

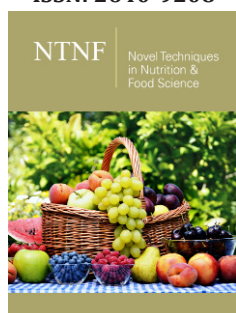
Which Type of Breakfast Cereals is Healthier: Evaluating Labels in the Portuguese Market

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Abstract

The need for nutritional improvement of Breakfast Cereal Products (BCP) has been pointed out, namely regarding sugar, salt, and fat contents. Fibre has several proven health benefits but has been ignored in previous studies. This study aimed to evaluate the nutritional quality of BCP in the Portuguese market, especially regarding fibre content. A total of 247 BCP available in online stores of the leading retailers were evaluated regarding the nutritional profile, using the information given in the products' label. BCP were divided by types according to texture/appearance and production method. Nutritional differences between branded and white-label BCP were also investigated. The majority of BCP have healthy values of total fat, saturates and salt. BCP marketed for children have the highest sugar content values ($p < 0.05$). Extruded rich in fibre and Flakes have the lowest sugar content and the highest fibre content ($p < 0.05$). Few BCP enriched in fibre were found (3.8%), with 10 to 29g of fibre/100g of product. The healthiest products are in the groups of Extruded rich in fibre, flakes, Extruded for adults, granolas, and muesli. However, there are also unhealthy products in flakes and extruded groups. There were few differences between branded and white-label BCP. In case of difference ($p < 0.05$), the branded cereals were healthier. Many BCP in the Portuguese market needs improvement regarding sugar content, namely all BCP marketed for children. Generally, a low percentage of the recommended daily dietary fibre intake is obtained from one BCP serving. Brands are rarely healthier than white-label products.

Keywords: Breakfast cereals; Nutritional quality; Food label

Introduction

The average consumption of Breakfast Cereals Products (BCP) per capita stands at 1.6kg worldwide in 2020 [1]. The breakfast cereals segment represented a revenue of US\$62,763 million worldwide in 2020 with an expected Compound Annual Growth Rate (CAGR) of 4.1% (in the years 2020-2025) [1]. Worldwide, about 50% of the population consume BCP and this percentage increases for children/adolescents [2-5]. Similarly, in Portugal, about half of the population consume BCP [6], but this value increases to about 66% if we consider the age group of children and adolescents [7]. In Portugal, the average intake is 15g/day [8], whereas for children under 10-year-old and for 10-17 years teenagers this value rises to 29g/day and 26g/day, respectively [8].

Compared with other types of breakfasts, BCP breakfast was associated with improved nutrient intake, also indirectly related with a higher milk/yoghurt and fruit intake [9]. BCP help reduce cholesterol, improve bowel function, lower the risk of diabetes and cardiovascular disease, and are consequently associated with lower mortality. Its regular consumption is associated with lower body mass index, lower risk of obesity and, in general, with improved well-being [10,11]. Individuals who regularly consume BCP have a healthier pattern of carbohydrates, dietary fibre, fat, and micronutrients (vitamins and minerals) [10,12].

Nevertheless, some nutritional improvements have been proposed for these products since several studies concluded that BCP consumption increases total energy, sugar, and sodium intake [10,12]. However, only one of these negative effects has been proven by a systematic review on these studies: the consumption of BCP is associated with higher intakes of total sugar [12]. The nutritional quality of breakfast cereals has been assessed worldwide, namely in Australia [13,14], Austria [15], Belgium [3], Canada [14,16], France [15], Italy [17], New Zealand [18,19], Romania [15], Spain, UK [14,20], and the USA [14]. Outputs from these studies demonstrated that different countries have different needs for BCP improvements regarding nutritional composition, including sugar, sodium or fat content, with the majority supporting the need to reduce sugar levels [14].

Regarding the Portuguese market, previous studies addressing some BCP indicated that the “children’s ready-to-eat cereals” may have higher sugar content than the “non-children’s ready-to-eat cereals” [7], revealing differences among BCP types in the Portuguese market and the need for nutritional improvement of the BCP marketed for children. However, information is still missing regarding the whole BCP market and further studies are still needed to reach this purpose. Dietary fibre has several proven health benefits, and diets low in fibre are related to high mortality rates worldwide [21]. A diet high in rapidly absorbed carbohydrates and low in cereal fibre is associated with risk of type 2 diabetes [22] and gestational diabetes risk [23]. Thus, dietary fibre content is also very important to assess beyond the sugar content; nevertheless, it has been devalued in nutritional composition evaluation studies.

This work aimed to evaluate the current state of the nutritional quality of BCP in Portugal, including dietary fibre content. An overview of the several types of BCP was intended by distinguishing products with a different appearance, production process or formulation. When applicable, within those groups, products marketed for children were separated from those sold for adults. The objective of this separation was to unveil the type of BCP in higher need for nutritional improvement. Possible nutritional differences between brands and white-label products were also analysed.

