into raw materials, oils, gums, salt and minor ingredients (added as a fortifiers). A nutritional role was assigned to the minor ingredients without technological contribution. Afterward, a frequency analysis and an alluvial plot were carried out with the ingredients to identify processing trends. A box-and-whisker plot compared the macronutrients composition of these beverages, classifying them by raw material. Salt was plotted considering both raw material and its presence or absence in the list of ingredients. Principal component analysis (PCA) was carried out to discriminate beverages according their nutritional pattern and recipe (type of oil, raw material and hydrocolloid).

## 3. Results and discussion

### 3.1. Plant based beverages composition

Plant based beverages present in groceries stores were analyzed, which accounted up to 306. Labels were analyzed in relation to their nutritional composition and the ingredients listed in the package. On average the beverages analyzed contained eight ingredients in their formulation, including vitamins and minerals added with the purpose of fortification. Ingredients used for processing were water, raw plant-based powders, and in some cases, oil, gums, and sugar. Water was the main ingredient, which allows soaking and softening the rest of ingredients, making them ready for grinding. Water is also the basis for preparing the emulsion that will result in the beverage.

The second ingredient in PBB were the vegetable powders or flours, such as almonds, coconut, rice, oats, soybeans, etc. The type of consumers of this type of beverage has changed and with that their preferences. PBB were sought primarily as dairy substitutes produced from soybeans, oats or coconut (Paul et al., 2020). Currently, a wide variety of grains, and even blends, are used to prepare PBB. In fact, 84% of the analyzed beverages contained a unique powder, 14% of them were formulated with two or more main ingredient, and 2% were produced from protein isolates (manly pea protein). An alluvial plot was used to show the relationships and frequencies of the different ingredients that were categorized as raw materials, oils and hydrocolloids (Fig. 1). Principal raw materials or sources of powder for PBB included, oat (76), soy (68), almond (57), rice (28), coconut (15), plant-based (7) (no defined) or tiger nut (3). To a lesser extent cashew (2), millet (2), flax (2), hazelnut (1), spelt (1), birdseed (1) and hemp (1) were used. A group of beverages contained blends (42), that were a variety of binary combinations of powders, mainly rice, oat and soy combined with different types of nuts, coconut or seeds. The analysis revealed that the PBB market is not expanded based in a unique source of vegetables, but it is rapidly growing to offer a great variety of flavors and textures from a range of vegetable sources. Therefore, technological properties and nutritional composition will be rather different, which force to adapt PBB processing to the type of raw material used (nuts, pulses, cereals, etc.) (Sethi et al., 2016). Therefore, the concentration of the other ingredients was variable since they were accommodated to the need and application of the ingredients. The other important aspect is that this trend in raw materials confirms the interest in bioactive compounds enrichment in PBB, as has been reported for other foods (Betoret and Rosell, 2020).

Vegetable oils are a common ingredient in PBB, because some consumers of this type of beverage often seek dairy substitutes resembling the texture of the cow milk. The system oil-in-water emulsion allows imitating many sensory characteristics of cow's milk, such as appearance, viscosity, stability, mouthfeel and taste (Aydar et al., 2020; Martínez-Padilla et al., 2020; McClements, 2015; Pineli et al., 2015). For this reason, among the 306 beverages gathered for this study, 31.37% of them contained vegetable oil as an ingredient in their labelling (Fig. 1). Within the group of beverages containing vegetable oils as part of their ingredients, sunflower oil was the most frequent one (78.13%) and particularly in PBB containing either rice or oat, which suggested those beverages were marketed as alternatives to dairy milk for those with dietary restrictions. Other oils present in the PBB were rapeseed oil in 11.46% of PBB containing oils, followed by oil blends (rapeseed + palm; sunflower + shea; canola + sunflower) in 3.12% of them, or rapeseed, canola, and flax in a minority (2.08%). The presence or absence of vegetable oils in the formulation could be related to the type of the vegetable powder or raw material. In fact, beverages made with high-fat raw materials like almond, coconut, soy, cashew, hazelnut, or tiger nut, rarely (<3%) contained other oil source in their label. Conversely, the presence of vegetable oil was higher in beverages based on cereal grains (rice, millet, spelt) or seeds (flax, birdseed). Surprisingly, oat based PBB showed added vegetable oil, despite of being a cereal with high fat content. In the case of blends, they were majorly combining a cereal with a high-fat commodity that might provide oil functionality in the emulsion. Because of that, more than 80% of the beverages made with blended raw materials did not require in their formulation the presence of oil to obtain the silky appearance and palatability characteristics. This is an interesting technological and nutritional advance, that attends one of the most recent demands of consumers, such as avoiding the consumption of added fats (Asioli et al., 2017).

