



## Trabajo Original

Epidemiología y dietética

### A comparison of the nutritional profile and price of gluten-free products and their gluten-containing counterparts available in the Spanish market

*Comparación del perfil nutricional y del precio de los productos sin gluten y sus homólogos con gluten disponibles en el mercado español*

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### Abstract

**Background:** to date, gluten-free (GF) diet is the only treatment available for individuals with celiac disease. Both individual and collective food intake assessments are a challenge because a food composition database of GF products (GFPs) is lacking.

**Objectives:** to describe the process of developing a food composition database of GFPs, and to compare the nutritional profile and price of some GFPs and non-GFPs.

**Methods:** initially, a total of 216 brands of GFPs marketed in Spain were recorded. Nutritional information was collected from nutritional labels and product fact sheets that had been provided by food companies or collected first-hand by researchers. Then, the nutritional profile and price of the cereal and cereal byproducts foodstuff groups, including 19 types of products, were compared. Statistical analyses were performed using the SPSS statistical program (22.0 edition; SPSS, Chicago, IL, USA).

**Results:** a total of 2,247 GFPs from 126 different foodstuff brands were included in the food composition database of GFPs (CELIAC-BASE). We classified these products into 14 foodstuff groups. The protein content of the GFPs studied was significantly lower, and the price was higher, than that of their non-GFP counterparts. Some, but not all, GFPs had a higher content of fat and sugar, and a lower content of dietary fiber as compared to their non-GFP counterparts. Some GFPs were up to 6 times more expensive than the corresponding non-GFPs.

**Conclusions:** CELIAC-BASE is a pioneering tool for dietitians. Many GFPs have poor nutritional profiles and should be consumed only occasionally in a balanced GF diet.

#### Keywords:

Celiac disease.  
Nutritional  
assessment. Gluten-  
free diet.

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*Specific author contributions:* Nancy Babio designed the study, wrote the manuscript, had full access to all the study data, is responsible for the integrity of the data and the accuracy of the data analysis, and approved the final version to be published. Núria Lladó-Bellette and María Besora-Moreno wrote the manuscript, had full access to all the study data, analyzed and interpreted the results, and revised and approved the final version of the manuscript. Pablo Hernández-Alonso had full access to all the study data, analyzed and interpreted part of the results, and revised and approved the final version of the manuscript. Gemma Castillejo, Núria Guillén, Francesc Martínez-Cerezo, Elisenda Vilchez, Esther Roger, and Jordi Salas-Salvadó had full access to the data, and revised critically for important intellectual content and approved the final version of the manuscript.

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## Resumen

**Introducción:** hasta la fecha, una dieta sin gluten (SG) es el único tratamiento para las personas con enfermedad celíaca. Tanto las evaluaciones de ingesta de alimentos individuales como las colectivas son un desafío debido a la falta de una base de datos de composición de productos SG (PSG).

**Objetivos:** describir el proceso de desarrollo de una base de datos de composición de PSG y comparar el perfil nutricional y el precio de algunos PSG y productos con gluten.

**Métodos:** inicialmente, se registraron un total de 216 marcas de PSG comercializadas en España. La información nutricional se recopiló de las etiquetas nutricionales y hojas informativas de los productos, que habían sido proporcionadas por las compañías de alimentos o recopiladas de primera mano por los investigadores. Luego, se compararon el perfil nutricional y el precio de los grupos de cereales y subproductos alimenticios, incluidos 19 tipos de productos. Los análisis estadísticos se realizaron utilizando el programa estadístico SPSS (edición 22.0; SPSS, Chicago, IL, EUA).

**Resultados:** se incluyeron un total de 2247 PSG de 126 marcas de alimentos diferentes en la base de datos de composición de PSG (CELIAC-BASE). Clasificamos estos productos en 14 grupos de alimentos. El contenido de proteínas de los PSG estudiados fue significativamente menor, y el precio de los mismos fue más alto, que el de sus homólogos con gluten. Algunos PSG, pero no todos, presentaron un mayor contenido de grasa y azúcar, y un menor contenido de fibra dietética, que sus homólogos con gluten. Algunos PSG eran hasta 6 veces más caros que sus homólogos con gluten.

**Conclusiones:** CELIAC-BASE es una herramienta pionera para dietistas-nutricionistas. Muchos PSG tienen perfiles nutricionales no saludables y deben consumirse solo ocasionalmente en una dieta equilibrada libre de gluten.

### Palabras clave:

Enfermedad celíaca. Evaluación nutricional. Dieta libre de gluten.