Materials and Methods

Breakfast cereals products selection on online stores

BCP on the Portuguese market were studied regarding their list of ingredients and nutritional information presented on the package or producers’ website. The data survey was conducted by searching on the major Portuguese retailers’ online stores, Auchan, Continente, El Corte Inglés, and Intermarché. Other retailers were not included because their websites lack BCP’s nutritional information. The online search was conducted in January 2021. All the products that had the list of ingredients and nutritional table available (either on the online store or on the producer website) were selected for this study. Both branded and white-label products

were collected for more truthful market insight. Lists of ingredients (data not shown) and the nutritional values were collected according to the “INCO Regulation” (energy, total fat, saturated lipids, total carbohydrates, sugars, fibre, proteins, salt) [24]. Data was double-checked on the website of the producer when available. The same product with different packages (for instance, 375 grams and 500 grams packages for the same product with the same list of ingredients, nutritional content, and same brand) were considered as one, thus counted only once. Simple whole grains (oat or barley) were excluded, even if processed (e.g., expanded grains), since nutritional content is only dependent on grain and not related to the formulation. Cereal bars and porridge were not included in this study.

A dataset was created with the nutritional values and the products were categorised into the twelve groups presented in Table 1. These groups were created based on the products’ appearance, formulation, and production process. There was also a separation of BCP within groups marketed for infants and adults when applicable. According to other studies, this separation was based on the package appearance; children’s BCP were those with cartoons or characters (fictional) on the packaging [14]. Muesli and granola were distinguished because, despite the similarity, granola has a form of agglomerates/clusters, which means they can have different nutritional compositions, namely on sugar content as sugar is often used to enable the agglomerates. Expanded and extruded products differ from each other in terms of ingredients and production process: expanded BCP are produced from whole refined grains that are forced to expand by temperature, and extruded BCP are made from flours submitted to extrusion processing.

Data analysis

For the evaluation of nutritional parameters of BCP, it was performed a descriptive statistics and results were presented using mean, standard deviation and range for energy, total fat, saturates, carbohydrates, sugars, fibre, protein and salt. For the analysis of the several types of BCP, they were grouped according to the types presented in Table 1 and the differences in the nutritional composition were evaluated by descriptive statistics. Data did not follow a normal distribution (Kolmogorov-Smirnov test) and variables were expressed as median by presenting the boxplots for each nutritional parameter at a significance level of $p < 0.05$. Differences among groups’ distribution were assessed using the Kruskal-Wallis. A Principal Component Analysis (PCA) was performed, using a varimax rotation method with Kaiser normalization to evaluate the inter-products variability regarding nutritional composition of BCP among groups. Finally, the differences in nutritional composition among groups of BCP between branded and white-label BCP were evaluated using a t-test analysis. All statistical analyses were performed utilising SPSS 22. software program (SPSS Inc., Chicago, IL, United States).

Table 1: Types of breakfast cereal products found in the Portuguese market.

Type of Breakfast Cereal Product	Illustrative photography
Simple Flakes	
Flakes+others (Flakes with chocolate, fruits and/or nuts)	
Fibre Flakes (Flakes rich in fibre)	
Corn flakes-Adults (with no cartoon-type of packaging) Corn flakes-Infants (with a cartoon-type packaging)	
Expanded-Adults (with no cartoon-type of packaging) Expanded-Infants (with a cartoon-type packaging)	
Extruded-Adults (with no cartoon-type of packaging) Extruded-Infants (with a cartoon-type packaging)	
Extruded rich in fibre (bran)	
Muesli	
Granola (also named as crunchy muesli in the market, they are muesli clusters)	

Result

Types of breakfast cereals products

A total of 247 BCP were found in the Portuguese market, considering the online stores of the leading Portuguese retailers (Auchan, Continente, El Corte Inglés, and Intermarché). Exploratory analysis excluded nine of these products due to the lack of one of the nutrients in the nutritional table: Five granola products, one muesli, one Extruded for infants, one Extruded for adults and one Flakes others product. These products were grouped in several types of BCP, as represented in Figure 1. The major number of products was found in the granolas group (28.2%), followed by Extruded for infants (with a cartoon type of packaging) (20.6%). Extruded products (which included the groups Extruded for adults, extruded

for infants and Extruded rich in fibre) represented 32.4% of the BCP in the Portuguese market, being the type of BCP comprising higher diversity of products. The least prevalent products were the expanded products (5.0% total, of which 4.2% for infants and 0.8% for adults) and BCP rich in fibre, representing 3.8% of the total BCP, of which 2.1% are flakes, and 1.7% are extruded products.

