Nutrient profile, nutritional claims and price of high-protein foods and supplements

Perfil nutricional, alegações nutricionais e preço de alimentos e suplementos ricos em proteína

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TRABALHO DE INVESTIGAÇÃO
1.º CICLO EM CIÊNCIAS DA NUTRIÇÃO | UNIDADE CURRICULAR ESTÁGIO
FACULDADE DE CIÊNCIAS DA NUTRIÇÃO E ALIMENTAÇÃO DA UNIVERSIDADE DO PORTO

TC

PORTO, 2022

Abstract and Keywords

Introduction: High protein foods and supplements have become popular due to the rising attention given to dietary choices and growing interest in health. **Objective**: To characterize high protein foods and supplements available for sale in a Portuguese food retail chain, according to food groups, regarding their nutrient profile, nutritional claims and price. **Methods**: Nutritional information, claims and price were collected in store. Differences of nutritional parameters and price according to food groups were studied using the Kruskal-Wallis test. To characterize nutritional claims, frequencies were used. The association between price and nutritional parameters was studied using the Spearman's correlation. **Results**: A total of 281 high protein products were identified, most of them being chocolate, snack bars and desserts, followed by yoghurts and familiar foods. Nutrient profile varied with different food groups. Supplements and egg-based products had the highest protein and salt content and the lowest sugar content. Nuts and seeds showed the highest energy and fat content. Cakes and sweet pastries presented the highest content of saturated fat and sugar. Excluding protein related claims, 25 nutritional claims were identified, with higher prevalence of "High fiber content" and "No added sugars". Price was the highest for chocolate, snack bars and desserts and the lowest was observed for beverages. **Conclusion**: Nutrient profile, nutritional claims and price of high protein products do not vary in the same direction. It is important that food industry becomes more concise referring to food labelling and consumers must be informed, in order to make balanced choices. **Keywords**: High protein, food, food supplements, food retail, food labelling

Resumo e Palavras-Chave

Introdução: Alimentos e suplementos proteicos têm ganho popularidade pela crescente atenção dada às escolhas alimentares e saúde. **Objetivo**: Caracterizar alimentos e suplementos ricos em proteína, disponíveis para venda numa cadeia de retalho alimentar portuguesa, em função dos grupos alimentares, quanto ao seu perfil nutricional, alegações nutricionais e preço. **Métodos**: Informação nutricional, alegações nutricionais e preço foram recolhidos em loja. As diferenças dos parâmetros nutricionais e preço foram estudadas pelo teste de Kruskal-Wallis. Para caracterizar as alegações nutricionais, foram utilizadas frequências. A associação entre o preço e os parâmetros nutricionais foi estudada pela correlação de Spearman. **Resultados**: No total, foram identificados 281 produtos, sendo a maioria chocolates, barras tipo "*snack*" e sobremesas, seguidos de iogurtes e similares. O perfil nutricional variou entre os grupos. Suplementos e ovo-produtos apresentaram o maior teor proteico e de sal e o menor teor de açúcar. Frutos gordos e sementes apresentaram os maiores teores de energia e gordura. Bolos e doces apresentaram o maior teor de gordura saturada e açúcar. Excluindo as alegações proteicas, foram encontradas 25 alegações, com maior prevalência de "Alto teor de fibra" e "Sem adição de açúcares". O preço mais alto foi observado nos chocolates, barras tipo "*snack*" e sobremesas e o mais baixo nas bebidas. **Conclusão**: O perfil, as alegações nutricionais e preço de produtos proteicos não variam no mesmo sentido. É importante que a indústria alimentar seja mais clara relativamente à rotulagem alimentar e que os consumidores estejam informados de forma a efetuarem escolhas alimentares mais equilibradas. **Palavras-Chave**:

Alto teor em proteína, alimento, suplementos alimentares, retalho alimentar, rotulagem alimentar

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Introduction

Higher concerns regarding being healthy and physically active are, nowadays, more evident, with a growing attention of the population regarding dietary choices [1]. Several drivers have been identified as determinants of dietary choices, namely, price [2], food availability [3], physiological and cultural factors [4], nutrition knowledge and beliefs related to food and nutrition, which may interact and make a good decision hard to make [5].

Focusing on protein, there is some evidence that shows potential adverse effects of long-term high protein intake. In particular, this ingestion seems associated with risk of developing bone disorders, renal and liver function abnormalities and coronary artery disease [6]. However, along with the strong evidence regarding both metabolic and physiologic importance of this nutrient [7], more advantages of protein intake has been recently studied. Particularly for overweight/obese adults and in sports, protein ingestion has been considered highly important due to its effect in sparing lean body mass during weight loss, promoting weight management and satiety [8], enhancing glycemic regulation, and increasing intestinal calcium absorption [9]. In this context, considering that individuals are becoming more concern about how different foods may affect the body's well-being, high-protein foods and supplements have experienced a growth demand [10].

Food industry has accompanied this trend by offering a growing variety of high-protein foods [11] and new strategies to communicate/promote these products have been observed in the market. The use of nutritional claims became more popular among both natural sources and new enriched products of a specific nutrient as a potential marketing tool related to food labelling [12].

