The current issue and full text archive of this journal is available at
www.emeraldinsight.com/0007-070X.htm

BFJ
116,12

1842

Received 28 May 2013
Revised 23 August 2013
Accepted 2 September 2013

Availability, cost and nutritional composition of gluten-free products

Amanda Bagolin do Nascimento
Programa de Pós-Graduação em Ciência dos Alimentos, Universidade Federal de Santa Catarina, Florianópolis, Brazil
Giovanna Medeiros Rataichesck Fiates
Departamento de Nutrição, Programa de Pós-Graduação em Nutrição, Universidade Federal de Santa Catarina, Florianópolis, Brazil
Adilson dos Anjos
Departamento de Estatística Universidade Federal do Paraná, Universidade Federal do Paraná, Florianópolis, Brazil and Programa de Pós-Graduação em Engenharia de Produção da Universidade Federal de Santa Catarina, Universidade Federal de Santa Catarina, Florianópolis, Brazil, and
Evanilda Teixeira
Departamento de Ciência e Tecnologia de Alimentos, Programa de Pós-Graduação em Ciência dos Alimentos, Universidade Federal de Santa Catarina, Florianópolis, Brazil

Abstract

Purpose – A gluten-free diet is the only possible treatment for coeliac disease, but studies about the nutritional content of gluten-free products and coeliac individual's diet quality are scarce. The purpose of this paper is to evaluate the availability, price, and nutritional composition of gluten-free products in retail stores of a Brazilian capital city.

Design/methodology/approach – All retail stores listed by the Brazilian Coeliac Association as gluten-free product selling places in the city of Florianópolis were visited. All available products were catalogued and their labels analysed for nutritional content. Similar gluten-containing products were systematically selected in order to allow comparisons. *t*-test, analyses of covariance, and cluster analysis were performed, all considering a 5 per cent significance level.

Findings – Availability and variety of gluten-free products was limited and prices were high. Cluster analysis found similarities in the nutritional content of gluten-free and conventional food products, suggesting that although raw materials different than wheat were being employed, the composition patterns are the same. Certain advantages in the composition of gluten-free products were observed, regarding mainly calories and sodium, however, protein and dietary fibre values were inferior.

Social implications – Results observed may negatively impact diet adherence and stimulate the intake of conventional products with harmful consequences to the quality of life and health of coeliac individuals.

Originality/value – This paper conducted a careful evaluation of nutrition composition of gluten-free products from different categories, available in retail stores, which is rare in researches on this topic. Moreover, results call attention to the need of better care in product formulation and dietary guidance for coeliac individuals.

British Food Journal
Vol. 116 No. 12, 2014
pp. 1842-1852

0007-070X
DOI 10.1108/BFJ-05-2013-0131

AB Nascimento receives a scholarship from FAPESC – Fundação de Amparo à Pesquisa e Inovação do Estado de Santa Catarina.

Keywords Price, Hierarchical clustering, Coeliac disease, Availability, Gluten-free, Nutritional content
Paper type Research paper

1. Introduction

Coeliac disease (CD) is an immune-mediated systemic disorder elicited by gluten and related prolamines in genetically susceptible individuals (Husby *et al.*, 2012). Until recently, it was common belief that CD was a rare pathology with predominant occurrence in developed countries in Europe, as well as in the USA, Canada, and Australia. Presently, longitudinal studies have brought to light the fact that the occurrences of CD have increased, reaching approximately 1 per cent of the world population. Although disease prevalence studies are scarce, prevalence in Brazil is similar to that of European countries (Rewers, 2005; Catassi and Cobellis, 2007; Fasano *et al.*, 2008).

Gluten is a structural protein found in wheat, rye, and barley. The main protein fractions of gluten, glutenin, and gliadin, play a key role in baking quality characteristics, being responsible for water absorption capacity, cohesivity, viscosity, and elasticity on dough (Wieser, 2007). Therefore, the absence of gluten often results in a liquid batter, problems with texture, poor colour, and other quality defects post-baking (Gallagher *et al.*, 2004).

A gluten-free diet is the only possible treatment for CD (Ludvigsson and Green, 2011). Although as a response to the increase of pathological onset an increase in the offer of gluten-free products would be expected (Pagliarini *et al.*, 2010), reality presents a situation of low availability and elevated cost for such products, which affects adherence to a gluten-free diet (Singh and Whelan, 2011; Roma *et al.*, 2010).