To obtain stable oil-in-water emulsion in the production of beverages, it is necessary the use of stabilizers that can reduce the droplet size of the oil used, thus keeping the aqueous and oil phases homogenized during the storage time (Krempel et al., 2019). Fig. 1 shows that 184 PBB (60% of total PBB analyzed) do contain hydrocolloids in their formulation. Within those PBB, the most used hydrocolloid was the gellan gum (51.11%), followed by a mixture of different sources (41.85%), and then locust bean gum (2.71%), guar gum (1.63%), carrageenan (1.63%), sodium carboxymethyl cellulose (0.54%) and xanthan gum (0.54%). When a mixture of different hydrocolloids was incorporated, 74% of those PBB had gellan gum within the mixture or gellan gum + locust bean gum. Hydrocolloids functionality in this type of emulsions stabilize

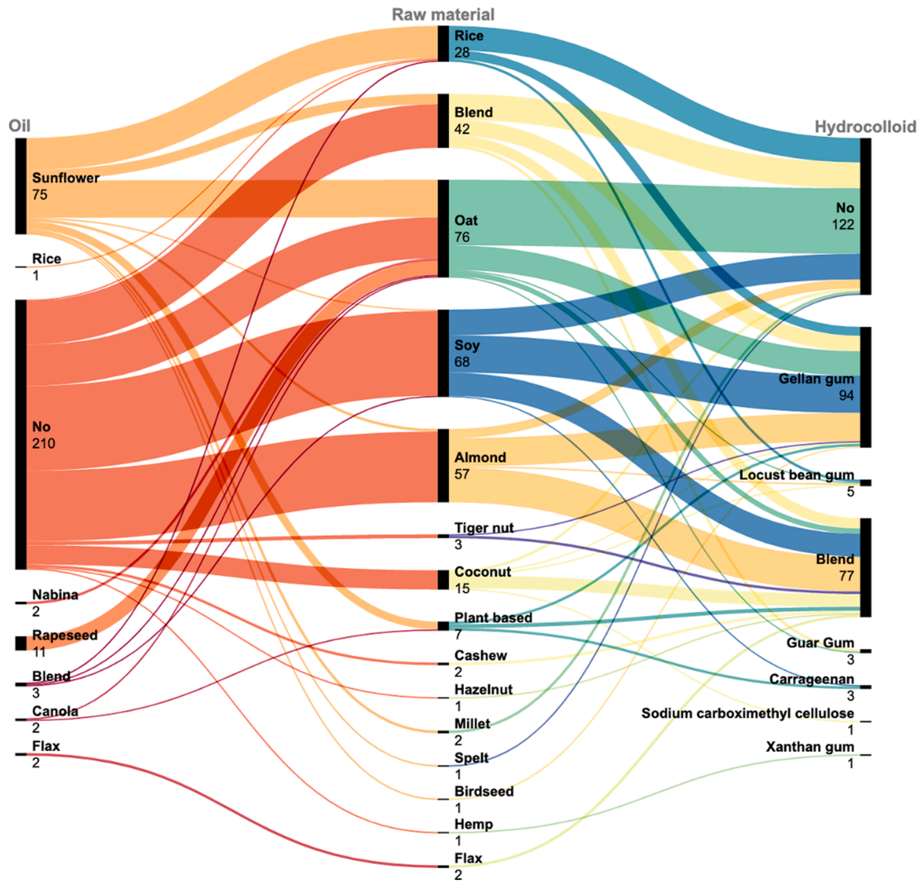


**Fig. 1.** Alluvial plot to the main ingredients of PBB. Relationship and frequencies between the type of oil, raw materials and hydrocolloids included in the labels of the marketed PBB.

the oil droplet, and reduce the surface tension of the emulsion interface, without increasing the viscosity during storage (Krempel et al., 2019). Fallourd & Viscione, (2009) pointed out that the selection of the hydrocolloid depends on many factors like the amount of protein, the pH and the amount of oil and particles in suspension, and those authors identified gellan gum as efficient suspending agent to prepare structured liquids and low viscosity gels.