## INTRODUCTION

Celiac disease is a chronic immune-mediated systemic disorder elicited by gluten intake in genetically predisposed subjects, and characterized by gluten-dependent clinical manifestations, CD antibodies, HLA-DQ2 or HLA-DQ8 haplotypes, and enteropathy (intestinal mucosa damage) (1-3). This disease may lead from mild to severe symptoms, and may sometimes cause severe complications (1,2,4).

The prevalence of celiac disease ranges from 0.5% to 1% in Europe and the United States, and available data suggest that celiac disease incidence is truly increasing (1,5).

A gluten-free (GF) diet is, to date, the only treatment available, which should always be strictly followed by these individuals (6-9). However, it is difficult to make individual and collective food consumption assessments because of the lack of a GFP food composition database of the GFPs available at stores. Although there is little data on nutritional quality (6,10-12), some authors have studied the nutritional quality of GFPs and concluded that it differs from that of their gluten-containing counterparts (6,10,12). Therefore, in order to plan a balanced GF diet or to assess the food consumption of individuals with celiac disease it is essential to have access to a national food composition database. In addition, there is a perception that GFPs are healthier than their gluten-containing counterparts and, consequently, the popularity of GFPs has increased among consumers (11). However, Wu and coworkers evaluated more than 600 GFPs in Australian supermarkets and demonstrated that it is unlikely that GFPs have health benefits in individuals without celiac disease, mainly because GFPs contain less protein and are generally more costly than non-GFP (11).

Despite the increasing demand for and consumption of GFPs, the assessment of their nutritional profile is inconclusive. There are few food composition databases of GFPs (10,13) but none of them contains a significant list of the ever-increasing number of products. To the best of our knowledge, to date, only two

GFP composition databases have been published (10,13). One is from Italy and contains 60 products from 5 brands (10), and the other is from Austria and contains 63 products (13). Additionally, there are other tools or mobile applications for GFPs that provide information about their ingredients and nutritional composition by scanning the package barcode. The *Gluten Free Food Checker App* would be an example of this type of tool (14). To date, there is no similar database in Spain.

Therefore, the main objective of the present study was to develop a Spanish food composition database of packaged GFPs. A secondary objective was to compare the nutritional profile and price of grain-based GFPs and their equivalent gluten-containing products.

## METHODS

### STUDY DESIGN

We designed a descriptive and comparative study on the nutritional profile and price of some GFPs and their non-GFP counterparts. As part of the study, we developed a food composition database of the GFPs marketed in Spain.

### SAMPLE

A total of 216 brands of foodstuffs for individuals with celiac disease and processed foodstuffs containing no gluten were taken from the annual list of GFPs provided by the *Associació Celíacs de Catalunya* (Celiac Association of Catalonia).

The GFPs included were selected only from those brands that provided fact sheets, nutritional labeling or ingredients, which had updated information on their official websites, or which did not answer to the contact request but provided their nutritional

information elsewhere (official websites of grocery stores and/or distributors, the product could be accessed directly).

Exclusion criteria included foodstuffs that are naturally GF; foodstuffs that naturally contain gluten; gluten-containing processed foodstuffs; foodstuffs and/or food products that meet the inclusion criteria but have no or incomplete nutritional information; or products that were not sold in Spain.

## STUDY PRODUCTS

The foodstuffs assessed in this study were: a) specific foodstuffs: groups of products designed and produced for celiacs (GFPs such as bread, pasta and pastries); b) processed foodstuffs: foodstuffs or food products that should not contain gluten but, due to contamination during the production chain, may retain traces. These were included when their nutritional label certified, with a GF logo or claim, the absence of gluten (cold meats, sauces, broths, cheese spread, etc.) (15).

The foodstuff subgroup of cereals and cereal byproducts included 19 types of products: bread and bread byproducts (baguette, sandwich bread, toasts, bread rolls); pasta and pasta byproducts (pasta); pizza, (pizza dough, ham pizza, cheese pizza); breakfast cereals (cornflakes, chocolate cereal, muesli); bakery and pastries (croissants, muffins, puff pastries, chocolate sponge cake); biscuits (Marie biscuits, American cookies, chocolate-filled biscuits); and baby biscuits (biscuits). They were all assessed and their nutritional composition and price compared.

For the comparison, we obtained three non-GF brands for each type of GFP used, two of which were popular brands in the Spanish market whereas the other one was a low-cost or generic brand in Spain. It is important to emphasize that all the non-GFPs selected were similar to their GFP counterparts. This selection criterion was made so that the comparison would be uniform between the different compared products. However, we did not follow the same selection criterion for baby biscuits and baguettes because the search became extremely difficult. In these cases we obtained three popular brands in the Spanish market for baby biscuits, as well as one popular Spanish brand and two low-cost Spanish brands for baguettes.