As nutritional prescriptions for CD are historically focused on foods which should be avoided, studies about the nutritional content of gluten-free products are limited (Caponio *et al.*, 2007; Segura and Rosell, 2011), as well as those investigating coeliac patient's diet quality (Thompson *et al.*, 2005; Lee *et al.*, 2009; Ohlund *et al.*, 2010; Wild *et al.*, 2010).

Scientific evidence regarding nutritional content of gluten-free products in comparison to conventional foods offered to the general public (which guide food tables and population food guides) is even scarcer (Thompson, 1999, 2000). Dietetic orientation premises and consumption-affecting factors such as nutrient content, availability, and price must not be neglected by researchers and health professionals, since the ingestion of gluten-free products alone is not enough to promote health among coeliac patients.

Therefore, the objective of this study was to analyse the nutritional content of gluten-free food products in stores of a Brazilian capital, as well as their cost and availability. Results will hopefully identify conditions where diet adherence could be compromised, and call attention to the need of better care in product formulation and dietary guidance for coeliac individuals.

2. Material and methods

2.1 Identification of available gluten-free products' in retail stores in Florianópolis, Brazil

The survey of gluten-free products was conducted in retail stores listed by the Brazilian Coeliac Association (*Associação dos Celíacos do Brasil – ACELBRA-SC*) as gluten-free product selling places (three supermarkets and six natural product stores) in the state capital, Florianópolis, after management approval. All establishments whose managers signed consent forms were surveyed. Data collection took place between February and May 2011, when a database of gluten-free products available in such stores was created.

2.2 Identification of nutritional content in gluten-free food products

Products considered in the present study were not the ones naturally gluten-free (such as fruits, eggs, potatoes), but the ones where wheat was replaced by substitute ingredients (such as corn, rice, cassava, amaranth, quinoa). Due to the need of gluten restrictions in coeliac diet, since 2003 the Brazilian government has enacted a bill mandating that all baked goods add to their labels the information "contains gluten" or "gluten-free" (Brasil, 2003a).

Mandatory nutritional information presented in food product's labels was collected. Gathered data were energy, carbohydrate, protein, total fat, saturated fat, trans fat, dietary fibre, and sodium values. The Brazilian Regulatory Agency determines that nutritional labels in packed foods must indicate caloric and nutritional content – (Brasil, 2003b). In addition to such information, brand, package weight, serving size, and price, were also collected. Products were classified in one of eight categories: Bread, Cake Mix, Snacks, Cookie, Cereal (energy bar and granola), Chocolate, Pasta, and Cake. In total, 20 food products presented rather discrepant characteristics among them and did not fit into any of the nine categories (such as soup mix, confectionery products, food supplements, chocolate milk powder); they also were not found in sufficient numbers to form a single category themselves. They were therefore not included in the analyses.

In order to compare the nutritional content of gluten-free food products with selected gluten-containing counterparts, an equivalent number of the latter was systematically selected to match similar gluten-free products. Nutritional information presented in gluten-containing food products' labels was also collected.

Products presented differing portion sizes, therefore all portion sizes were allocated as 100 *g*. Similarly, the nutrient values per serving were also calculated for a 100 g serving size.

2.3 Statistical analysis

Statistical analyses were performed using the R language. The *t*-test was used to compare average nutrition content in all product categories, with and without gluten. The ANCOVA analysis of covariance was performed in order to compare the average product prices in each category, using package weight as covariate. When the ANCOVA results were not significant, ANOVA analysis of variance was used (Montgomery, 2001). All analyses considered a 5 per cent significance level ($p < 0.05$).

In order to identify similarities in nutritional content of both gluten-free and gluten-containing products as well as within their categories, a cluster analysis was performed using the hierarchical clustering on principle components method in the FactoMineR package of the R Software (Husson *et al.*, 2010). Cluster analysis' objective is to form groups in such way that objects in the same group are similar to each other, whereas objects in different groups are as dissimilar as possible. Therefore, objects in the same groups (called cluster) are more similar (in some sense or another) to each other than to those in other group (cluster). In the present study the objects' were food products, clustered according to their energy, carbohydrate, protein, total fat, saturated fat, fibre, and sodium content.