This highlights the importance of having a clear and appropriate food and nutritional labelling policy, to allow individuals to make informed choices, which are better suited to its needs and preferences. Despite being optional, food marketers have been giving a lot of attention to nutritional claims. It has been shown that, in the presence of a nutrition or health claim on the front of the package, consumers tend less to take heed of other nutrition information and are more predisposed to focus exclusively on that claim to make their food choices, which allow products with claims to become more likely to be selected, compared to identical products without one [13]. However, in order to be included in a product, nutritional claims must meet specific criteria regarding each specific nutrient as stated in Regulation (EC) No. 1924/2006 [14] and (UE) No. 1047/2012 [15].

In this context, it seems clear that nowadays, a higher demand and variety of high-protein foods is available, along with a growing use of claims as a promotion strategy of these products, and with protein content of food becoming a determinant factor for purchasing food and beverages [10, 16].

Objectives

This work aims to characterize the high protein foods and supplements available for sale in a portuguese food retail chain, according to food groups, regarding the following choice determinants: i. nutrient profile, ii. nutritional claims and iii. Price.

Methodology

Data Collection

Food products and supplements that contained a protein-related nutritional claim on commercial or regulatory designations or packaging, such as “high protein content”/ “rich in protein” or “source of protein” available for sale, between April and December 2021, in a representative supermarket of a Portuguese food retail chain were included in this study. Fresh products were excluded.

Collected data of industrial and private branded products included commercial and regulatory designations, non-promotional price, and photographs of product’s packaging, focusing on nutritional information, claims and ingredient list. Information was typed into a database in Excel® after photographs’ analysis.

Measures and Procedures

Nutritional information

Nutritional parameters were expressed for 100g of drained weight of product, which includes energy (kcal), lipids (g), lipids of which saturated (g), carbohydrates (g), carbohydrates of which sugars (g), protein (g), fiber (g) and salt (g). For products whose nutritional information was expressed for 100 ml (such as plant-based drinks, soft drinks and flavored milks), a density factor established in Food and Agriculture Organization and INFOODS’s Density Database 2.0 [17] was used to convert nutritional information to 100g of product. In cases where the amount of a nutritional parameter was expressed using the symbol “<” were converted to the closest lower decimal number (e.g. “<0,1” was manually converted to 0 and “<0,5” was manually converted to 0,4).

Nutritional claims

The identification of nutritional claims was performed through the analysis of the taken photographs. For each nutritional claim stated in Regulation (EC) No. 1924/2006 [14] and (UE) No. 1047/2012 [15]), a dichotomous variable was created, expressing its presence (1) or absence (0) for each food product. Some claims, referring the same nutrient, were grouped into new variables (e.g. "Sugar related claim", included the following claims - "Low sugar content", "No added sugars" and "Sugar free"). Available nutritional claims and respective criteria can be found in Appendix A.

Price

Non-promotional price of each product's unit was collected (€). A conversion was performed to obtain price to 100g of product.

Food classification

To allow a more specific analysis, products were divided into different food groups, following an adapted version of the European Nutrient Profile Model: the Portuguese Nutrient Profile Model by the Directorate-General of Health [18]. This model showcases 20 different food groups, however, in this study, two food groups were condensed and renamed, considering similar nutritional profile of referred products, and to overcome constraints related to some groups' low sample size: a. original group 1 became "Chocolate and sugar confectionary, snack bars, sweet toppings and desserts", which now included edible ices (originally corresponding to group 6) and b. group 12 "Bread, bread products and crisp breads" was condensed with group 13 "Fresh or dried pasta, rice and grains" and became "Cereals, Bread and other familiar products and pasta". Two groups were created

considering the specific study objectives: “Powder supplements and egg-based products” and “Processed and canned plant-based foods/meat analogues”. Final groups used in this study were the following: 1 – “Chocolate and sugar confectionery, snack bars, sweet toppings and desserts”, 2 – “Cakes, sweet biscuits and pastries, other sweet bakery wares, and dry mixes for making such”, 3 – “Nuts, seeds and nut butters”, 4 – “Beverages”, 5 – “Cereals, Bread and other familiar foods and pasta”, 6 – “Yoghurts, fermented milk, cream and other familiar foods”, 7- “Cheese and similar products”, 8 – “Ready-made and convenience foods and composite dishes”, 9 – “Processed meat, poultry and meat products”, 10 – “Processed fruit, vegetables and legumes”, 11 – “Powder Supplements and egg-based products” and, lastly, 12 – “Processed and canned plant-based foods/meat analogues”.

Statistical Analysis

Data analysis was performed in IBM SPSS Statistics v26. Normality tests were conducted for nutritional parameters and price. Means and Standard Deviations (SD) were used to characterize the nutrient profile and price. The Kruskal-Wallis test was used to study differences of nutritional parameters and price according food groups. To characterize nutritional claims (presence/absence and total number of claims used, according to food groups), frequencies were used. Protein related claims were excluded from those analysis. The association between price and nutritional parameters was studied using the Spearman’s correlation.

Results

Food groups’ characterization

A total of 281 food products were identified. Most were classified as “Chocolate and sugar confectionery, snack bars, sweet toppings and desserts” (19.2%), followed by “Yoghurts, fermented milk, cream and other familiar foods” (18.9%), “Processed fruit, vegetables and legumes” (11.4%), “Processed meat, poultry and meat products” (10%) and “Cereals, bread and other familiar products and pasta” (9.6%).