Despite the stabilizing functionality of the hydrocolloids, some PBB did not contain any, and those were mainly composed of cereals. Specifically, from the cereal-based beverages (107), only 34 contained hydrocolloids. Considering that PBB processing comprised a heat treatment and homogenization stage (Penha et al., 2021; Qamar et al., 2020), presumably the starch content of cereals provides the stabilizing functionality in the absence of hydrocolloids. In fact, Boulemkahel et al., (2021) reported that low pressure homogenization modifies the rice flour properties increasing the emulsifying properties.

### *3.2. Analysis of the nutritional facts of the currently marketed plant-based beverages*

As the market of PBB is expanded, a special attention must be paid to their nutritional profile. Energy is one of the main indicators that consumers consider and affects the purchasing decision. Typically, health-conscious consumers relate high calories content to less healthy products, associated to obesity among other diseases (Charbonnier et al., 2015). As shown in Fig. 2 A, the energy content of the different PBB analyzed was rather variable. In general, cereal-based beverages provide higher energy than the PBB average, and the least energy dense PBB were those made from coconut, nuts and seeds. Hemp based beverages provides similar energy than millet-based ones, 55 kcal/100 mL and 58.33 kcal/100 mL, respectively; nonetheless, the presence in the market is still incipient. The tiger nut-based drinks were the most caloric ones, ranging from 52 to 84 kcal/ 100 mL, all of them over the average value, 41.73 kcal/ 100 mL. Tiger nut has been used from ancient times to obtain a sweet and cold drink consumed mainly during hot periods (Martín-Esparza & González-Martínez, 2016). Traditionally, this drink is prepared adding sugar, which results in a high caloric drink (Corrales et al., 2012). Vegetable drinks made of powders blends showed the highest deviation in the energy content (4.17–74 kcal/ 100 mL), related to the variability of raw materials. In contrast, rice-based beverages had the lowest variation of all plant-based drinks (45–57 kcal/ 100 mL). Chalupa-Krebzdak et al., (2018) also reported great variability in the energy content of marketed PBB from different brands, being energy dense PBB those with higher content in carbohydrates and sugars, which also raises the glycemic index of these beverages (Walther et al., 2022).

PBB have low total fat content, with an average value of 1.56 g/ 100 mL (Fig. 2B), which is far lower than the fat content of whole cow's milk (3.2 g/ 100 mL, being 1.86 g/ 100 mL coming from saturated fat) reported by the USDA (2022). Likewise, the fat content in the present analysis was lower than that described by Vanga & Raghavan, (2018), who reported values that were 40–50% higher for PBB made of almond, coconut, rice, or soybean. This divergence confirms that the PBB segment is shifting towards low fat content beverages. Nevertheless, the present analysis found some exceptions, like PBB made with almond, blended powders, flax, oat or soy, that exceeded the amount of fat in whole cow's milk, particularly those containing almond (4.7 g fat/ 100 mL). In general, results agree with those described by Chalupa-Krebzdak et al., (2018), except for soy beverages that presently contain low fat values (Fig. 2B), confirming the nutritional improvement of this type of beverages. Regarding the type of fats, saturated and unsaturated, the