Types of Breakfast Cereal Products in the Portuguese market

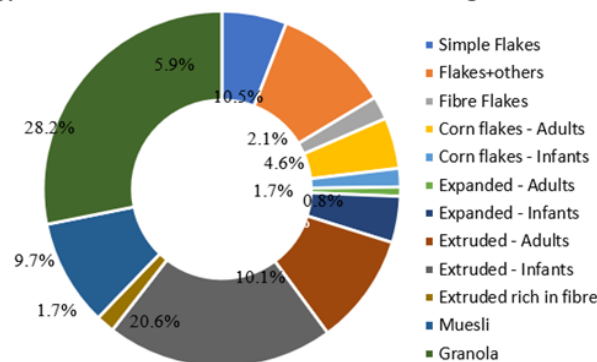


Figure 1: Types of breakfast cereal products by percentage in the Portuguese market in January of 2021. Simple Flakes n=14, Flakes+others n=25, Fibre Flakes n=5, Corn flakes-Adults n=11, Corn flakes-Infants n=4, Expanded-Adults n=2, Expanded-Infants n=10, Extruded-Adults n=24, Extruded-Infants n=49, Extruded rich in fibre (bran) n=4, Muesli n=23 and Granola n=67.

Nutritional composition of the breakfast cereal products

Detailed information of the 238 BCP included in the study was collected and analysed. Table 2 provides an overview of the nutritional composition of the BCP and (Figure 2) presents the exploratory analysis of data by type of BCP for each nutritional component. Carbohydrates (which include simple sugars) are the main component (69.8g/100g on average), and simple sugars are the second principal component (20.5g/100g average). On average, the Portuguese BCP have approximately 7g of fibre/100g, 9g of protein/100g and 8.5g of fat/100g (Table 2). Nevertheless, Portuguese BCP comprise a large variation of the nutritional parameters (Table 2). Energy values vary between 314 and 497kcal/100g of product. Granolas and expanded for adults BCP present the highest energy values, whereas the Extruded rich in fibre has the lowest energy values (Figure 2A). Regarding total and saturated fat contents (0.5-25.8g/100g and 0.0-12.0g/100g, respectively-(Table 2)), the granolas group is the only one with products that have total and saturated fat contents above the red light according to the UK Traffic Light (17.5g total fat per 100g of product and 5g of saturates per 100g of product respectively-see Figure 2B & 2C). The BCP with the lowest total and saturated fat contents are corn flakes, Simple flakes, and Fibre flakes (Figure 2B & 2C). The granolas group show the most considerable product variability (higher number of different products) and consequently, nutritional composition variation on total and saturated fat (Figure 2B & 2C).