Nutrient profile

The nutrient profile according to food groups is described in Table 1. The group “Nuts, seeds and nut butters” presented the highest mean content of energy (604.6 ± 67.2 kcal; $p<0.001$) and fat (51.9 ± 4.9 g; $p<0.001$) of all groups. In contrast, the group “Beverages” showed the lowest mean content of energy (47.6 ± 17.0 kcal; $p<0.001$), saturated fat (0.2 ± 0.1 g; $p<0.001$) and protein (4.9 ± 3.4 g; $p<0.001$). Furthermore, the group “Yoghurts, fermented milk, cream and other familiar foods” presented the lowest mean content of fat (0.5 ± 0.4 g; $p<0.001$), fiber (0.3 ± 0.3 g; $p<0.001$) and salt (0.1 ± 0.01 g; $p<0.001$). The group “Cakes, sweet biscuits and pastries, other sweet bakery wares, and dry mixes for making such”, presented the highest mean content of saturated fat (9.1 ± 7.6 g; $p<0.001$) and sugar (9.0 ± 7.2 g; $p<0.001$). Moreover, the group “Cereals, Bread and other familiar foods and pasta” showed the highest mean values for carbohydrates (49.4 ± 15.7 g; $p<0.001$) and fiber (11.1 ± 3.4 g; $p<0.001$). The group “Powder Supplements and egg-based products” presented the highest mean content of protein (64.0 ± 35.4 g; $p<0.001$), and salt (2.4 ± 1.3 g; $p<0.001$), although showed the lowest mean content of sugar (0.1 ± 0.1 g; $p<0.001$). Lastly, the group “Processed meat, poultry and meat products” presented the lowest mean content of carbohydrates (2.8 ± 1.2 g; $p<0.001$).

Table 1: Mean nutrient content of high-protein products by food groups

Food groups	Energy (kcal/100g)	Fat (g/100g)	Saturated fat (g/100g)	Carbohydrates (g/100g)	Sugar (g/100g)	Protein (g/100g)	Fiber (g/100g)[1]	Salt (g/100g)
	Mean ± Standard Deviation							
All products (n=281)	**207.0 ± 160.5**	**8.2 ± 10.7**	**2.5 ± 3.8**	**14.8 ± 17.3**	**3.9 ± 5.9**	**17.0 ± 16.2**	**6.6 ± 6.6**	**0.7 ± 0.8**
1 (n=54)	271.3 ± 187.4	11.3 ± 12.3	4.4 ± 5.1	18.6 ± 14.8	6.2 ± 9.2	22.5 ± 18.1	8.5 ± 8.6	0.6 ± 1.1
2 (n=6)	470.7 ± 67.1	22.1 ± 14.0	9.1 ± 7.6	43.0 ± 17.0	9.0 ± 7.2	22.8 ± 7.5	4.9 ± 3.0	0.4 ± 0.2
3 (n=7)	604.6 ± 67.2	51.9 ± 4.9	7.6 ± 1.8	9.3 ± 4.7	5.4 ± 2.8	26.9 ± 6.1	7.9 ± 2.5	0.3 ± 0.3
4 (n=13)	47.6 ± 17.0	1.2 ± 0.9	0.2 ± 0.1	3.5 ± 2.0	3.2 ± 1.9	4.9 ± 3.4	1.1 ± 0.6	0.1 ± 0.04
5 (n=27)	376.2 ± 46.2	10.1 ± 3.7	1.8 ± 1.0	49.4 ± 15.7	5.9 ± 6.0	17.0 ± 7.3	11.1 ± 3.4	0.2 ± 0.3
6 (n=53)	60.6 ± 9.0	0.5 ± 0.4	0.3 ± 0.2	4.7 ± 2.2	4.1 ± 1.8	9.0 ± 1.5	0.3 ± 0.3	0.1 ± 0.01
7 (n=11)	255.0 ± 102.8	17.8 ± 6.7	8.0 ± 0.7	26.8 ± 1.8	5.3 ± 1.1	13.5 ± 3.5	2.7 ± 0.9	1.6 ± 0.4
8 (n=12)	165.2 ± 66.4	7.5 ± 4.3	1.2 ± 1.1	9.5 ± 5.8	2.3 ± 0.8	12.2 ± 8.1	5.2 ± 2.3	1.0 ± 0.3
9 (n=28)	124.1 ± 28.8	4.5 ± 4.7	1.6 ± 1.5	2.8 ± 1.2	0.7 ± 0.2	12.0 ± 1.8	0.4 ± 0.0	1.7 ± 0.3
10 (n=32)	151.6 ± 94.1	1.4 ± 1.5	0.4 ± 0.5	20.2 ± 14.7	2.7 ± 7.4	11.7 ± 12.0	9.4 ± 6.3	0.5 ± 0.4
11 (n=12)	330.8 ± 134.6	3.1 ± 3.7	0.8 ± 1.1	4.2 ± 2.6	0.1 ± 0.1	64.0 ± 35.4	2.6 ± 2.2	2.4 ± 1.3
12 (n=26)	207.7 ± 59.3	11.1 ± 6.0	1.7 ± 1.2	8.6 ± 7.5	1.7 ± 3.3	15.9 ± 11.7	4.6 ± 5.3	1.2 ± 0.6
p -Value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

[1]This sample is lower to fiber due to missing values (n=200) | Food groups: 1 - "Chocolate and sugar confectionery, snack bars, sweet toppings and desserts", 2 - "Cakes, sweet biscuits and pastries, other sweet bakery wares, and dry mixes for making such", 3 - "Nuts, seeds and nut butters", 4 - "Beverages", 5 - "Cereals, Bread and other familiar foods and pasta", 6 - "Yoghurts, fermented milk, cream and other familiar foods", 7 - "Cheese and similar products", 8 - "Ready-made and convenience foods and composite dishes", 9 - "Processed meat, poultry and meat products", 10 - "Processed fruit, vegetables and legumes", 11 - "Powder supplements and egg-based products" and 12 - "Processed and canned plant-based foods/meat analogues".

