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Short Communication

The development of a composition database of gluten-free products

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Abstract

Objective: To develop a composition database of a number of foods representative of different categories of gluten-free products in the Italian diet.
Design: The database was built using the nutritional composition of the products, taking into consideration both the composition of the ingredients and the nutritional information reported on the product label.
Setting: The nutrient composition of each ingredient was obtained from two Italian databases (European Institute of Oncology and the National Institute for Food and Nutrition).
Subjects: The study developed a food composition database including a total of sixty foods representative of different categories of gluten-free products sold on the Italian market. The composition of the products included in the database is given in terms of quantity of macro- and micronutrients per 100 g of product as sold, and includes the full range of nutrient data present in traditional databases of gluten-containing foods.
Results: As expected, most of the products had a high content of carbohydrates and some of them can be labelled as a source of fibre (>3 g/100 g). Regarding micronutrients, among the products considered, breads, pizzas and snacks were especially very high in Na content (>400–500 mg/100 g).
Conclusions: This database provides an initial useful tool for future nutritional surveys on the dietary habits of coeliac people.

Keywords
Coeliac disease
Gluten-free products
Gluten-free diet
Food composition database

Coeliac disease is an immune-mediated systemic disorder occurring in genetically susceptible individuals. It is elicited by gluten and related prolamines and characterized by the presence of a variable combination of gluten-dependent clinical manifestations[1]. Several studies have brought to light an increase in the occurrence of such disease, with an estimated prevalence worldwide of approximately 1 %[2,3]. Coeliac disease is currently treated with a lifelong exclusion of gluten from the diet. The coeliac diet is characterized by a combination of naturally occurring gluten-free (GF) foods and GF substitutes of bread, cookies, pasta and other cereal-based foods. The GF foods are made by either ingredients that do not include gluten-containing cereals (e.g. wheat, rye, barley) or by ingredients from such cereals that have been specially processed to remove gluten. Because derivates of gluten-rich grains are important sources of nutrients in the general diet[4], their exclusion from the diet of coeliac patients could potentially have a major effect on their nutritional status if such foods are not replaced with balanced alternatives.

In previous years, a large amount of research has been carried out on the development of GF products. Starches, dairy products, gums and hydrocolloids, non-gluten proteins, prebiotics and combinations thereof have been explored as alternatives to gluten to improve the structure, mouthfeel, acceptability and shelf-life of GF bakery products[5]. However, little information is available on the nutritional composition of these GF products. Composition data useful to evaluate the adequacy of nutrient intake of coeliac patients, on which the debate is still open[6–9], are therefore strongly needed. In the present work, we built a database of composition of a number of foods representing the main sources of intake of GF products in the Italian diet. For this purpose, we estimated the nutritional composition of the products

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taking into consideration both the composition of the ingredients and the nutritional information reported on the product label.

Methods

Five commercial brands of GF foods were selected based on the results of a nutritional survey carried out on forty coeliac patients[9], on the Italian National Register of GF products (2010) and on the data from an Italian market share of GF products[10]. The GF products selected in the portfolio of such brands were grouped according to categories of non-GF foods reported in two Italian food databases made by the European Institute of Oncology[11] and the National Institute for Food and Nutrition[12].

The categories considered were the following: cookies, breakfast products, sweet products, breads, pizzas, savoury snacks, pasta dishes and flours. The products included in each category were those most consumed in Italy by coeliac individuals on a market share basis. Each food category included different foods, further grouped into sub-categories according to common dietary habits of the general population. As an example of this strategy, the five brands selected included in their portfolios a total of thirty-six types of bread products, which were grouped in eight sub-categories: sliced white bread (sandwich-type); bread prepared with olives; white table bread of different sizes (i.e. loaf of 250 g and loaf of 50 g); whole-meal bread; bread prepared with oil; and flat breads (ciabatta and piadina).

To estimate the full nutrient composition of single GF foods, we used the data on nutrient composition of the ingredients reported on the label and the nutrition information of each product. First, the nutrient composition of each ingredient was obtained from the two Italian databases cited above, complemented, when necessary, by data from the National Nutrient Database for Standard References of the US Department of Agriculture[13]. For each ingredient, we placed in quantity order on a Microsoft Excel worksheet the composition in macro- and micronutrients per 100 g in its raw form. As a second step, we estimated for each GF product the quantity of each ingredient (as a percentage of the final recipe) based on its rank order reported on the label and the percentage of some ingredients when explicitly stated on the label. Then, after calculating the theoretical nutrient composition of the product based on the ingredient data and their percentage in the final product, we compared the results of macronutrients with those present on the nutrition label, which, at least in its short form (i.e. macronutrients and energy), is mandatory for GF products. Finally, the process was reiterated by adjusting the percentage of the different ingredients until results reflected the values of macronutrients reported on the nutrition label. In addition, as thermal treatments and other food preparation steps can affect the nutrient composition, especially that of micronutrients, to estimate the nutrient content of processed and composite foods (e.g. biscuits and pizzas) we applied, when available, the retention factors of the following micronutrients[14]: thiamin, riboflavin, niacin, folate, vitamin C and β-carotene equivalents. Such retention factors account for the nutrient content retained in a food after losses due to heating or other food preparation steps.