The protocol was certified by our local institutional review board, and did not require evaluation by that committee.

## PROCEDURE

From official institutions such as the Celiac Association of Catalonia and the *Federación de Asociaciones de Celíacos de España* (FACE) (Spanish Federation of Celiac Associations), which certify GFP brands in Spain, we obtained the annual list (2018) of GF products so that we could locate the brands currently available at Spain. These brands offer a broad spectrum of GFPs that are characteristic of the Spanish GFP market.

After we had contacted retailers, we classified the brands according to the information provided (fact sheets, updated infor-

mation on their official websites, grocery stores, official websites, distributors, or the product directly).

Those brands that did not answer to our contact request or that provided no or incomplete nutritional information were excluded.

The nutritional information for different products and brands was stored in a Microsoft Access digital database. The nutritional information about the products in the database was given in terms of quantity of macro- and micronutrients per 100 g of food, as shown on the mandatory nutritional labels of products, and also included the full range of nutrient data in conventional food compositional tables.

Although some information was not available, this database has the following fields: product code (foodstuff numerical identification), foodstuff group (classification of different foodstuff groups into categories), foodstuff subgroups (classification of different foodstuff groups into categories), foodstuff name (commercial name of each foodstuff product), brand (commercial brand name), brand code (brand numerical identification), calories (kcal/100 g), water (mL/100 g), edible portion, macronutrients (total protein, animal protein, vegetable protein, total fat, saturated fatty acids, monounsaturated fatty acids, polyunsaturated fatty acids, trans-fatty acids, total carbohydrates, sugars, fiber; all in g/100 g), cholesterol (mg/100 g), polyalcohol compounds (g/100 g), minerals, vitamins, net weight (g or mL) and serving size (g or mL).

The cereals and cereal byproducts representing the most commonly consumed grain-based processed foods were compared in terms of their nutritional profile (mandatory nutritional information on the food label) and their price. In regard to the data collection, all products were collected within a period of seven months (June 2017-January 2018). After including all the products, price data were collected for each product between January and February 2018.

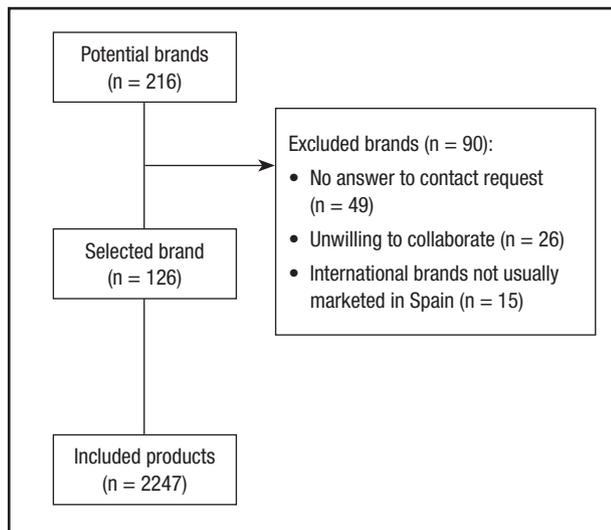
Given the diversity of products and their different formats, to facilitate comparison cost was standardized as price per weight of product (€/kg of product).

## STATISTICAL ANALYSES

Quantitative data are presented as median [IQR] considering both the non-normal distribution of the studied variables in each food group and category (GFP and non-GFP), and the reduced sample size of the GFP categories. Therefore, in order to confirm potential differences between GFP and non-GFP categories, statistical analyses were performed using the non-parametric Wilcoxon's test. The R software (version 3.5.1) was used to execute all statistical analyses. A p-value < 0.05 was considered significant.

## RESULTS

In order to construct the food composition database, 216 GF brands available in the Spanish market were recorded. After that, 90 brands were excluded because no nutritional information was available. Finally, a total of 126 brands and 2,247 products were



**Figure 1.**

Flow chart of gluten-free brands and products included in CELIAC-BASE.

included in the CELIAC-BASE (Fig. 1). All these products were classified in 14 foodstuff groups and, more specifically, in 36 foodstuff subgroups (Table I).

The database was largely built on the basis of the mandatory nutritional information of the products reported on the food label. However, CELIAC-BASE has several specific nutrient fields that could only be completed for those products whose brands provided fact sheets or ingredient information (see Supplemental Digital Content). CELIAC-BASE was previously published by the *Universitat Rovira i Virgili* and has open online access at <http://digital.publicacionsurv.cat/index.php/purv/catalog/book/334>.