Nutritional claims

Regarding protein related claims, 86,1% of products had “High protein content” and 13,9% were a “Source of protein”. In addition to protein related claims, a total of 25 nutritional claims were observed. The four most frequent claims were “High fiber content” (29,5%), “No added sugars” (18,5%), “Fat free” (13,9%) and “Low sugar content” (12,5%). The four least frequent claims were “Low salt content” (0.4%), “Natural” (0.4%), “Source of manganese” (0.4%) and “Source of zinc” (0.4%). The relative frequencies of nutritional claims are described in Figure 1.

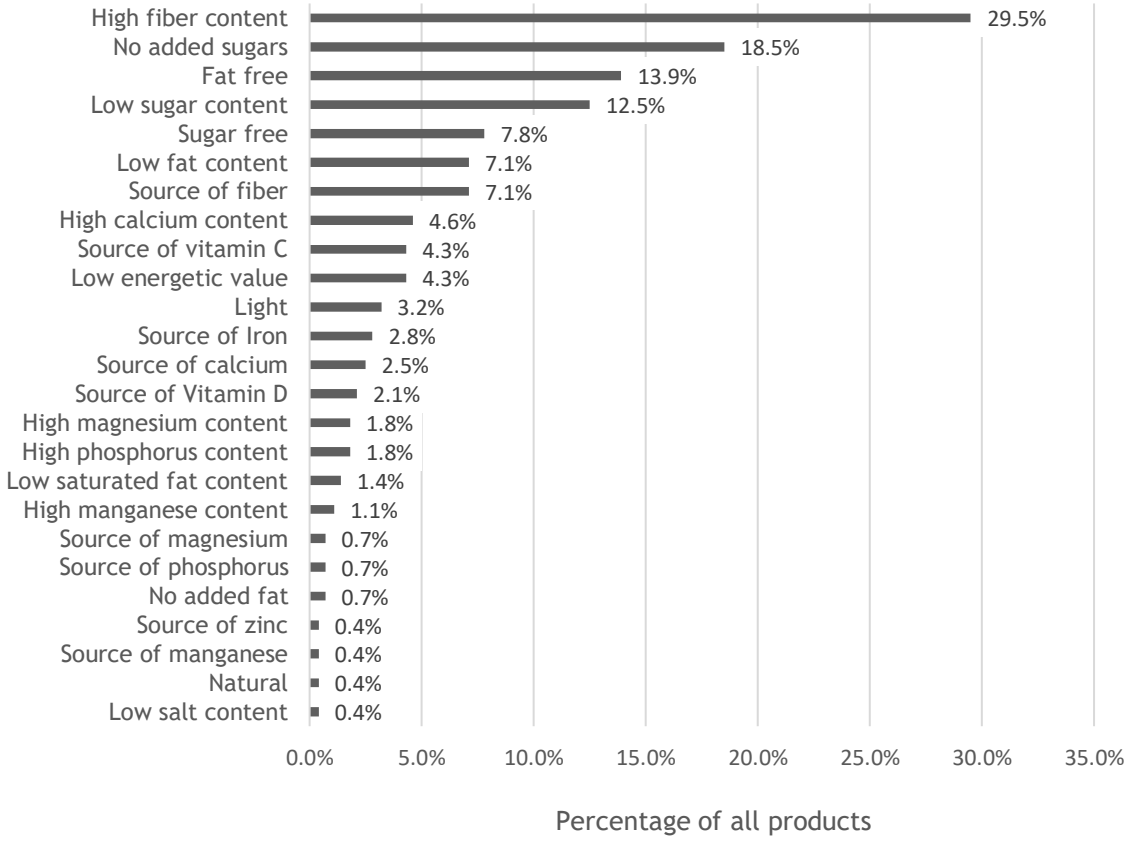
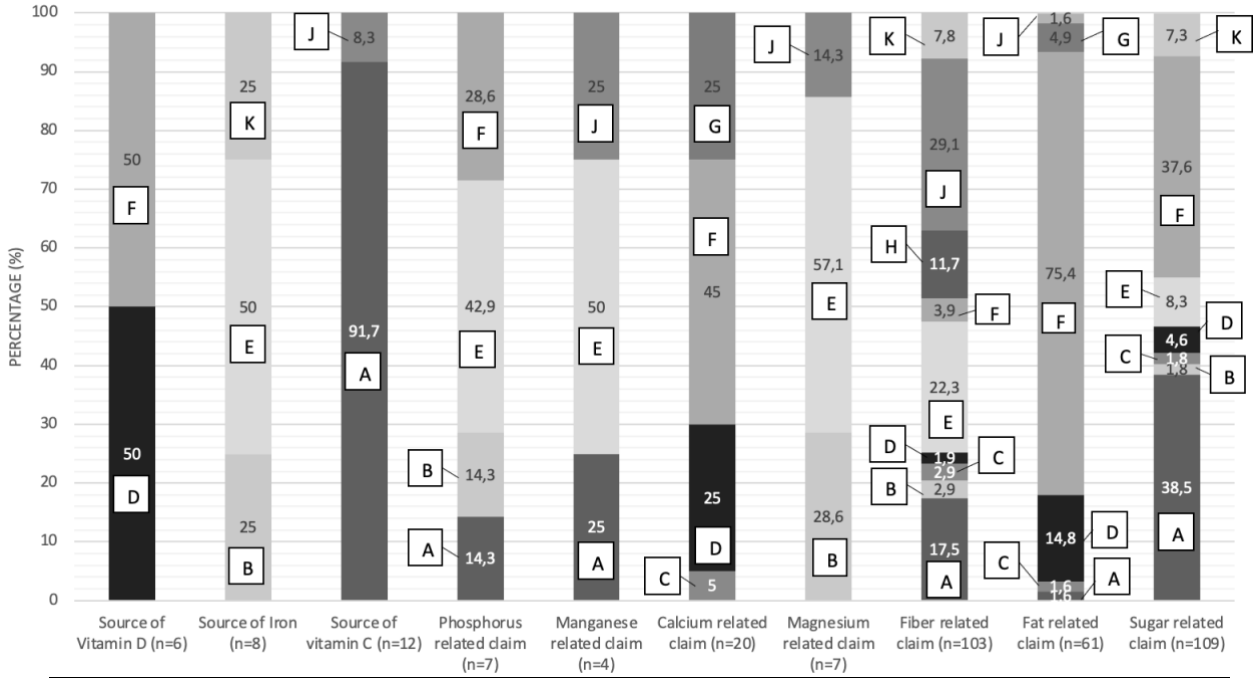