3. Results

Eight out of nine managers of requested retail stores agreed to participate. The non-participating store was for sale and stocks were reduced. A total of 168 gluten-free food products were identified, and 162 similar gluten-containing counterparts were

systematically selected and distributed in eight categories (Table I). Although the number of gluten-free and conventional products was not exactly the same, since mean values were compared by category, and variance and covariance analyses were employed this little difference does not significantly interfere in the results.

In the Cookies and Pasta categories, the package weight covariate presented no correlation to product price when analysing the average product price. The calculated price average for the remaining categories was corrected with analysis of covariance, as they presented correlation between package weight and product price. Compared results in each of the eight categories can be observed in Table II.

With the exception of the Cake category, all gluten-free products' categories presented higher average prices in comparison to the average prices of conventional gluten-containing products. Among the gluten-free products the Cookies category presented the highest difference between prices, costing approximately 86 per cent more; next came Cake Mix (81 per cent), Pasta (63 per cent), Snacks (56 per cent), Chocolate (36 per cent), Bread (33 per cent), and Cereal (28 per cent). Significant differences between prices of both product types were found in the Cookies, Bread, Snacks, and Cake Mix categories ($p < 0.01$).

The comparison of calories and nutrients between conventional product with gluten and gluten-free products in each category is presented in Table III.

The Cookies category comprised the highest amount of products (37 per cent). Gluten-free cookies had significantly less calories, protein, saturated fat, and sodium than conventional ones ($p < 0.01$). Nutritional content of gluten-containing and gluten-free products in the Chocolate category did not differ significantly. In the Pasta

Category	Number of products	%
Cookie	62	37.0
Chocolate	28	16.7
Pasta	18	10.7
Bread	15	8.9
Snacks	14	8.3
Cake	12	7.1
Cereal (energy bar and granola)	11	6.5
Cake mix	8	4.8
Total	168	100

Table I. Gluten-free food products identified in retail stores located in the city of Florianópolis, SC, by category

Category	Conventional products with gluten Mean (US$)	Gluten free products Mean (US$)	*p*-value
Cookie	1.55	2.90	<0.01
Chocolate	2.43	3.30	0.06
Pasta	2.35	3.83	0.16
Bread	2.38	3.16	<0.01
Snack	0.96	1.49	<0.01
Cake	2.12	2.08	0.91
Cereal (energy bar and granola)	2.32	2.97	0.07
Cake mix	2.00	3.64	<0.01

Source: Florianópolis (2011)

Table II. Analysis of covariance to compare average prices (US$) of conventional products with gluten and gluten-free products in each category

Table III.
Average calories and nutrients comparison in 100 g of conventional products with gluten (CG) and gluten-free (GF) products in each category

Category	Calories		CHO (g)		PTN (g)		Totfat (g)		Satfat (g)		Transfat (g)		Fibre (g)		Sodium (mg)	
	Mean	*p*-value	Mean	*p*-value	Mean	*p*-value	Mean	*p*-value	Mean	*p*-value	Mean	*p*-value	Mean	*p*-value	Mean	*p*-value
Cookie																
CG	436	<0.01	66.8	0.10	9.5	<0.01	14.8	0.09	4.4	<0.01	0.2	0.62	4.2	0.13	511.7	<0.01
GF	387		63.2		6.5		12.6		2.8		0.3		3.2		257.3	
Chocolate																
CG	526	0.61	55.7	0.92	6.8	0.18	31.3	0.40	17.2	0.27	0.3	0.67	3.3	0.05	92.3	0.40
GF	557		56.4		8.4		34.8		15.8		0.5		5.5		74.4	
Pasta																
CG	354	0.32	73.6	0.74	11.7	<0.01	1.4	0.59	0.1	0.22	0.0	1	2.6	<0.01	84.6	0.45
GF	360		72.3		7.5		1.2		0.2		0.0		1.5		162.4	
Bread																
CG	246	0.77	43.5	0.83	10.0	<0.01	3.5	0.08	0.8	0.27	0.0	0.33	4.3	<0.01	423.6	0.08
GF	243		42.8		4.4		4.9		0.6		0.1		0.7		358.3	
Snack																
CG	497	<0.01	58.9	0.65	7.5	<0.01	24.1	<0.01	7.7	<0.01	0.0	1	2.7	<0.01	960.9	<0.01
GF	390		60.0		10.8		12.1		2.7		0.0		4.9		422.3	
Cake																
CG	384	0.33	58.7	0.26	5.9	0.77	14.2	0.56	6.1	0.41	0.5	0.72	1.6	0.13	210.3	0.02
GF	347		51.9		6.2		12.8		4.6		0.4		1.0		76.5	
Cereal (energy bar and granola)																
CG	416	<0.01	64.6	0.30	10.0	0.46	13.4	0.07	3.7	0.10	0.0	1	7.7	0.89	126.3	<0.01
GF	360		69.3		8.3		8.7		1.6		0.0		7.9		307.1	
Cake mix																
CG	403	0.11	78.2	0.78	5.3	0.03	1.8	<0.01	2.3	0.03	1.5	<0.01	1.1	0.47	717.3	<0.01
GF	346		76.5		3.0		8.7		0.7		0.0		1.5		85.7	