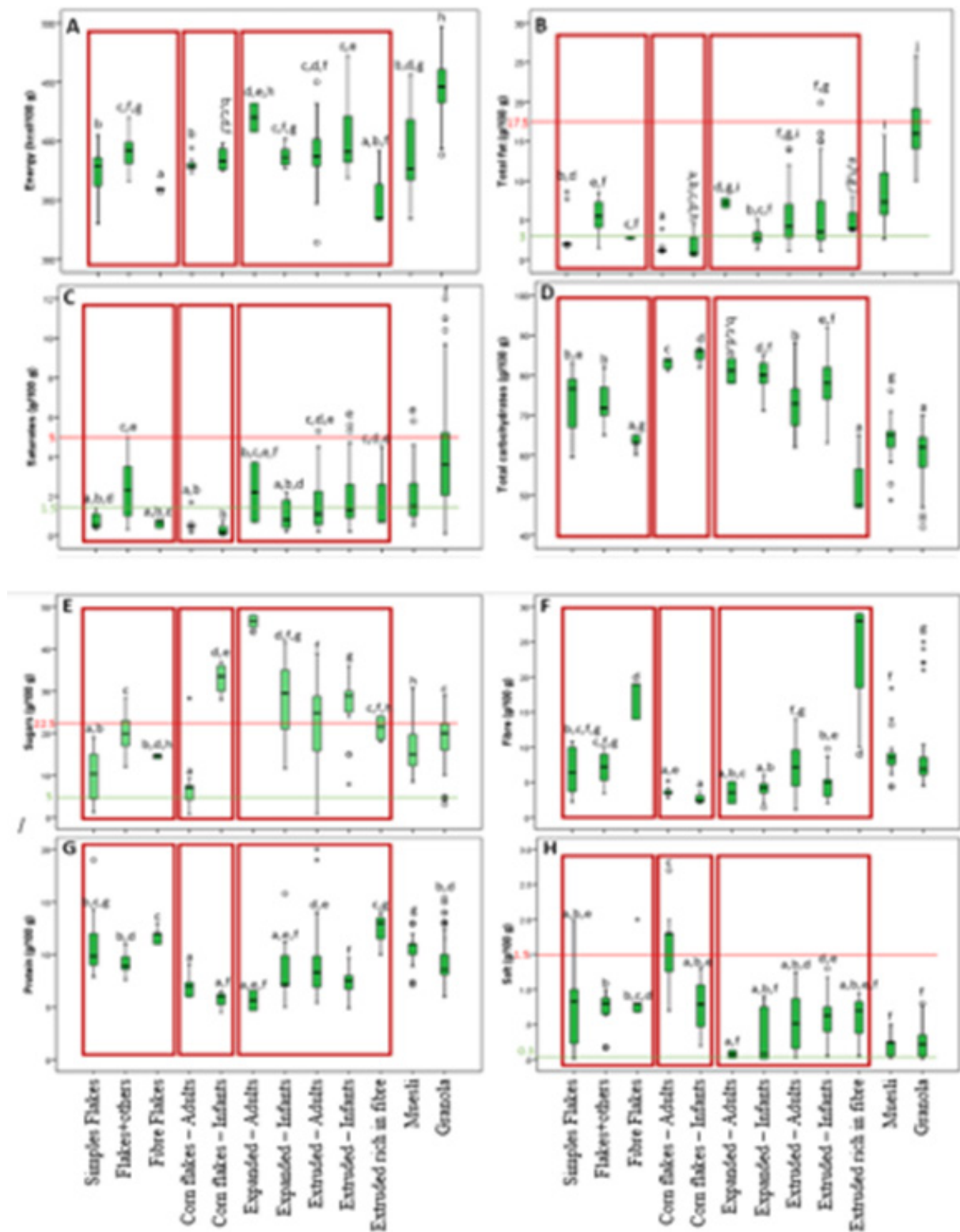


Figure 2: Statistical analysis of the nutritional composition of breakfast cereal products in the Portuguese market by product type. Legend from left to right: Simple Flakes (n=14), Flakes+others (n=25), Fibre Flakes (n=5), Corn flakes-Adults (n=11), Corn flakes-Infants (n=4), Expanded-Adults (n=2), Expanded-Infants (n=10), Extruded-Adults (n=24), Extruded-Infants (n=49), Extruded rich in fibre (bran) (n=4), Muesli (n=23) and Granola (n=67). Medians between types of BCP with different superscript letters differ (p< 0.05). Red and green lines represent the red and green lights according to the UK Traffic Light labelling system.

Table 2: Mean nutritional composition of breakfast cereal products in the Portuguese market per 100 g of product.

	Nutritional Content		
	Mean	SD	Range
Energy (kcal/100g)	405.8	35.9	314.0-497.0
Total fat (g/100g)	8.5	6.5	0.5-25.8
Saturated fat (g/100g)	2.4	2.2	0.0-12.0
Carbohydrates (g/100g)	69.8	10.1	42.0-92.0
Sugars (g/100g)	20.5	8.7	0.8-48.0
Fibre (g/100g)	7.2	4.5	1.1-29.0
Protein (g/100g)	9	2.5	4.5-20.0
Salt (g/100g)	0.5	0.4	0.0-2.7

SD: Standard Deviation.

Carbohydrates' content varies a lot among BCP types (42 to 92g/100g of product- Table 2). Flakes, corn flakes and expanded/extruded, have similar carbohydrates content, whereas, in general, BCP rich in fibre (Fibre flakes and Extruded rich in fibre), muesli and granolas show lower contents (Figure 2D). Simple carbohydrates (sugars) content also varies greatly (0.8 to 48g/100g). The expanded products marketed for adults had the highest sugar content of all (two products with 45.2 and 48g of sugar/100g), followed by expanded products for infants, extruded (both adults and infants) and Corn flakes for infants (Figure 2E). The Simple flakes, Fibre flakes and Corn flakes for adults are the only groups with less than 22.5g of sugar per 100g of product (red light for sugar in the UK Traffic Light). Also, most of the products from flakes others, muesli, and granola groups are below the red light (Figure 2E).

Fibre content range between 1 and 29g/100g of product (Table 2) according to the complexity of the ingredients. Corn flakes are made from corn (68 to 99.9% of the ingredients) and minor ingredients (sugar, salt, additives); thus, their fibre comes essentially from corn, which typically has a low fiber content (1.9 to 7.3g/100g [25]). Therefore, as expectable, these products have the lowest fibre content (Figure 2F). The expanded products are also produced with one main cereal ingredient such as wheat (n=6), rice (n=4) or spelt (n=2), and other minor ingredients, which also explains their lower fibre contents, with no significant differences when compared with the corn flakes group ($p>0.05$). Fibre flakes and Extruded rich in fibre have significantly ($p<0.05$) higher fibre content than the rest of BCP with 17g of fibre per 100g of product and 24g of fibre per 100g of product (minimum 14% and 10% and a maximum of 19% and 29% respectively). Surprisingly, the muesli and granola groups do not have the highest fibre content on average, although there are outliers in these groups with similar fibre content to the groups with the highest fibre content.