Figure 1: Relative frequencies of nutritional claims (n= 281).

The 10 most frequent nutritional claims (a specific claim or the combination of related claims regarding a specific nutrient) were also presented according to food groups (Figure 2). Sugar related claims and “Source of vitamin C” were more

frequent in the group “Chocolate and sugar confectionery, snack bars, sweet toppings and desserts” (38.5% and 91.7%, respectively). Fat and calcium related claims were more frequent among “Yoghurts, fermented milk, cream and other familiar foods” (75.4% and 45%) while fiber related claims were most prevalent in “Processed fruit, vegetables and legumes” (29.1%). Focusing on micronutrient, magnesium and phosphorus related claims were mostly present in “Cereals, Bread and other familiar foods and pasta” (57.1% and 49.2%, respectively). The claim “Source of vitamin D” was only and equally observed in groups “Beverages” and “Yoghurts, fermented milk, cream and other familiar foods” (50% for both groups). Half of the products containing a manganese related claim and “Source of iron” were “Cereals, Bread and other familiar foods and pasta” (50% for both groups).



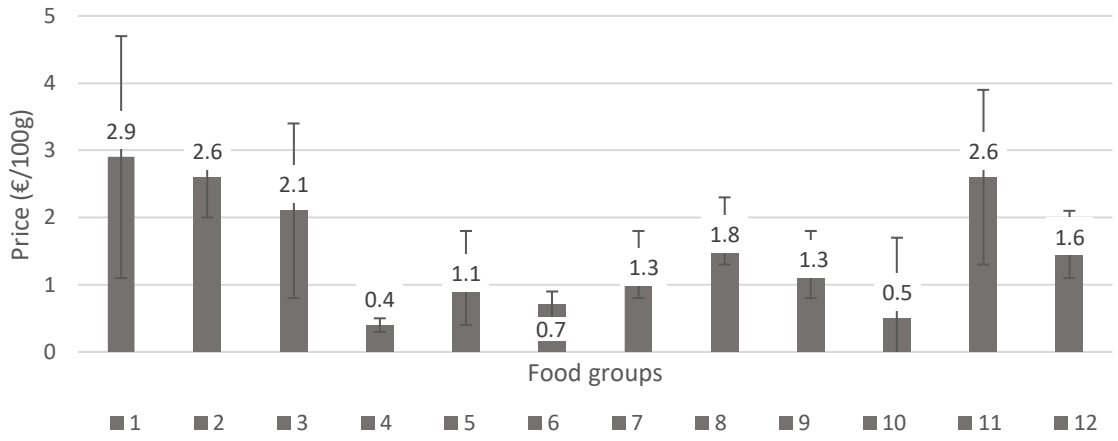
Food groups: A - “Chocolate and sugar confectionery, snack bars, sweet toppings and desserts”, B - “Cakes, sweet biscuits and pastries, other sweet bakery wares, and dry mixes for making such”, C - “Nuts, seeds and nut butters”, D - “Beverages”, E - “Cereals, Bread and other familiar foods and pasta”, F - “Yoghurts, fermented milk, cream and other familiar foods”, G - “Cheese and similar products”, H - “Ready-made and convenience foods and composite dishes”, I - “Processed meat, poultry and meat products”, J - “Processed fruit, vegetables and legumes”, K - “Processed and canned plant-based foods/meat analogues”.

Figure 2: Percentage of nutritional claims according food groups.

Specifically, the number of nutritional claims used in the studied products across food groups was presented in Appendix B. Most products contained one or two nutritional claims (64.1%), while 35.9% of products contained three or more. In particular, “Chocolate and sugar confectionery, snack bars, sweet toppings and desserts” and “Yoghurts, fermented milk, cream and other familiar foods” were the food groups that had mostly three or more claims present (53.7% and 77.4%, respectively).