In the case of special food additives, such as gums and protein isolates, the purity, quantity and nutrient composition of those generally used in GF products were estimated with the assistance of experts in the industrial production of GF foods.

The calculated nutritional components of each food item were: energy expressed in kcal and kJ, water, macronutrients (i.e. available carbohydrates, sugar, protein, lipids, saturated lipids), fibre, cholesterol, minerals (i.e. Fe, Ca, Na, K, P and Zn) and vitamins (D, E, retinol, β-carotene equivalents, thiamin, riboflavin, niacin, folate and C).

The described process was done for 149 products. However, the developed composition database includes sixty foods because the nutritional values of each food item were calculated as the average of the nutritional values for all the single similar foods from each brand included in each sub-category.

Results

The composition of the sixty products included in the database is given in terms of quantity of macro- and micronutrients per 100 g of product as sold, and includes the full range of nutrient data present in the traditional databases of non-GF foods.

Table 1 reports the macronutrient composition of sweet products. As expected, the energy content was similar among the products considered and most of them showed a high content of fat and sugar. With regard to the micronutrient content (see online supplementary material, Supplemental Table 1), panettone and pandoro cakes exhibited the highest content of Ca; brioches had a very high content of Na (>500 mg/100 g), whereas pastry with cream filling can be classified as a food with a 'low sodium content' (<120 mg/100 g)[15]. Concerning folate content, there was a great variability among the samples considered.

Table 2 presents the macronutrient composition of breads, pizzas, snacks and flours. Unsurprisingly, all of the products had a high content of available carbohydrates and sugar, and most of them can be labelled as a source of fibre (>3 g/100 g)[15], whereas there was a wide range of protein, fat and cholesterol content. Concerning micronutrient content (online supplementary material, Supplemental Table 2), all items considered showed a similar amount of Fe, with the exception of the frozen pastry pockets with cheese that exhibited the highest value. Interestingly, all GF products belonging to these

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Table 1 Macronutrient composition of commercial gluten-free cookies, breakfast and sweet products in Italy. Values are expressed per 100 g of product

Food	Energy (kcal)	Energy (kJ)	Water (g)	Available carbohydrates (g)	of which sugar (g)	Fibre (g)	Protein (g)	Lipids (g)	of which saturates (g)	Cholesterol (mg)
Cookies										
Chocolate biscuits	463	1939	2	68·0	25·3	2·5	6·2	20·5	7·9	44
Biscuits filled with chocolate	489	2045	4	61·9	34·1	2·4	5·1	26·0	10·6	35
Biscuits plain	453	1894	3	72·9	17·8	1·8	5·5	17·3	6·9	30
Chocolate-coated biscuits	484	2026	4	63·6	32·8	2·0	5·7	24·6	13·4	15
Ladyfinger biscuits	367	1536	12	74·9	30·7	2·5	5·8	6·5	1·2	176
Breakfast cookies	451	1885	4	72·3	21·3	1·6	5·3	17·5	7·1	63
Whole-meal biscuits	456	1908	5	69·1	16·3	5·1	3·9	18·9	3·8	0
Breakfast products										
Melba toast	403	1688	5	7·8	6·4	4·5	3·7	9·1	2·9	0
Muesli	374	1567	13	60·0	29·8	6·0	13·1	10·7	4·0	0
Sweet products										
Margherita cake	431	1804	16	53·6	29·7	2·5	5·1	22·8	4·7	176
Sponge cake	458	1914	17	52·3	25·5	1·7	5·4	26·3	12·2	146
Panettone cake	336	1407	26	51·1	22·9	3·1	5·8	13·6	5·4	243
Pandoro cake	337	1411	29	47·3	16·4	2·1	6·4	15·4	6·1	347
Tiramisu cake	184	771	63	22·3	16·6	0·9	4·7	8·9	3·9	146
Plum cake	390	1633	22	47·2	22·3	1·5	5·0	21·1	7·4	153
Plum cake with chocolate	423	1768	19	50·3	27·2	2·2	5·3	23·3	8·9	135
Brioche bread	340	1423	35	52·5	12·2	2·2	3·1	7·4	2·8	50
Brioches	352	1471	34	42·2	6·9	2·6	3·6	18·9	3·8	23
Croissant with jam	331	1384	36	45·5	11·6	2·2	2·8	16·1	3·3	10
Croissant with chocolate	365	1527	30	45·6	14·1	2·9	3·3	19·5	5·3	10
Pastry with chocolate filling	397	1660	19	53·2	31·3	3·5	5·3	19·1	5·3	87
Pastry with jam filling	367	1536	20	58·5	25·3	3·5	5·2	13·1	3·7	111
Pastry with cream filling	452	1891	5	70·8	41·8	1·5	4·9	18·3	8·5	0
Cereal bars	389	1627	8	67·1	26·6	5·3	5·9	11·4	5·6	4
Muffin	391	1636	17	60·7	29·4	0·8	5·5	15·6	6·6	136
Puff pastry	404	1688	39	29·7	4·1	12·6	2·3	28·8	5·8	0
Chocolate ice cream	307	1353	45	35·2	21·8	4·7	3·7	16·4	5·3	10