Notes: CHO, Carbohydrate; PTN, protein; Totfat, total fatty; Satfat, saturated fatty

and Bread categories, the average protein and dietary fibre content in gluten-free products was significantly lower ($p < 0.01$). Gluten-free products in the Snacks category had significantly less calories, total fat, saturated fat and sodium, and more protein and dietary fibre ($p < 0.01$). Gluten-free cakes presented lower amounts of sodium ($p < 0.05$). Products in the gluten-free Cereal group presented less calories and more sodium ($p < 0.01$) than their conventional counterparts. Gluten-free products in the Cake Mix category had significant smaller amounts of protein and saturated fat ($p < 0.05$), trans fat and sodium ($p < 0.01$) and larger amounts of total fat ($p < 0.01$) than conventional products.

Cluster analysis was performed with 321 products containing and not containing gluten. Three distinct groups with similar characteristics were identified (Figure 1).

Cluster 1: 183 products, of which 86 were gluten-free. These had higher amounts of carbohydrates, sodium, and protein, and lower total and saturated fat values. The five main representative products in this cluster were conventional cookies (chocolate donuts from two distinct brands, milk and oat cookies, maize cookie, and champagne biscuits).

Cluster 2: 70 products, of which 48 were gluten-free. Products in this group had lower amounts of dietary fibre, protein, total fat, saturated fat, carbohydrates, and calories. Gluten-free cassava bread, gluten-free potato bread with seeds, gluten-free cassava bread with seeds, conventional cassava homemade bread, and conventional carrot cake with chocolate represent these food products.

Cluster 3: 68 food products (26 gluten-free), had higher values of total fat, saturated fat, calories, and dietary fibre, as well as smaller amounts of sodium and carbohydrates. The five main representatives of this cluster were in the Chocolate category, being two gluten-free and three conventional.

4. Discussion

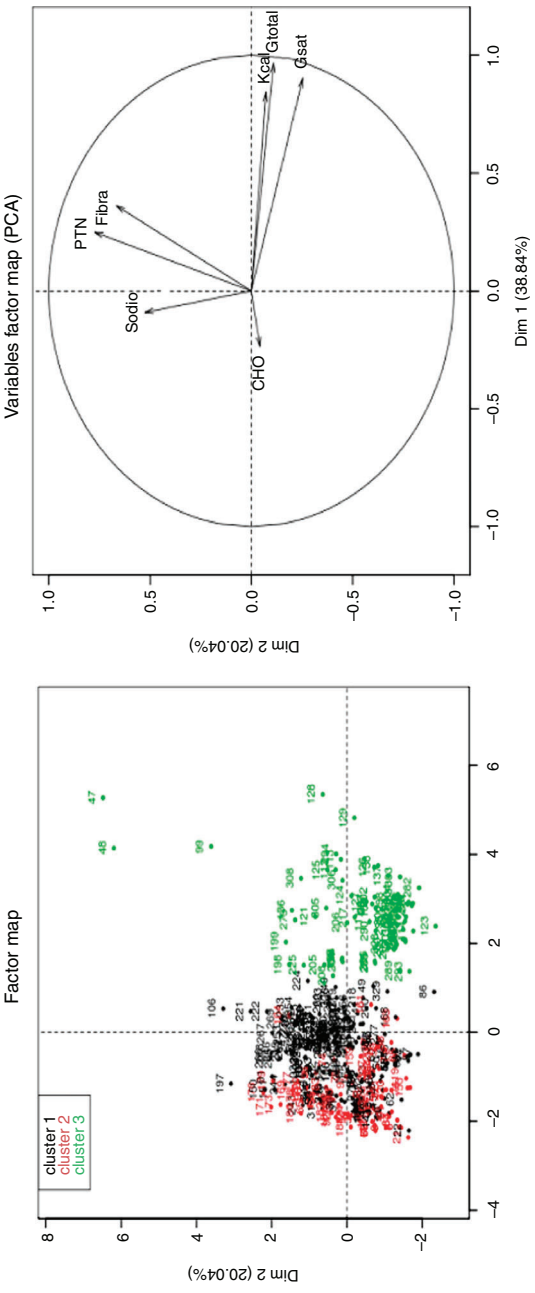
This study has identified 168 gluten-free products in the eight retail stores investigated. This can be considered a rather limited number when compared with the universe of gluten-containing products available for the consumer.