Price

Regarding price, the four most expensive food groups were “Chocolate and sugar confectionery, snack bars, sweet toppings and desserts” (2.9 ± 1.8 €/100g), “Powder supplements and egg-based products” (2.6 ± 1.3 €/100g), “Cakes, sweet biscuits and pastries; other sweet bakery wares, and dry mixes for making such” (2.6 ± 0.6 €/100g) and “Nuts, seeds and nut butters” (2.1 ± 1.3 €/100g). On the other hand, the four cheapest food groups were “Beverages” (0.4 ± 0.1 €/100g), “Processed fruit, vegetables and legumes” (0.5 ± 1.2 €/100g), “Yoghurts, fermented milk, cream and other familiar foods” (0.7 ± 0.2 €/100g) and “Cereals, Bread and other familiar foods and pasta” (1.1 ± 0.7 €/100g) (Figure 4).



Food groups: 1 - "Chocolate and sugar confectionery, snack bars, sweet toppings and desserts", 2 - "Cakes, sweet biscuits and pastries, other sweet bakery wares, and dry mixes for making such", 3 - "Nuts, seeds and nut butters", 4 - "Beverages", 5 - "Cereals, Bread and other familiar foods and pasta", 6 - "Yoghurts, fermented milk, cream and other familiar foods", 7- "Cheese and similar products", 8 - "Ready-made and convenience foods and composite dishes", 9 - "Processed meat, poultry and meat products", 10 - "Processed fruit, vegetables and legumes", 11 - "Powder Supplements and egg-based products" 12 - "Processed and canned plant-based foods/meat analogues".

Figure 3: Mean price (€/100g) of products according to food groups.

Association between price and nutrient profile

A significant positive moderate correlation was observed between price and i. energy ($\rho = 0.524$; $p < 0.001$) and ii. protein ($\rho = 0.616$; $p < 0.001$). Furthermore, a significant positive but weak correlation was observed between price and i. fat ($\rho = 0.472$; $p < 0.001$), ii. saturated fat ($\rho = 0.477$; $p < 0.001$) and iii. salt ($\rho = 0.300$; $p < 0.001$). Regarding the association between carbohydrate content and price, a significant positive, but very weak correlation was observed ($\rho = 0.128$; $p = 0.032$). In contrast, there is a non-significant correlation between price and i. sugar content ($\rho = 0.092$; $p= 0.125$) and ii. fiber ($\rho = 1.222$; $p= 0.085$).

Discussion

In this study, a total of 281 high protein foods and supplements were found available for sale in a Portuguese retail chain, most of them being "Chocolate and sugar confectionery, snack bars, sweet toppings and desserts" which is in line with previous findings that reported enriched snack bars as the most common high protein foods in the market [19]. The group "Yoghurts, fermented milk, cream and other familiar foods" was the second most prevalent, followed by "Processed fruit, vegetables and legumes", "Processed meat, poultry and meat products" and "Cereals, bread and other familiar products and pasta", reflecting a heterogeneity of foods, some of which do not naturally have an appreciable protein content.

The most available group "Chocolate and sugar confectionery, snack bars, sweet toppings and desserts" showed the second highest mean content of sugar, however, sugar related claims (emphasizing the reduced content and absence of sugar) were the most prevalent in this group. This may occur because these products tend to use more artificial sweeteners in order to reduce added sugars [20], but, yet, showed higher sugar content comparing to other high protein foods. Notably, the use of nutritional claims can be unexpected: for example, our results showed that the claim "Source of vitamin C" was most prevalent in this group too. While this claim mentions a crucial micronutrient to human health [21], in this case, this high prevalence is due to jelly powder, a product that is included in this group and that contains ascorbic acid as an antioxidant agent [22]. In this context, considering that this is the most available group, and that a higher number of claims was observed in their products, this group may potentially be chosen during consumer's food purchases, since it has been shown that more products carrying

nutritional claims seem to be perceived as “healthier” and, therefore, tend to be bought more often than its counterparts without claims [23].

Furthermore, the second most prevalent group “Yoghurts, fermented milk, cream and other familiar foods” showed the lowest mean content of fat, which makes sense considering that an increased attempt to produce low fat high protein yoghurts is occurring in food industry [24]. In line with these results, a frequent presence of fat related claims was observed as expected. In addition to fat claims, also calcium related claims were prevalent in this group since foods that belong to this group are natural sources of calcium [25]. Moreover, manufacturers occasionally add vitamin D to dairy products to fortify them [26] which might explain the fact that the claim “Source of vitamin D” was evenly present in this group and “Beverages”, which included mostly plant based and milk drinks, foods that are frequently fortified with this nutrient [26].

Regarding “Processed fruit, vegetables and legumes”, the third most prevalent group, fiber related claims were mostly present in these foods. These results came as expected since products such as i. breakfast cereals, oats and rye-based products and ii. canned beans and other legumes are important natural sources of fiber [27]. However, the highest mean content of fiber was observed in “Cereals, Bread and other familiar foods and pasta”, along with the highest carbohydrates content. This group also showed the highest prevalence of micronutrient claims, namely phosphorus, manganese and magnesium related claims. This is in line with previous results showing that these products can be recommended as dietary sources of these minerals [28]. In contrast, “Processed meat, poultry and meat products” presented the lowest mean content of carbohydrates, which was also expected since animal meat products are a good source of high quality protein

with low carbohydrates content [29]. Considering that the group "Powder supplements and egg-based products" is extensively used to assure protein supplementation in sports nutrition with low sugar and energy intake [30], it seems important to highlight that these contained the highest amount of protein (approximately 13 times higher than the mean content of protein observed in high protein beverages) and the lowest of sugar, despite no sugar related claims were used among their products. Interestingly, this group also showed the highest mean content of salt, which may be concerning since it has been shown that over 90% of protein supplements have excess sodium [31]. This finding highlights the importance of a moderate intake of these products by consumers who do not have increased sodium needs. In alternative, it could be interesting to increase the focus on "Yoghurts, fermented milk, cream and other familiar foods" since these are also high-protein dairy foods, with the lowest mean content of salt.