Protein content varies between 4.5 and 20g/100g of product (Table 2). The highest values are found in outlier products from the group of Simple flakes (19g of protein/100g of product) and the group of Extruded for adults (two outliers with 19 and 20g of protein/100g of product). However, on average, Fibre flakes and Extruded rich in fibre groups contain the highest protein content

with 12 and 13g/100g of product, respectively, followed by Simple flakes with 11g/100g of product. These three groups are not significantly different regarding protein content ($p>0.05$) (Figure 2G). The average salt content of all BCP was 0.5g/100g of product (Table 2). However, a few products (n=8) are high in salt (above the red light at 1.5g/100g of product). These products belong to the Corn flakes for adults and Simple flakes groups (Figure 2H). Corn flakes products had the highest salt content on average (1.6g/100g; minimum 0.7 and a maximum of 2.7g/100g) (Figure 2H).

Adults (n=2), Expanded-Infants (n=10), Extruded-Adults (n=24), Extruded-Infants (n=49), Extruded rich in fibre (bran) (n=4), Muesli (n=23) and Granola (n=67). Medians between types of BCP with different superscript letters differ ($p < 0.05$). Red and green lines represent the red and green lights according to the UK Traffic Light labelling system.

Inter-products variability of the nutritional composition of the breakfast cereal products

The PCA was performed to summaries and analyse the differences in the nutritional profile among all types of BCP (Figure 3). The types of BCP explained 72.019% of the variation of the results, as shown in Figure 3. This analysis reveals the high variability among types of BCP as well as within groups, which is in line with recent previous studies that had found substantial differences in the nutritional profile of BCP, even when similar nutrition claims are used [15,17,26]. This analysis clearly shows that the granolas group (n=67) has the highest nutritional composition dispersion among their products (light purple circles in Figure 3B). Accordingly, in previous studies with the separation of granolas as a group ("Crunchy mueslis"), this group was the one with a higher range of variability [27]. Similarly, the Extruded for adults' group (n=24, grey circles) also presents high variability but with a mirrored dispersion of samples compared to the granola group. The last is in energy, total fat, saturated fatty acids, fibre, and protein quadrants, whereas the Extruded for adults' group is dispersed in the quadrants of total carbohydrates, sugars, and salt (Figure 3). The PCA results shows that in both groups, there are very healthy products and less healthy products. However, the less healthy granola products are healthier than the less healthy products from Extruded for adults' group. Part of the variability associated to the Extruded for adults' group may be related to the classification criteria: some of the products that were included in this group for not having any cartoon character (thus not falling into the infants' group) are however marketed for young consumers presenting a 'fun' packaging and having high sugar content similar to the BCP for infants.

The Extruded for infants' group (n=49) has a similar nutritional composition of Extruded for adults with the difference that in this group, there are no products in the 3rd quadrant of the PCA plot, which is the quadrant of the healthiest products (since the products in this quadrant have a lower content of sugars, energy, saturates, total fat and higher content on fibre and protein). Among the four Extruded rich in fibre products, one is quite different from the

others due to lower fibre content and higher values of energy, total fat, and saturated fatty acids (Figure 2 & 3). Contrastingly, the five Fibre flakes products have very similar nutritional compositions as they are presented closely grouped in the samples plot (Figure 3). The Corn flakes for adults (n=11) have a consistent nutritional

composition among them, and in this analysis, it is evident that these products are the richest in salt (Figure 3). It is also clear that the Corn flakes for infants (n=4) are different from the ones marketed for adults due mainly to higher sugar content and lower salt content (Figure 2 & 3).