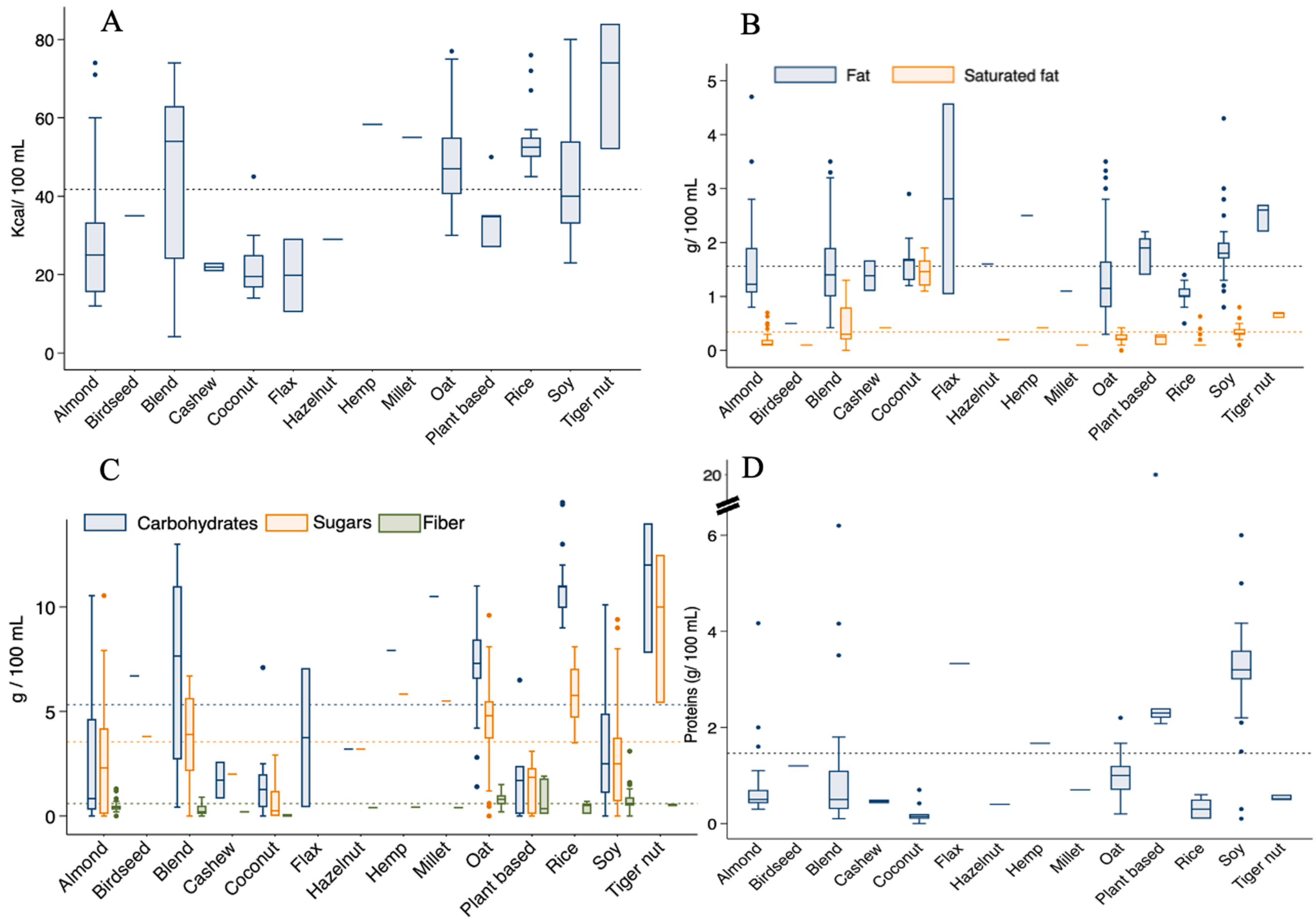


**Fig. 2.** Analysis of nutritional facts of pbb. a: energy (kcal); b: total fats (blue) and saturated fats (orange); c: carbohydrate (blue), sugars (orange) and fiber (green); d: proteins. horizontal dotted lines represent the mean of all values obtained for that compound. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

information was available in some PBB, which, although no general statement could be done, but the analysis revealed that PBB have low content of saturated fats, and more monounsaturated and polyunsaturated fats. Recently, Craig & Fresán, (2021) described that in soy, flax and hemp-based beverages, polyunsaturated fats were predominant, whereas rice and almond based beverages, contained mainly monounsaturated fats, which are associated with cardiovascular health because of their action controlling the levels of glucose in blood and reducing total cholesterol (Jenkins et al., 2006; Sabaté et al., 2003). The average content of saturated fat in those beverages was 0.34 g/ 100 mL; only coconut-based beverages showed a completely different profile, with a much higher saturated fat content (1.90 g/ 100 mL). Although saturated fat contents are related to unhealthy diet, because they raise LDL cholesterol levels, coconut oil increases HDL cholesterol, being able to compensate for its high saturated fat composition (Eyres et al., 2016). It must also consider that coconut oil contains lauric acid, as saturated fat, which has been associated to brain development and boosting the immune system (Sethi et al., 2016). As expected, PBB do not declare cholesterol content, whereas whole cow's milk contains 12 mg/ serving (USDA, 2022). Therefore, except for coconut-based beverages, analyzed PBB show healthier lipid profile than cow's milk for people suffering diseases related to high blood lipid levels.