Regarding price, considering that the most expensive group was "Chocolate and sugar confectionery, snack bars, sweet toppings and desserts", which showed the second highest sugar content, and the least expensive group was "Beverages", which showed the lowest mean content of energy and saturated fat, these results seems to contradict recent research that supports that energy-dense and low nutritional quality foods tend to be cheaper [32]. Likewise, "Cakes, sweet biscuits and pastries, other sweet bakery wares, and dry mixes for making such" that showed the highest mean content of saturated fat and sugar, was one of the most expensive groups. In line with these results, a positive association was found in this study regarding price and i. energy, ii. fat and iii. Saturated fat. This unexpected association between fat and price may be partially explained since the group of "Nuts, seeds and nut butters" showed the highest fat content and is

one of the most expensive groups as well. Nevertheless, it has been stated that there is a positive association between price and protein content [33], whose our results align with. This can be due to processing: fortifying products with milk protein concentrate is a common practice in the food industry to increase the protein content in food products [34], however, it carries a greater cost [35].

It is important to note that this study has some limitations. Firstly, total fat, saturated fat, sugar, fiber, and salt values may have suffered an underestimation due to rounding. Secondly, only one Portuguese food retail chain was studied, meaning that some high protein products available for sale in Portuguese market were not considered in this study.

Conclusion

Despite the high availability of high-protein foods and supplements in this Portuguese food retail chain, the three food choice determinants studied (nutrient profile, nutritional claims and price) did not always evolve in the same direction. On the other hand, it was observed that claims of a specific nutrient were used in products with significantly different mean content of the referred nutrient, namely, protein. In line with this, it is extremely important that food legislation force food industry to become more concise referring to food labelling. On the other hand, consumers must be informed and able to interpret this, sometimes, confusing data, to make balanced choices. It is also up to nutritionists to provide guidance and thoughtful advice to help consumers to make healthy and balanced choices when consumers must deal with a lot of contradictory stimuli. Future research regarding consumer behavior and protein consumption will certainly be aided with the information provided in this study.

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Appendices

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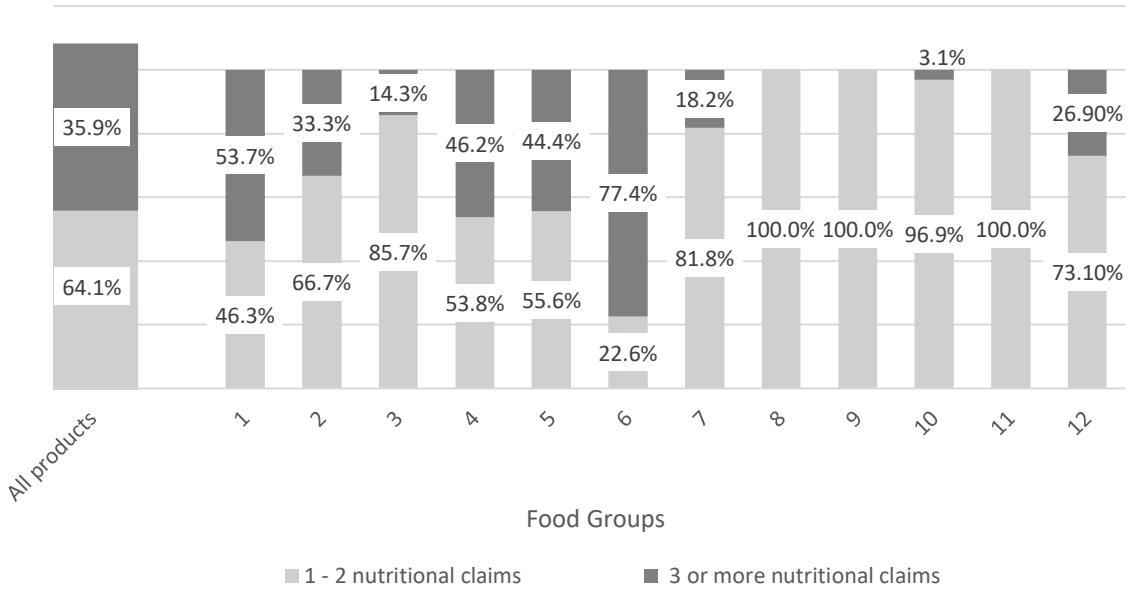
Appendix A – Nutritional claims and respective criteria