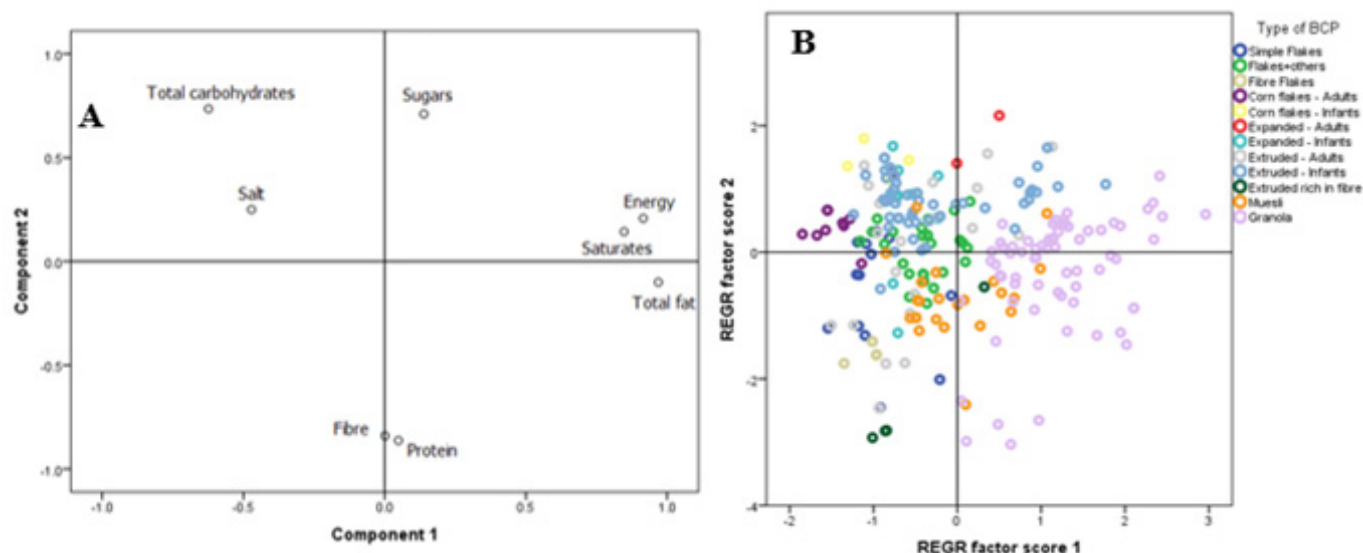


Figure 3 Principal component analysis for nutritional composition of BCP by type. The first component explained 40.934% of the variance across the samples and the second component explained 31.085%. Plot A shows the variables (nutritional parameters), and plot B shows the information about the samples (types of BCP).

Branded versus white-label breakfast cereal products

This study analysed the differences among BCP from brands and white label. The Extruded rich in fibre and the Expanded for adults' groups were not considered in this analysis for lack of data. The first has only four products, one branded and three are white-label products, while the second has only two products (both branded). Likewise, previous studies on other countries also verified different proportions of brands within types of BCP [28]. The results of this analysis are presented in Table 3. Regarding energy values, the products are very similar between groups. The only difference

is observed for the flakes others type of BCP ($p=0.014$). In this case, the branded BCP presented a lower mean of energy values (Table 3). There were no significant differences in total fat content between brands ($p>0.05$). However, the mean values are higher for the white-label products (Table 3). White-label BCP had higher saturated fat content in the Expanded for infants (with cartoon-type packaging) ($p=0.042$) as well as in the muesli group ($p=0.008$), where the means vary from 1.8 to 4.1g/100g in branded and white-label, respectively. Also, white-label BCP have higher carbohydrate content, but only in the flake's others' group was significantly different ($p=0.004$) from the branded cereals.

Table 3: Comparative evaluation of the nutritional composition of different breakfast cereals products: branded and white-label branded products.

Type of BCP		Energy (kcal/100 g)		Total fat (g/100 g)		Saturates (g/100 g)		Total carbohydrates (g/100 g)		Sugars (g/100 g)		Fibre (g/100 g)		Protein (g/100 g)		Salt (g/100 g)	
		White label	Branded	White label	Branded	White label	Branded	White label	Branded	White label	Branded	White label	Branded	White label	Branded	White label	Branded
Simple Flakes	Mean	383	372.27	1.83	3.04	0.7	0.66	79.7	71.41	16.37 a	8.11 b	4.03	7.38	10	11.16	0.89	0.64
	SD	6.08	19.45	0.15	2.55	0.36	0.43	0.61	7.79	3	5.95	1.23	3.2	1.87	3.21	0.12	0.61
Flakes + others	Mean	404.13a	388.50b	5.24	5.46	2.7	2.16	76.94a	71.69b	19.71	19.59	6.45	7.74	9.16	9.26	0.82	0.68
	SD	14.87	13.47	2.33	1.93	1.81	1.35	3.85	3.88	3.82	3.85	2.72	1.93	1.28	0.95	0.13	0.29
Fibre Flakes	Mean	360	358.33	2.9	2.7	0.8	0.5	63	63.33	14.8	14.33	19	15.67	11	12.33	0.8	1.12
	SD	0	1.15	0	0.17	0	0.17	0	2.89	0.28	0.58	0	2.89	0	0.58	0	0.76
Corn flakes - Adults	Mean	378.75	380.33	1.23	1.5	0.43	0.63	83.25	82.83	6.73	8.27	3.85	3.5	6.78	7.07	1.53	1.64
	SD	3.5	6.63	0.25	1.07	0.15	0.49	1.5	1.18	0.68	9.43	0.9	0.5	1.55	0.87	0.55	0.59