Carbohydrates and sugars content in the marketed PBB were different, which was largely dependent on the raw material of the beverages (Fig. 2C). Drinks based on almond, cashew, coconut, flax, undefined plants, or soy, had lower carbohydrate content than the average (5.33 g/ 100 mL). Tiger nut-based drinks had the highest carbohydrate content (11.27 g/ 100 mL), despite the low carbohydrate content reported for tiger nuts (Sánchez et al., 2016), but they usually content high amounts of added sugar (70% of carbohydrates were sugars). Rice based beverages, and in general those containing cereals (millet and oat) showed high carbohydrate content, which was expected considering their starch content (Sultana et al., 2022). Therefore, in general, PBB have higher amount of carbohydrates than whole cow's milk (4.67 g/ 100 mL) (USDA, 2022).

The content of sugars (Fig. 2C) in the analyzed beverages followed the same trend described for total carbohydrates, although with lower levels. However, it must be stressed that the great difference between total carbohydrates and sugars content in the cereal-based drinks occurred in those containing coconut or blends. The level of carbohydrate and sugars in beverages made from nuts (almonds, cashews, hazelnuts), seeds (flax, birdseed, hemp) and legumes (soy) was rather similar, and most of the carbohydrates content were due to the sugar content. The highest average was found in the tiger nut-based beverages (9.30 g/ 100 mL), as mentioned before, and the lowest in the coconut-based beverages (0.82 g/ 100 mL). Only 78 from 306 beverages had sugar in their list of ingredients, so most of the sugars content was from the raw materials used in the formulation of the beverages.

Although the fiber content (Fig. 2C) was not always declared, these beverages did not have a notable fiber content (mean value was 0.59 g/ 100 mL), with oat, soy, and plant blend based showing 0.79, 0.71 and 0.77 g/ 100 mL, respectively. The fiber content was mainly determined by the type of raw material, but in some cases the incorporation of fiber was remarkable, i.e., a beverage from the group of plant-based containing chicory root reached 1.9 g/ 100 mL of fiber. In addition, it should be considered that hydrocolloids presence could provide an extra contribution of fiber, although no direct relationship was found between the beverages with added hydrocolloids and fiber content. The production of fiber-rich foods have been challenging for research and industry, especially in beverage segment, where consumer perception is largely affected by the appearance and texture of the liquid (Moss et al., 2022).

Just like the rest of macronutrients, the market study revealed large differences in the protein content (Fig. 2D). The highest content was observed in beverage group made with undefined plants, particularly a PBB with 20 g protein/ 100 mL, which was enriched with 2.5% pea protein isolate (Fig. 2D). Apart from those, the PBB with higher amount of proteins were those containing flax (3.3 g/ 100 mL) or soy (3.15 g/ 100 mL). The rest of beverages had lower protein content than the overall average (1.46 g/ 100 mL). Protein content of these PBB was below the protein contribution of whole cow's milk (3.18 g/ 100 mL) (USDA, 2022). An alternative to increase the amount of proteins is enhancing the level of seeds or blending different protein rich raw materials, like tiger-nut (Sethi et al., 2016), which could also improve the quality of the amino acids profile (Qamar et al., 2020).

The salt content was not correlated with its presence or absence as ingredient in the manufacturer's label (Fig. 3). From the 306 PBB, 263 of them declared salt as an ingredient (blue shadowed in Fig. 3) and 37 did not (pink shadowed in Fig. 3), whereas 6 of them did not mention the salt neither as ingredient nor in the nutritional facts. Overall, the average salt content was 0.1 g/ 100 mL. In general, salt content of the beverages without salt added was lower than the content in PBB containing salt as ingredient. Undefined plant-based beverage was the group with the highest salt content in both PBB clusters, with or without salt as ingredient. Nevertheless, within non-added salt PBB it should be stressed that the group of plant-based beverages displayed the highest salt content (mean of 0.16 g/ 100 mL). Salt is commonly used to enhance flavor, presumably salt is masking off-flavors in the group of undefined plants, being added with that purpose or through plants that have high salt content. Within the group of PBB that declared salt as an ingredient, two outliers were detected with 0.33 g salt/100 mL, which contained oat or rice-coconut blend. Health worldwide authorities advise low salt intake (less than5 g per day in adults) to reduce blood pressure and the risk of cardiovascular disease, stroke and myocardial infarction (World Health Organization, 2023). According to the European Commission in its "REGULATION (EC) No 1924/2006 on nutrition and health claims"