NUTRITIONAL CLAIM	CRITERIA
High protein content (or rich in protein)	≥ 20% of the energy value of the food is provided by protein.
Source of protein	≥ 12% of the energy value of the food is provided by protein.
Source of fiber	≥ 3g of fiber/100 g or ≥ 1.5g of fiber/100 kcal.
High fiber content (or rich in fiber)	≥ 6g of fiber/100 g or ≥ 3g of fiber/100 kcal.
Salt/sodium free	≤ 0.005g of sodium (or the equivalent value of salt)/100g.
No salt/sodium added	The product does not contain added sodium/salt or any other ingredient containing added sodium/salt. ≤ 0.12g of sodium (or the equivalent value of salt)/100g or ml.
Low salt/sodium content	≤ 0.12g of sodium (or the equivalent value of salt)/100g or ml.
Very low salt/sodium content	≤ 0.04g of sodium (or the equivalent value of salt)/100 g or ml. This claim cannot be used for natural mineral waters or other waters.
Sugar free (or zero sugar)	≤ 0.5 g of sugars/100g or ml.
No added sugar	The product does not contain any added monosaccharides or disaccharides, nor any other food used for its sweetening properties. If sugars are naturally present in the food, the label must also bear the following indication: "Contains naturally present sugars".
Low sugar content	≤ 5g of sugars/100g for solids or ≤ 2.5g of sugars/100ml for liquids.
Fat free (or zero fat)	≤ 0.5g of fat/100g or ml. Claims such as "X% fat free" are prohibited.
No added fat	When the product does not contain any added fat.
Low fat content	≤ 3g of fat/100g for solids or ≤1.5g of fat/100ml for liquids (≤1.8g of fat/100 ml for semi-skimmed milk).
No saturated fat	The sum of saturated fat and trans fatty acids does not exceed 0.1 g of saturated fat/100g or ml.
Low saturated fat content	The sum of saturated fatty acids and trans fatty acids contained in the product does not exceed 1.5g/100g for solids or 0.75g/100ml for liquids; in

	either case, the sum of saturated fatty acids and trans fatty acids cannot provide more than 10% of the energy value.
No energetic value	≤ 4 kcal (17 kJ)/100 ml. For tabletop sweeteners, the limit of 0.4 kcal (1.7 kJ)/portion applies, with sweetening properties equivalent to 6 g of sucrose (approximately one teaspoon of sucrose).
Low energetic value	≤ 40 kcal (170 kJ)/100 g for solids or ≤ 20 kcal (80 kJ)/100 ml for liquids. For tabletop sweeteners, the limit of 4 kcal (17 kJ)/portion applies, with sweetening properties equivalent to 6 g of sucrose (approximately one teaspoon of sucrose).
Reduced energetic value	The energy value is reduced by at least 30%, with an indication of the characteristic(s) that cause the total energy value of the food to be reduced.
Light	A claim that the content of one or more nutrients other than vitamins and minerals has been enhanced, or any claim likely to have the same meaning for the consumer, may only be made where the product fulfills the conditions of the claim "Source of" and the increase in content is at least 30% compared to a similar product.
Natural	If a food naturally meets the criteria established for the use of a nutrition claim, that claim may be accompanied by the term "naturally/natural".
Source of magnesium	≥ 56,25mg/100g or ml in the case of products other than beverages, or ≥ 28,125mg/100 ml in the case of beverages, or ≥ 56,25mg per serving if the package contains only one serving.
High magnesium content (or rich in magnesium)	When the product contains at least twice the content required for the respective source claim.
Source of calcium	≥ 120mg/100g or ml in the case of products other than beverages, or ≥ 60mg/100ml in the case of beverages, or ≥ 120mg per serving if the package contains only one serving.
High calcium content (or rich in calcium)	When the product contains at least twice the content required for the respective source claim.
Source of phosphorus	≥ 105mg/100 g or ml in the case of products other than beverages, or ≥ 52,5mg/100ml in the case of beverages, or ≥105mg per serving if the package contains only one serving.

High phosphorus content (or rich in phosphorus)	When the product contains at least twice the content required for the respective source claim.
Source of manganese	≥ 0,3mg provided/100g or ml in the case of products other than beverages, or ≥ 0,15mg provided/100 ml in the case of beverages, or ≥ 0,3mg per serving if the package contains only one serving.
High manganese content (or rich in manganese)	When the product contains at least twice the content required for the respective source claim.
Source of vitamin c	≥ 12mg/100g or ml in the case of products other than beverages, or ≥ 6mg/100ml in the case of beverages, or ≥ 12mg per serving if the package contains only one serving.
Source of iron	≥ 2,1mg/100g or ml in the case of products other than beverages, or ≥ 1,05mg/100 ml in the case of beverages, or ≥ 2,1mg per serving if the package contains only one serving.
Source of vitamin d	≥ 0,75mg/100g or ml in the case of products other than beverages, or ≥ 0,375mg/100ml in the case of beverages, or ≥ 0,75mg per serving if the package contains only one serving.
Source of zinc	≥ 1,5mg/100g or ml in the case of products other than beverages, or ≥ 0,75mg/100ml in the case of beverages, or ≥1,5mg per serving if the package contains only one serving.

Appendix B – Number of nutritional claims in products across food groups



Food groups: 1 - "Chocolate and sugar confectionery, snack bars, sweet toppings and desserts", 2 - "Cakes, sweet biscuits and pastries, other sweet bakery wares, and dry mixes for making such", 3 - "Nuts, seeds and nut butters", 4 - "Beverages", 5 - "Cereals, Bread and other familiar foods and pasta", 6 - "Yoghurts, fermented milk, cream and other familiar foods", 7- "Cheese and similar products", 8 - "Ready-made and convenience foods and composite dishes", 9 - "Processed meat, poultry and meat products", 10 - "Processed fruit, vegetables and legumes", 11 - "Powder Supplements and egg-based products" and 12 - "Processed and canned plant-based foods/meat analogues".