Table II shows the comparison of nutritional profiles and prices for the two types of products studied. The protein content of the GFPs studied was significantly lower, and their price was higher than that of non-GFP products. A few GFPs presented a significantly higher content in fat (baguette, bread rolls), SFA (baguette) and sugar (bread rolls, pizza dough) than their non-GFP counterparts. In contrast, a few non-GFPs presented a significantly higher content of SFA (puff pastries) or sugar (sandwich bread, pasta, muffins).

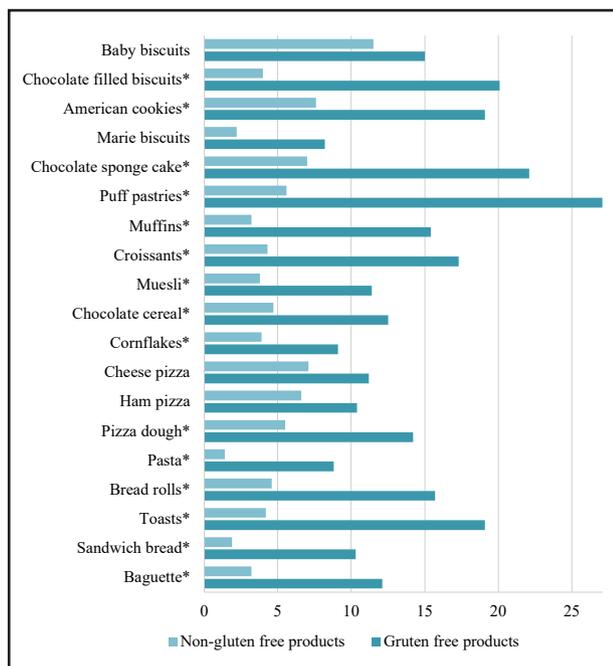
As far as energy content goes, chocolate-filled biscuits with gluten had significantly more calories than their GF counterparts. Even though no statistical differences were found between the two types of most bakery products, pastries and biscuits, the content of sugar, fat, and SFA was high in both GFPs and non-GFPs.

Finally, sodium was the only nutrient that showed no significant differences in any of the products used in the comparison.

The price was the category that presented significant differences in the largest number of products (in 15 out of 19 products). Nevertheless, all GF products were more expensive than gluten-containing products. The price difference can be anything from a ratio between 1.3 and 6.9 higher in GFPs (Fig. 2 and Table II). The most significant price difference between the two

**Table I.** Gluten-free product classification in foodstuff groups and subgroups from CELIAC-BASE

Foodstuff groups (n = 14)	Foodstuff subgroups (n = 36)
<b>Cereal and cereal by-products</b> (n = 946)	Bread and bread byproducts (n = 256) Bakery and pastries (n = 230) Biscuits (n = 124) Pasta and pasta byproducts (n = 120) Flour, bread, and bakery mixes (n = 71) Breakfast cereal (n = 68) Pizza (n = 39) Ready-to-eat meals (n = 36) Other (n = 2)
<b>Meat, poultry, and meat byproducts</b> (n = 349)	Meat, poultry and byproducts (n = 255) Cold meat and cold meat byproducts (n = 48) Ready-to-eat meals (n = 33) Broths (n = 20)
<b>Sweets and sweet byproducts</b> (n = 238)	Chocolate and chocolate byproducts (n = 169) Candy (n = 47) <i>Turrón</i> (nougat) and its byproducts (n = 22)
<b>Dairy and dairy by-products</b> (n = 190)	Yogurt and yogurt byproducts (n = 53) Dairy desserts (n = 53) Ice cream (n = 35) Cheese (n = 33) Milkshakes (n = 16)
<b>Vegetables and legumes</b> (n = 137)	Ready-to-eat meals (n = 93) Soups (n = 19) Vegetable spreads (n = 13) Broths (n = 8) Pasta and pasta by-products (n = 3) Flour, bread and bakery mixes (n = 1)
<b>Sauces and spices</b> (n = 116)	Sauces (n = 109) Spices (n = 7)
<b>Snacks</b> (n = 106)	Snacks (n = 106)
<b>Fish, seafood and fish by-product</b> (n = 88)	Canned food (n = 28) Ready-to-eat meals (n = 27) Fish by-products (n = 19) Broths (n = 13) Soups (n = 1)
<b>Baby foodstuff</b> (n = 36)	Baby food (n = 18) Baby soups (n = 13) Baby biscuits (n = 2) Baby formula (n = 2) Bread and bread by-products (n = 1)
<b>Drinks and drink by-products</b> (n = 13)	Non-alcoholic drinks (n = 7) Alcoholic drinks (n = 6)
<b>Fruit and fruit by-products</b> (n = 12)	Dried fruit (n = 12)
<b>Nuts and seeds</b> (n = 9)	Nuts (n = 9)
<b>Tuber and tuber by-products</b> (n = 5)	Ready-to-eat meals (n = 5)
<b>Fats and oils</b> (n = 2)	Margarine (n = 2)



**Figure 2.** Comparison of price (€/kg) between study gluten-free and non-gluten-free products. \*p-value < 0.05.

product categories was found in the pasta group, which presented a difference of 586%. In contrast, the lowest percentage difference (32.7%) observed was for baby biscuits (Table II).