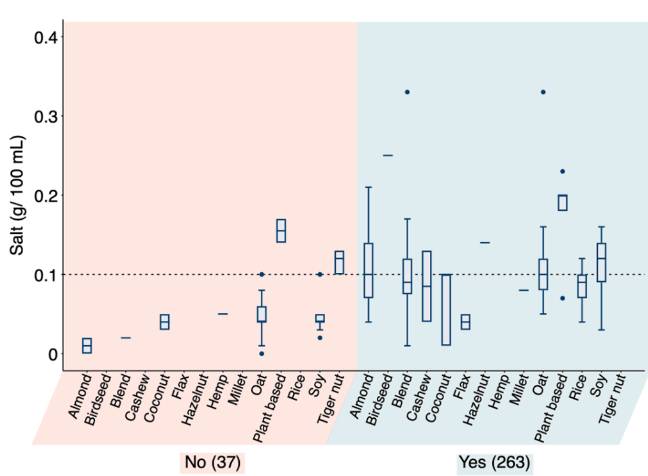


**Fig. 3.** Analysis of salt content in the plant-based beverages (PBB) gathered from the market. PBB containing salt as an ingredient (blue bottom) or without salt (red bottom) were split in the plot. Horizontal dotted line represents the mean salt content of all beverages analyzed. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

PBB could be considered low salt when its content is less than 0.3 g/ 100 mL, or very low salt when its content is less than 0.1 g/ 100 mL.

Dairy substitute beverages have been used as vehicles to introduce a greater number of vitamins, minerals and even probiotics to achieve balanced diets. In the analyzed beverages, more than 50% of them were fortified with either vitamins, a calcium salt or a combination of several salts and vitamins. Calcium is an essential nutrient necessary for human growth and development and it is a limiting nutrient in cereals such as rice and oats (Sethi et al., 2016). From those, 159 were fortified with calcium but only 136 beverages declared the calcium content in their nutritional information, with an average of 122.32 mg calcium/ 100 mL, comparable to 123 g of calcium/ 100 mL of whole cow's milk (USDA, 2022), although it is still questioned if they have similar bioavailability (Chalupa-Krebzdak et al., 2018). Calcium carbonate was the most used salt (46%), followed by tricalcium phosphate (37%) and a mixture of both (7%). Nowadays, calcium carbonate is the most common calcium salt and its absorption is similar to calcium from bovine milk (Kruger et al., 2003; Zhao et al., 2005). Other salts such as tricalcium citrate, dicalcium phosphate or calcium salts of orthophosphoric acid were also used, in lesser extent (10% among the three salts). Regarding vitamins, the number of fortified beverages was lower (1 4 1) than that of minerals, and vitamin D was the most frequent added vitamin (in 136 PBB). This vitamin D has been targeted because it is one of the most deficient vitamins worldwide, related to many diseases such as cardiovascular diseases, hypertension or problems in calcium homeostasis (Müller et al., 2011). Other vitamins widely used for the fortification of PBB are vitamins B12, B2, A and E, always in combination with vitamin D. Only 6 beverages were fortified with vitamin B6, B9, B3 or C. However, there is very limited information about the bioavailability of vitamins and minerals after processing, which is particularly important considering the presence of anti-nutrients in the raw materials (Aydar et al., 2020). In addition, it is important to consider that some of the raw ingredients currently present in the PBB are increasing their vitamins composition. For instance, almonds are an excellent source of vitamin E, which cannot be synthetized by the body and its antioxidant action is required for protecting against free-radical reactions (Sethi et al., 2016).