Table 2 Macronutrient composition of commercial gluten-free breads, pizzas, snacks and flours in Italy. Values are expressed per 100 g of product

Food	Energy (kcal)	Energy (kJ)	Water (g)	Available carbohydrates (g)	of which sugar (g)	Fibre (g)	Protein (g)	Lipids (g)	of which saturates (g)	Cholesterol (mg)
Breads										
Sliced white bread (sandwich-type)	248	1039	45	42·1	3·5	4·7	4·2	5·5	1·1	0
Bread prepared with olives	227	951	52	32·2	2·0	3·5	5·4	8·7	1·0	0
Bread white (loaf 250 g)	247	1034	41	47·4	3·6	5·6	3·6	5·1	1·0	0
Breadcrumbs	403	1686	7	73·7	6·3	4·5	5·0	11·0	3·2	10
Whole-meal bread	230	963	44	40·7	3·5	6·4	4·1	5·3	1·0	0
Bread white (loaf 50 g)	277	1157	38	54·1	3·8	3·8	2·5	4·4	1·1	0
Bread prepared with oil	246	1030	42	46·1	2·4	5·7	3·0	5·5	0·9	0
Ciabatta bread	307	1283	44	45·3	2·4	5·4	3·1	3·6	0·9	0
Piadina bread	330	1380	24	56·4	5·8	4·4	4·6	10·2	2·0	5
Pizzas										
Focaccia	293	1225	35	49·8	2·6	4·3	2·8	8·0	1·6	0
Pizza with tomato	198	829	56	38·2	2·4	4·8	3·3	3·7	0·4	0
Pizza with tomato and mozzarella	235	982	52	32·1	5·1	4·4	6·6	8·8	2·6	10
Calzone	284	1187	40	39·2	5·0	2·8	6·9	11·5	4·1	11
Pizza dough	367	1534	32	57·1	3·0	2·9	2·8	5·3	1·1	0
Frozen pastry pockets with cheese	169	707	65	25·2	6·0	4·4	4·5	5·6	2·3	25
Savoury snacks										
Salted crackers	401	1676	5	80·0	3·1	2·7	3·5	9·2	2·9	10
Cracotte (crisp bread)	348	1457	8	79·0	3·4	1·6	7·4	2·6	0·9	0
Saltine crackers	459	1919	7	72·3	3·1	0·1	0·5	20·6	9·4	0
Bread sticks	414	1732	7	78·3	3·9	2·0	3·4	10·5	2·5	14
Flours										
Mixed flours	336	1405	10	82·7	4·3	4·4	3·1	0·5	0·1	1
Flour for cake	344	1437	9	86·8	22·9	1·8	2·0	0·7	0·1	0
Flour for bread	329	1378	11	79·4	3·3	4·5	3·6	0·9	0·2	2

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Table 3 Macronutrient composition of commercial gluten-free pasta dishes in Italy. Values are expressed per 100 g of product

Food	Energy (kcal)	Energy (kJ)	Water (g)	Available carbohydrates (g)	of which sugar (g)	Fibre (g)	Protein (g)	Lipids (g)	of which saturates (g)	Cholesterol (mg)
Egg pasta (fresh)	274	1148	46	57·6	0·5	3·9	5·4	3·3	0·7	76
Egg pasta (dry)	351	1470	11	76·6	1·2	1·9	7·4	3·5	0·9	119
Whole-meal pasta	381	1595	9	80·3	0·9	4·8	7·6	2·9	0·6	0
Pasta made with different flours	333	1392	12	75·7	0·7	2·1	7·4	2·0	0·2	0
Corn pasta	336	1405	15	75·0	1·4	2·4	8·0	2·5	0·3	0
Rice pasta	337	1410	11	79·9	0·0	1·0	6·6	1·2	0·1	0
Pasta for broth	333	1392	12	75·7	0·7	2·1	7·4	2·0	0·2	0
Pasta filled with meat	219	916	52	33·7	2·0	2·4	7·3	6·6	2·5	50
Pasta filled with vegetables	262	1096	44	36·4	2·9	2·2	11·2	8·5	3·0	94
Gnocchi	153	642	59	36·5	0·5	3·3	3·0	0·5	0·1	10
Cous cous	339	1420	12	75·8	1·4	2·4	8·1	2·5	0·3	0

categories, with the exception of calzone and two flours, showed a very high Na content (>400–500 mg/100 g).