**DISCUSSION**

The present study describes the development of a food composition database of GFPs in Spain, and compares the nutritional profile and price of some GFPs and their non-GFP counterparts.

The results of the study show that GFPs had a significantly lower content of protein. The only significant differences in the other nutrients evaluated were found in specific nutrients and foodstuff products. Nutrients associated with a worse nutritional profile – for example, saturated fatty acids and sugars – were not always found in more substantial amounts in GFPs than in their counterparts with gluten. In terms of price, GF products were up to 6.9 times more expensive than their equivalents.

These results are in line with previous studies (13) since they also found that GFPs had a lower protein (11-13) content and were more expensive (11,13,16-20).

Some studies suggest that protein content is lower due to the use of GF cereals as substitutes for wheat, which contains a larger quantity of protein (16). A study from 2014, which came up with the same nutritional comparison between both categories of products, found out that GF bread had significantly more calories, more fat, and less protein than bread with gluten.

**Table II.** Comparison of nutritional composition profile and price between gluten-free and non-gluten-free products

Type of product	Type of foods	n	Energy (kcal) median [IQR]	Protein (g) median [IQR]	Fat (g) median [IQR]	SFA (g) median [IQR]	CHO (g) median [IQR]	Sugar (g) median [IQR]	Na (mg) median [IQR]	Price (€/kg) median [IQR]	GFP vs non-GFP ratio	% change from GFP
GFP	Baguette	19	266 [247; 290]	2.2 [1.4; 2.9]	4.62 [2.7; 6.1]	0.7 [0.4; 1.1]	55.9 [46.4; 61.6]	2.7 [1.7; 3.8]	590 [362; 600]	10.8 [9.1; 13.5]	3.0	203.4
Non-GFP	Baguette	3	258 [257; 269]	9.6 [8.9; 9.6]	1.1 [1.1; 1.2]	0.2 [0.2; 0.3]	52.0 [51.1; 54.5]	2.1 [1.8; 2.2]	520 [350; 520]	3.6 [2.7; 3.9]		
GFP	Sandwich bread	18	269.91 [248; 286]	2.3 [1.9; 3.4]	5.1 [3.5; 6.0]	0.9 [0.6; 1.8]	50.2 [45.3; 58.9]	3.4 [3.3; 6.7]	560 [500; 600]	9.9 [7.6; 12.2]	4.7	372.7
Non-GFP	Sandwich bread	3	246 [245; 250]	9.4 [9.2; 9.8]	2.0 [1.9; 2.3]	0.5 [0.5; 0.6]	47.0 [46.5; 48.0]	5.0 [4.4; 5.1]	440 [414; 480]	2.1 [1.7; 2.3]		
GFP	Toast	7	394 [372; 407]	4.2 [2.3; 7.3]	6.2 [3.4; 7.1]	3.4 [1.1; 3.9]	78.8 [75.5; 82.8]	5.2 [3.3; 7.1]	640 [360; 674]	18.7 [15.9; 21.4]	5.1	405.9
Non-GFP	Toast	3	389 [387; 389]	11 [10.5; 11.2]	4.8 [4.7; 6.8]	0.6 [0.5; 0.8]	72 [71.5; 72.7]	5.2 [5.1; 6.1]	480 [396; 595]	3.7 [3.03; 5.09]		

(Continuation in the next page)

**Table II (Cont.).** Comparison of nutritional composition profile and price between gluten-free and non-gluten-free products