### *3.3. Overall analysis of marketed plant-based beverages using a principal component analysis*

A principal component analysis was built up to identify potential PBB clusters based on the nutritional composition, type of raw material, oil and hydrocolloid, and the presence or absence of salt. Those variables could explain 46.6% of the differences among the commercial beverages analyzed (Fig. 4). Principal component 1 (PC1) explained 27.9% of the variability, based on ingredients, specifically hydrocolloids and salt (in the negative x-axis) and oil type (in the positive x-axis). Conversely, raw materials and macronutrients composition allowed differentiate PBB along principal component 2 (PC2), with the raw material in the negative y-axis and fiber, proteins and fat content in the positive y-axis. Soybeans, almonds, oats, and blends based PBB were scattered in all quartiles, indicating their large variability. Soy and almond based beverages were characterized by the presence of hydrocolloids and salt. The other extensive cluster included the PBB made from powder or raw material blends, that were extended along x- axis, confirming the variability in their formulation and they contained higher levels of saturated fats. Tiger-nut-based beverages were grouped because of their high sugar and carbohydrates content. As it was explained above, this type of beverages are traditionally sweet drinks with high sugar content (Sánchez et al., 2016). Rice drinks clustered on the x- axis and was associated with a high caloric content and a high presence of carbohydrates, as shown during the study. It is noteworthy to mention that oat-based beverages were grouped because their high fat content, that was associated to the addition of oil, which resulted in energy dense drinks. Coconut drinks formed a well-defined cluster distinguished by their content in saturated fat, mainly due to the lipid profile of coconut (Sethi

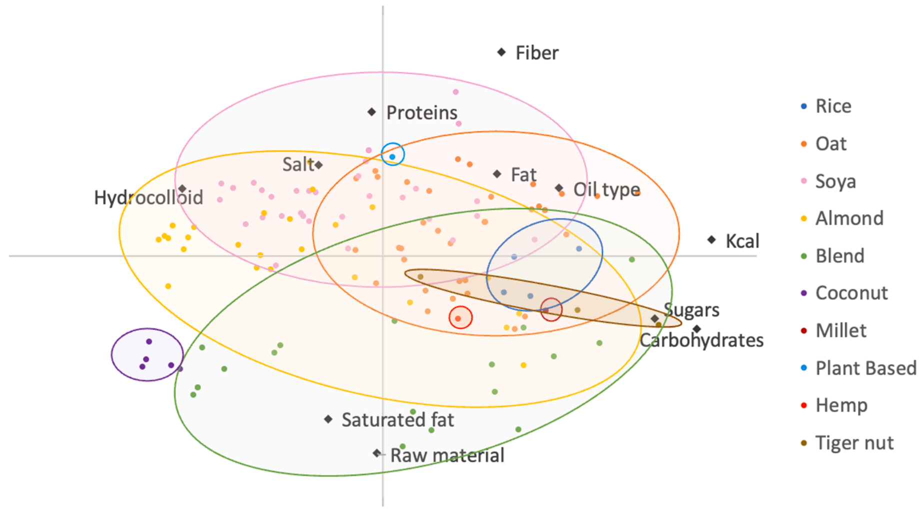


**Fig. 4.** Principal component analysis of PBB that included all the variables analyzed (ingredients in the formulation and nutritional facts). Identified clusters based on their raw materials, appeared circled in different colors.

et al., 2016).

## 4. Conclusions

Plant based beverages existing in the market are rapidly changing, incorporating a variety of vegetable powders or raw materials, that directly affect their final composition. The raw materials used for making PBB reflects the trend towards healthy foods and beverages. Specifically, beverages were mainly based on cereal grains (rice, millet, oats and spelt), seeds (birdseed and flax) and nuts or legumes. Regarding their nutritional composition, it was largely dependent on the raw material. Despite the improvement in the type of ingredients used in their formulations, the salt and oil reduction in PBBs, as well as fiber enrichment, would be advisable. It should be noted that more than 50% of the beverages analyzed were fortified with vitamins and/or minerals, which is desirable for people concerned about a balanced diet and health. Regarding nutritional differences either within the same raw materials or commercial brands, it would be important to develop a public education initiative on labelling reading.

## 5. Ethics statement

Authors declare that there are not ethical issues associated with the research carried out in the manuscript entitled Understanding the functionality of the marketed plant-based beverages.

## CRediT authorship contribution statement

**Eva Grau-Fuentes:** Formal analysis, Investigation, Writing – original draft. **Dolores Rodrigo:** Supervision, Writing – review & editing. **Raquel Garzón:** Conceptualization, Supervision, Formal analysis, Writing – review & editing. **Cristina M. Rosell:** Funding acquisition, Conceptualization, 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

Data will be made available on request.

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