Corn flakes - Infants	Mean	383	386.5	0.8	2.55	0.1	0.4	86	84.5	30	36	3	2.25	6.25	5.25	0.75	0.79
	SD	8.49	16.26	0.42	2.76	0.14	0.42	0	3.54	2.83	1.41	0.99	0.35	0.35	1.06	0.78	0.06
Expanded - Infants	Mean	389.8	385	3	2.76	1.52a	0.56b	81.2	78.54	28.8	26.96	3.48	4.46	7.74	9.22	0.52	0.16
	SD	5.63	10.22	0.96	1.35	0.84	0.27	2.77	5.28	7.66	13.88	1.24	1.49	1.26	4.31	0.41	0.33
Extruded - Adults	Mean	401.29	384.06	5.56	5.23	1.65	1.63	78.39	71.72	29.17a	19.23b	4.67b	7.72a	7.26	9.8	0.68	0.48
	SD	19.34	28.21	5.16	3.15	1	1.58	8.19	5.67	4.66	9.78	2.41	3.15	1.53	4.05	0.32	0.4
Extruded - Infants	Mean	405.74	400.45	6.15	6.3	2.02	1.89	78.47	76.05	29.65	26.33	4.18	4.99	7.12	7.42	0.61	0.62
	SD	29.83	25.91	5.87	4.92	1.69	1.31	7.74	5.41	2.97	5.23	1.17	2.05	0.95	1.16	0.26	0.29
Muesli	Mean	398	385.89	9.67	8.19	4.07a	1.80b	65	63.09	14.17	16.81	7.2	9.22	8.73b	10.72a	0.28	0.18
	SD	50.32	27.92	5.4	3.48	0.35	1.31	4.58	5.98	5.75	5.76	2.56	3.03	1.36	1.51	0.22	0.14
Granola	Mean	446	444.16	16.26	16.93	3.87	4.38	61.19	59.4	18.19	19.51	8.84	8.12	9.18	9.62	0.21	0.27
	SD	19.92	29.43	3	4.33	1.71	2.96	8.16	6.07	7.01	6.17	6.28	3.68	2.21	2.19	0.18	0.22

a,b: Means between White label branded and Branded groups with different superscript letters differ ($p < 0.05$); SD is the standard deviation of the means; Simple Flakes (nbrand=11, nwhite label=3), Flakes+others (nbrand=17, nwhite label=8), Fibre Flakes (nbrand=3, nwhite label=2), Corn flakes-Adults (nbrand=7, nwhite label=4), Corn flakes-Infants (nbrand=2, nwhite label=2), Expanded-Infants (nbrand=5, nwhite label=5), Extruded-Adults (nbrand=18, nwhite label=6), Extruded-Infants (nbrand=30, nwhite label=19), Muesli (nbrand=20, nwhite label=3) and Granola (nbrand=51, nwhite label=16).

Regarding sugar content, branded and white-label products differ in Simple flakes and extruded for adults' groups ($p=0.042$ and $p=0.018$ respectively), with the branded products presenting the lowest sugar content. In general, branded products have higher fibre content, but significant differences were only observed in the Extruded for adults ($p=0.031$) group. Regarding protein content, the only significant difference between branded and white-label products is in the Muesli group, where the higher mean is in the branded products ($p=0.042$). In salt, there were no significant differences between branded and white-label products.

Discussion

The healthiness of the several types of breakfast cereals: what to improve?

Traffic Light labelling has been proposed and adopted by several companies and governments to enhance consumers ability to choose healthier food products and push the food industry to improve products healthiness [14,20]. The British Nutrition Foundation indicates that "We should be cutting down on foods with lots of red on the label, or if they are eaten, to have less often and in small amounts" [29]. Thus, consumer awareness of the relationship between health and diet is increasing, and consequently, the demand for healthier products increases as well [30]. The red-light values for total fat, saturated fat, sugars, and salt are 17.5, 5, 22.5 and 1.5g/100g, respectively. Above these values, the products are considered high on those parameters [31]. The green light values for the same components are 3, 1.5, 5 and 0.3g/100g, respectively [31]. Values are classified as "medium" if between green and red light and as "low" when below the green light. Both lights are represented in Figure 2 with red and green lines.

The Portuguese BCP are mostly medium for fat, saturated fat and salt, but are mostly high in sugar. With the exception of some products from the Expanded for infants' group, all BCP intended for

children (corn flakes, expanded or extruded BCP) are high sugar (Figure 2E). Recently Petty et al. [32] verified that children have a higher sucrose detection threshold than adolescents that in turn have a higher sucrose detection threshold than adults, which can explain why children market products are richer in simple sugar. The PCA (Figure 3) shows that these products also have the lowest fibre and protein contents. Similarly, a recent study concluded that children's cereals had lower protein and fibre contents and higher sugar content than adults' intend BCP [13]. Additionally, recent studies have found that the BCP marketed for children had an unhealthy nutritional profile in New Zealand, Australia, the UK, Canada, the USA, Guatemala, Mexico and Ecuador [14,20]. In Portugal, previously [7] studied the breakfast pattern of Portuguese children, which included some BCP and verified that "children's ready-to-eat cereals" had 26% more sugar than the "non-children's ready-to-eat cereals", nevertheless this study included a very small sampling of BCP in the Portuguese market. The present work corroborates the need for reducing the sugar content in the BCP marketed for children, whether branded or white-label products (Table 3).