Type of product	Type of foods	n	Energy (kcal) median [IQR]	Protein (g) median [IQR]	Fat (g) median [IQR]	SFA (g) median [IQR]	CHO (g) median [IQR]	Sugar (g) median [IQR]	Na (mg) median [IQR]	Price (€/kg) median [IQR]	GFP vs non-GFP ratio	% change from GFP
GFP	Bread rolls	13	288 [255; 298]	2.2 [1.5; 3.0]	5.6 [3.5; 7.3]	0.9 [0.6; 2.8]	55.9 [49.0; 64.0]	3.3 [1.9; 7.7]	560 [400; 600]	14.5 [13.4; 15.6]	3.3	226.3
Non-GFP	Bread rolls	3	270 [264; 280]	8.5 [8.2; 8.9]	1.4 [1.3; 1.4]	0.3 [0.3; 0.3]	55 [54; 56.8]	1.9 [1.6; 2.3]	600 [600; 620]	4.5 [3.5; 5.6]		
GFP	Pasta	26	357 [351; 358]	6.5 [5.5; 7.5]	1.65 [0.9; 1.8]	0.4 [0; 0.5]	78.3 [77.0; 79.0]	0.7 [0.5; 1.0]	8 [0; 20]	9.3 [5.1; 10.7]	6.9	586.0
Non-GFP	Pasta	3	354 [349; 356]	12 [11.5; 12.4]	2.0 [1.7; 2.0]	0.5 [0.4; 0.5]	70.9 [69.5; 71.5]	3.5 [3.5; 3.5]	12 [8.6; 22]	1.4 [1.2; 1.6]		
GFP	Pizza dough	13	294 [278; 319]	2.2 [1; 2.7]	6.9 [4.9; 7.4]	3.5 [1.0; 3.9]	58.0 [50.7; 61.0]	2.9 [1.6; 5.4]	560 [480; 600]	14.8 [11.7; 16.6]	3.4	241.8
Non-GFP	Pizza dough	3	287 [281; 303]	7.8 [6.1; 8]	7.0 [5.6; 7.2]	1.5 [1.2; 1.9]	46.8 [37.7; 50.9]	0.5 [0.3; 0.7]	500 [490; 550]	4.3 [4.2; 6.3]		
GFP	Ham pizza	6	235 [208; 264]	9.3 [6.1; 10]	9.1 [7.0; 11.6]	3.2 [2.7; 3.7]	27.3 [23.9; 31.5]	2.4 [1.8; 3.23]	580 [530; 870]	9.1 [7.9; 10.6]	1.4	39.3
Non-GFP	Ham pizza	3	224 [224; 228]	14 [12.5; 14]	7.5 [7.5; 8.6]	3.4 [3.4; 3.8]	25.2 [24.8; 25.2]	1.6 [1.6; 2.1]	600 [560; 600]	6.5 [5.7; 7.4]		
GFP	Cheese pizza	4	285.5 [269; 293]	10.3 [8.9; 12.8]	12.4 [11.0; 14.2]	7.3 [6.2; 8.6]	28.4 [22.3; 32.1]	2.4 [1.9; 2.7]	675 [560; 857]	9.5 [7.7; 12.9]	1.4	39.9
Non-GFP	Cheese pizza	3	267 [260; 267]	14.4 [13.1; 14.4]	11.0 [11.0; 11.2]	6.8 [6; 6.8]	27.6 [26.4; 27.6]	2.2 [2.2; 2.7]	560 [520; 560]	6.77 [6.2; 7.8]		
GFP	Cornflakes	11	374 [370; 384]	7.1 [6.3; 7.6]	1.0 [0.9; 2.2]	0.4 [0.2; 0.8]	81.6 [80.0; 82.8]	4.4 [4.1; 10.0]	640 [370; 810]	9.2 [7.2; 10.7]	2.3	130.0
Non-GFP	Cornflakes	3	378 [372; 379]	7.8 [7.4; 8.5]	0.9 [0.7; 1.1]	0.2 [0.2; 0.4]	84.0 [80.0; 85.0]	8.0 [6.5; 10.0]	456 [413; 2488]	4.0 [3.1; 4.7]		
GFP	Chocolate cereal	6	380 [377; 394]	7.48 [6.6; 8.3]	2.4 [1.7; 3.8]	1.3 [0.9; 1.8]	81.4 [80.6; 81.9]	20.6 [20.0; 26.3]	130 [31; 265]	13.3 [9.9; 14.5]	2.5	150.8
Non-GFP	Chocolate cereal	3	385 [377; 386]	7.8 [6.7; 7.8]	2.5 [2.1; 2.6]	1.0 [0.8; 1.1]	79.0 [77.4; 81.5]	30.0 [27.5; 30.5]	200 [190; 250]	5.3 [3.9; 5.8]		
GFP	Muesli	7	380 [371; 387]	11.6 [9.8; 13.2]	8.4 [6.45; 11.4]	1.4 [1.4; 1.7]	55.3 [53.4; 63]	15.0 [9.9; 26.7]	40 [25; 185]	11.3 [10.9; 12.3]	3.2	224.5
Non-GFP	Muesli	3	361 [353; 361]	9.1 [9.1; 9.2]	5.8 [5.15; 6.7]	2.6 [1.9; 3.2]	62.2 [60.6; 63.1]	20.0 [17.5; 20.5]	32 [21; 136]	3.5 [2.5; 4.9]		