The macronutrient content of pasta dishes is reported in Table 3. The energy and carbohydrate content was similar, with the exception of gnocchi and pastas filled with meat and with vegetables that had lower values because of a high content of water. The whole-meal pasta showed the highest fibre content followed by the fresh egg pasta. With regard to the micronutrient content (online supplementary material, Supplemental Table 3), different types of GF pastas had a quite similar amount of Fe, but different Ca and Na contents. Five GF pasta samples could be labelled as 'without sodium content' (≤5 mg/100 g) and the egg pasta (fresh and dry) and the whole-meal pasta can be considered as foods with a 'low sodium content' (≤120 mg/100 g)[15].

Discussion

The present study represents a systematic attempt to build a composition database of GF products based on the ingredients listed on the label. The overall results from the sixty foods representative of different categories of GF products sold on the Italian market demonstrate that almost all products had a high content of available carbohydrates and 50 % of them contained a good amount of dietary fibre due to the presence of hydrocolloids in their formulation.

Having these data at hand can allow an accurate assessment of the dietary habits of coeliac patients and then an evaluation of the nutritional adequacy of the GF diet. To date, several studies have been carried out in different countries on the nutritional adequacy of the GF diet in terms of macro- and micronutrients, mostly presenting conflicting results. In fact regarding the macronutrient intake, several authors have reported similar intakes of energy[9,16–18], fat[17], protein, carbohydrates[9,17], including starch and sugars, fibre and cholesterol between coeliac patients and controls. Conversely, other authors showed significantly lower energy[6,16] and fibre intakes[17,18], but higher intakes of total and saturated fat[16] in the diet of coeliac patients compared with healthy controls. In relation to micronutrient intakes, the majority of studies showed lower levels of folate, niacin, vitamin B_{12}, vitamin E, vitamin A, P, Ca, Zn and Se in coeliac individuals than in controls[8,9,17–20]. As a consequence, despite the relatively abundant literature on the dietary habits of coeliac individuals, it is still difficult to draw a conclusion on the nutritional adequacy of the GF diet. This discrepancy among the studies could be partly linked to the limited data on GF foods in the databases. In fact, in almost all of the cited studies the process applied to calculate the nutrient composition data of GF products, used to estimate the nutritional intake of the coeliac group investigated, was not clearly described. On the contrary, in the present communication the process applied for the construction of the composition database of GF products is described step-by-step and several strategies were applied to minimize errors. In particular, the weight changes of ingredients during cooking and food processing were taken into account as the quantity of each ingredient (as a percentage of the final recipe) was adjusted on the basis of the values of macronutrients reported on the nutrition label. This approach allows us to avoid applying the yield factors traditionally used in estimating the nutrient content of composite dishes by using the ingredients[21]. Moreover, to improve the accuracy of the nutrient estimation in calculating the nutrient content of composite foods, the losses of micronutrients (i.e. vitamins) due to heating or other food preparation processes were taken into account by applying the nutrient retention factors evaluated for cereal-based foods[14] at the ingredient level. Finally, the nutritional values of each single food item included in the developed database were calculated as the average of the nutritional values of all the single similar foods from each brand included in each sub-category (e.g. sliced white bread). Therefore, this allows for the consideration of the nutritional composition variability for each food item due to its ingredient formulation.

Some limitations related to our data should be taken into account. First of all, since the nutritional composition data of GF products have been estimated, they cannot

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substitute a direct analysis. As a consequence, the comparison between these data and those of their gluten-containing counterparts, included in the databases[11,12] and obtained by a direct analysis, in some cases would be misleading. However, our newly developed database will facilitate research into assessment of the dietary habits of coeliac patients and will provide the basis for improvement of the nutritional quality of GF foods. Moreover, the composition data of the ingredients were taken from food composition databases which, in some cases, report approximate data. However, it is already permitted for generic foods to produce the nutritional labelling based on the ingredients used for the recipe, thus our data are likely to be just as accurate as the majority of data reported for any kind of food product present on the market. Finally, it must be highlighted that the nutrient composition concerns GF products sold in Italy, even though more than 50 % of them are produced by companies that distribute their products all over Europe.

Nowadays there is a lack of data on the nutritional adequacy of the coeliac diet. Despite the limitations, the present database provides a first attempt to increase the accuracy of the dietary assessment tools used for future nutritional surveys on the dietary habits of coeliac people.

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Supplementary material

To view supplementary material for this article, please visit http://dx.doi.org/10.1017/S1368980014001682

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