The Extruded for adults group presented the higher variation on sugar content (Figure 2E), so it is the most challenging group to categories as healthy or not. This group has healthy products with low sugar content (0.9-13.4g/100g), high fibre (9.6-10.5g/100g) and protein content (9.6-19g/100g), and less healthy products with high sugar content (up to 30g/100g) and low fibre content (minimum was 1.1g/100g). Interestingly, there are products from the Extruded for adults and Simple flakes groups with very similar nutritional composition as the Fibre flakes' group (Figure 3), which demonstrates that distinct types of BCP obtained by different production processes (extrusion and cooked flakes) and showing different texture/taste, can deliver similar and high nutritional quality. Important to notice that several production

processes may achieve healthy BCP. It widens the possibilities for the R&D department to develop new food products with different kinds of ingredients, including new emerging ones, as fruit and vegetable by-products flours [33]. The expanded products are the type of products with more limitations for improvement as they are limited to the composition of the used grains. Studies on sugar and salt content in BCP are frequent, and the high variability in these nutritional parameters are common in several countries [17,34,35]. Some products need a salt reduction in the Portuguese market, mainly in the Corn flakes for adults and Simple flakes groups, in order to stay below the red line of the UK Traffic Light labelling system (Figure 2H). Previous studies revealed that programmed for the progressive reduction of salt content in BCP are a successful strategy to improve the nutritional content of BCP [35].

Dietary fibre in breakfast cereals: should it be revised?

The health benefits of dietary fibre have been determined by many studies. A recent Global Burden of Disease study estimated that 877,850,000 deaths are caused by a diet low in fibre (less than 23.5g/day) [21]. Both EFSA and FAO recommend a minimum dietary fibre intake of 25g/day [36], and US Department of Health and Human Services recommend 33.6g/day for men between 19-30 years and 28g/day for women of the same age [37]. However, the actual intake amount is still under the recommendations in EU countries [36,38] and the USA [39]. Cereals are rich in Insoluble Dietary Fibre (IDF), and both Total Dietary Fibre (TDF) and IDF intake are highly associated with a lower risk of overweight and elevated waist-to-hip ratio, blood pressure, cholesterol, triacylglycerols, and homocysteine [40], and also lower risk of circulatory, digestive, and non-cardiovascular non-cancer inflammatory diseases [41]. Cereal and fruit fibre intake was also related with decreased risk of diabetes [22,23]. As BCP are consumed worldwide by at least 50% of the population, this product could be used as vehicle to increase dietary fibre intake. The nutrition claims regarding fibre in the EU are "SOURCE OF FIBRE" to be used "where the product contains at least 3g of fibre per 100g or at least 1,5g of fibre per 100kcal", and "HIGH FIBRE" for when "the product contains at least 6g of fibre per 100g or at least 3g of fibre per 100kcal". One serving (\approx 30g) of a "HIGH FIBRE" BCP will contain at least 1.8g of fibre, which represents 7.2% of the daily recommended intake amount (considering 25g/day). The BCP in Portugal had a mean fibre content of 7.2g/100g, representing 8.6% of the daily recommended dosage in one serving of 30g of BCP. Considering the range limits observed for the fiber content in Portuguese BCP, the minimum (1.1g/100g) would correspond to 1.3% of the recommendation, whereas the maximum (29g/100g) would correspond to 35% of the recommended daily dietary fibre intake (in one serving of 30g of BCP). Considering this, it is clear that there is a need to increase the fibre content in BCP by increasing the number and the type of products rich in fibre. For now, there are very few products able to meet this goal, mainly Fibre flakes and Extruded rich in fibre groups, which corresponds to 3.8% of the total BCP. Also, the types of fibre could be increased. Currently, BCP has limited fibre sources that come from the main ingredients: maize, oat, and wheat (whole or bran) [38]. Alternatively, fruit and vegetable flours could be used, namely flours produced from by-products [33].

Are branded breakfast cereals healthier?

Culturally, there is the widespread assumption that branded BCP are healthier than white-label BCP. However, previous studies found that this is not necessarily true [42] and there is no systematic relation between brands and nutritional quality of BCP [28]. Similarly, in the present work, few differences were detected between brands. More often than not, mean values were healthier on the branded products (Table 3), i.e., lower energy values, lower fat, saturated fat and sugar contents, and higher fibre and protein content. However, these means were rarely significantly different ($p>0.05$). These statistical results could be due to the high standard deviation of the data, which results from the high variation of the BCP formulations. Despite the division of the products into twelve groups, it cannot be concluded that branded BCP are always healthier than white-label products. To take that conclusion, a direct comparison between homologous products would be necessary, comparing product by product. This study allowed verifying that healthy products can be found in both branded and white-label products.

Conclusion and Future Perspectives

In general, Portuguese BCP are healthy regarding fat, saturated fat and salt contents. Few products need improvement regarding total and saturated fat, and these products belong to the granolas group. Regarding salt, very few products need improvement; they are products from Corn flakes for adults and Simple flakes groups. Sugar content needs to be reduced in all the BCP marketed for children and some extruded products for adults. Regarding fibre content, only the products from Fibre flakes and Extruded rich in fibre groups can provide a good percentage of the recommended daily dietary fibre intake (above 16% of the recommended amount). There were few differences between branded and white-label BCP; thus, healthy BCP can be found in both branded and white-label products.

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