(Continuation in the next page)

Table II (Cont.). Comparison of nutritional composition profile and price between gluten-free and non-gluten-free products

Type of product	Type of foods	n	Energy (kcal) median [IQR]	Protein (g) median [IQR]	Fat (g) median [IQR]	SFA (g) median [IQR]	CHO (g) median [IQR]	Sugar (g) median [IQR]	Na (mg) median [IQR]	Price (€/kg) median [IQR]	GFP vs non-GFP ratio	% change from GFP
GFP	Croissants	10	371 [343; 391]	<b>1.8</b> [1.8; 3.9]	18 [15.5; 20.8]	8.8 [5.9; 10.9]	46.5 [45.7; 50.2]	7.6 [6.1; 11.0]	420 [340; 520]	<b>17.3</b> [13.2; 22.1]	4.1	308.2
Non-GFP	Croissants	3	467 [466; 468]	<b>6.9</b> [6.8; 7.6]	28.0 [28.0; 29.5]	14.0 [13.5; 14]	46.0 [42.5; 46.5]	12.0 [10.3; 12.0]	300 [285; 320]	<b>4.2</b> [3.3; 5.2]		
GFP	Muffins	23	432 [407; 440]	3.8 [3.1; 5.4]	23.2 [20.0; 26.0]	3.5 [2.8; 3.8]	48.0 [44.3; 53.5]	<b>26.0</b> [23.05; 28.0]	220 [170; 370]	<b>16.3</b> [12.2; 18.6]	5.1	408.1
Non-GFP	Muffins	3	432 [420; 435]	5.0 [4.95; 5.4]	22 [20.5; 23.0]	2.7 [2.7; 2.8]	53.0 [52.5; 53.5]	<b>31.0</b> [30.5; 31.5]	240 [225; 308]	<b>3.2</b> [2.4; 3.9]		
GFP	Puff pastries	5	456.57 [447; 468]	<b>1.8</b> [1.4; 2.9]	19.9 [15.2; 25.6]	<b>8.4</b> [5.7; 10.7]	57.4 [47.0; 61.4]	15.1 [11.3; 21.6]	345 [266; 447]	<b>28.2</b> [23.7; 29.9]		
Non-GFP	Puff pastries	3	518 [512; 539]	<b>5.1</b> [4.9; 6.4]	28 [27.5; 30]	<b>15</b> [14.5; 15]	60.0 [60.0; 60.5]	20.0 [18.0; 25.0]	320 [320; 350]	<b>5.2</b> [4.2; 6.8]	5.4	439.2
GFP	Chocolate sponge cake	9	398 [303; 433]	6.0 [4.7; 6.8]	20.1 [8.4; 22.0]	5.4 [3.6; 9.5]	47.0 [44.4; 51.0]	25.6 [22.0; 31.0]	270 [140; 510]	<b>20.9</b> [14.4; 24.9]	2.6	162.5
Non-GFP	Chocolate sponge cake	3	424 [393; 424]	7.6 [7.1; 7.6]	25 [21.0; 25.0]	3.6 [3.6; 3.9]	37.0 [36.7; 41.0]	26.0 [26.0; 28.0]	200 [200; 230]	<b>7.9</b> [6.6; 7.9]		
GFP	Marie cookies	6	465 [462; 467]	3.4 [2.2; 5.9]	16.5 [15.0; 17.7]	2.0 [1.5; 6.7]	74 [70.8; 75.0]	21.0 [20.0; 25.7]	290 [182; 360]	<b>7.0</b> [4.9; 9.6]	2.8	181.1
Non-GFP	Marie cookies	3	461 [450; 471]	7.0 [6.7; 7.3]	14.0 [12.2; 17.0]	4.2 [2.8; 4.7]	76.0 [72.0; 76.5]	23.0 [22.0; 23.5]	330 [325; 365]	<b>2.49</b> [1.9; 2.7]		
GFP	American cookies	14	486.5 [449; 495]	4.85 [4.5; 5.8]	23.0 [22.0; 24.7]	11.2 [6.0; 12.0]	64.4 [62.0; 67.7]	26.2 [22.6; 34.5]	260 [170; 550]	<b>15.9</b> [12.5; 24.3]	2.0	101.1
Non-GFP	American cookies	3	496 [489; 500]	5.6 [5.5; 6.1]	23.0 [22.5; 23.7]	12.5 [9.8; 12.8]	64.0 [64.0; 65.0]	31.5 [30.7; 35.2]	420 [340; 430]	<b>7.9</b> [5.9; 9.5]		
GFP	Chocolate filled biscuits	4	<b>473,5</b> [471; 475]	4.6 [4.1; 5.48]	19.0 [18.9; 21.2]	11.2 [8.7; 13.3]	68.5 [65.4; 69.2]	32.0 [22.9; 34.3]	255 [145; 342]	18.1 [15.6; 22.7]	3.7	267.7
Non-GFP	Chocolate filled biscuits	3	<b>490</b> [486; 490]	6.0 [5.8; 6.2]	20.0 [18.5; 20.5]	7.2 [6.4; 9.1]	68.0 [67.7; 68.0]	31.5 [29.7; 33.3]	200 [175; 215]	4.9 [3.4; 5.1]		
GFP	Baby biscuits	3	457 [447; 461]	4.1 [2.3; 4.3]	14.0 [13.0; 15.5]	5.6 [3.4; 8.8]	77.0 [75.0; 79.5]	20.0 [18.0; 1.3]	130 [90; 155]	14.6 [12.4; 17.3]	1.3	32.7
Non-GFP	Baby biscuits	3	426 [420; 435]	8.5 [7.8; 9.8]	10.9 [9.7; 11.7]	5.4 [4.9; 5.9]	74.6 [71.8; 74.8]	24 [23.0; 24.5]	192 [141; 276]	11.0 [10.4; 12.2]		

A non-parametric Wilcoxon test was used;  $p < 0.05$  was considered significant (in **bold**). CHO: carbohydrates; GFP: gluten-free products; Na: sodium; Non-GFP: non-gluten-free products; SFA: saturated fatty acids.

The same study found that GF pasta had more fat, saturated fatty acids, and sodium, and less fiber, sugar and protein. In all cases the differences were statistically significant. The results of our study agree with these results only in the fact that GF pasta has less sugar and both GF pasta and GF bread have less protein ( $p < 0.05$ ) (12). A study published in 2018 focused on gluten-free products targeting children reported that gluten-free products contain lower amounts of sodium, total fat, and saturated fatty acids (21). However, in line with the present study, the total protein count was lower in baby biscuits specifically, and sugar content was similar to that in their non-GFP counterparts (21).

In line with the published scientific literature that analyzes GFPs, it does indeed follow that these products are more expensive (11,13,16-20). GFPs are usually made with GF cereals, such as corn and rice, which are more expensive than wheat, and the absence of gluten limits the handling of these specific ingredients. On the other hand, GF products are subjected to mandatory strict tests to ensure that their gluten content is lower than 20 ppm, which might be another reason why GFPs are high priced.

Regarding sodium, saturated fat and total sugars content, for the most part, GF and non-GF products were similar, in line with some authors (11,13), but differently than in other studies (12,22). In order to improve the organoleptic properties of GFPs, which are often affected by the extraction of gluten, studies have observed that GFPs have higher amounts of fat, sugar and sodium (22). Maybe Spanish companies are making an effort to improve the nutritional profile of their GFPs.

In line with our results, regarding the energy profile, some studies reported that GFPs in general exhibited caloric values comparable to those of non-GFPs (10,11,13,23,24), while other authors found a lower energy density in GF bakery products (12).

Several studies evaluate the diet adequacy and the nutritional status of patients with celiac disease (13). Currently, there is controversy over the nutritional balance between a GF diet and a regular gluten-containing diet. In fact, our research group detected nutritional deficiencies in GF diets and concluded that patients do not make balanced food group choices (25). They also have an excessive intake of specific GF foodstuff. Thus, considering that GFPs are processed products (with a high quantity of ingredients and sugar; maltodextrins and fats are frequently present), individuals with celiac disease or suffering other gluten/wheat disorders should consume these products only occasionally.

The main strength of the present study is that the food composition database of GFPs attempts to be an innovative tool that will help evaluate nutritional adequacy in individuals with celiac disease. It is important to note that this should be a task for registered dietitians only to increase the adherence and improve the adequacy of a GF diet. It is recommended that there be a continuous follow-up of these subjects with a trained registered dietitian (3,7).

Our study has some limitations. For example, it obtains the nutritional information from food labeling instead of from chemical analyses, which is a more objective and precise procedure. Con-

sequently, we could not record complete information on micronutrients. Another limitation is the reduced number of non-GF brands used for the nutritional comparison with the GF brands, but they were popular brands or low-cost Spanish brands.

## CONCLUSION

CELIAC-BASE is a pioneering tool for dietitians that will help them with the dietary assessment of individuals with celiac disease. Some critical nutrients must be monitored in a balanced GF diet with GF products. Therefore, individuals with celiac disease or other gluten/wheat disorders should consume these products only occasionally.

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