According to Furst *et al.* (1996), dietary choices are the result of a complex multi-factored process, where several decisions are made and assessed until choice is achieved. The authors imply that within food choices individuals may take the following features into consideration: sensorial aspects; economic factors; convenience; health and nutrition; product quality; and the preferences and needs of the people with whom one lives. When the availability of food products is limited, as is this case of gluten-free products, several features are automatically ignored, although they would be assessed in other situations. Therefore, to our understanding, the food choices of coeliac people are often not conceptual, but are made over a lack of alternatives.

The issue of gluten-free product availability identified in our study is corroborated by the findings of Brazilian and foreign studies which investigated coeliac patient satisfaction towards such products (Araújo and Araújo, 2011; Sverker *et al.*, 2005; Zarkadas *et al.*, 2006). Participants mentioned dissatisfaction with gluten-free product variety and availability, a situation that restrict food choices and difficult daily life management.

All gluten-free products' categories, except the Cake category, presented higher average prices. These results were expected and have been reported in Brazil and abroad (Araújo and Araújo, 2011; Lee *et al.*, 2007; Stevens and Rashid, 2008). This is another issue to be considered when addressing diet adherence by coeliac.

Regarding the nutritional content of gluten-free and conventional products, it was possible to observe significant differences between both product types in most



Source: Florianópolis, SC (2011)

Figure 1.
Graphic representation of the main component analysis of 321 gluten-free and conventional gluten-containing food products

categories and nutrients. In general, there was a tendency of gluten-free products having fewer calories (51 per cent of products represented by Cookies, Snacks, and Cereal) and less sodium (57 per cent of products, such as Cookies, Snacks, Cake, and Cake Mix). On the other hand, most gluten-free products had significantly lower protein values (61 per cent of the products, represented by Cookies, Pasta, Bread, and Cake Mix).

Segura and Rosell (2011) assessed the chemical composition of gluten-free commercial breads, and observed that the majority had adequate amounts of dietary fibre (>3 g/100 g), whereas the average dietary fibre content in the breads evaluated in this study was 0.69 g/100 g. It has been pointed out that it is common practice for raw materials employed in the manufacturing of gluten-free products to be composed of starch or refined flours, compromising dietary fibre content, and possibly other essential nutrients for the maintenance of health (Gallagher *et al.*, 2004). Traditionally, rice is the raw material used in the formulation of gluten-free bread and pasta (Caperuto *et al.*, 2001; Song and Shin, 2007; De la Barca *et al.*, 2010), whereas gluten-free snacks are made of varied raw materials, such as apple, beetroot, carrot, cranberry, and gluten-free teff flour cereal (İbanoglu *et al.*, 2006; Stojceska *et al.*, 2010). This is probably the reason why the snack bar was richer in nutrients when compared to bread and pasta.

Another noteworthy result is the fat content of gluten-free products. Although studies point out that they usually have elevated amounts of fat (Caponio *et al.*, 2007; Segura and Rosell, 2011; Saturni *et al.*, 2010), such results were not confirmed in the present study. Saturated fat levels were significantly lower for gluten-free Cookies and Cake Mix, and significantly smaller amounts of trans fat were observed in Snacks and Cake Mix, and less total fat in gluten-free Snacks. However, total fat was significantly higher in gluten-free Cake Mix.

The cluster analysis showed that most gluten-free and conventional products analysed have similarities; Cluster 1 gathered more than half the total products (57 per cent), of which a similar amount of both product types were present (47 per cent gluten-free), what indicates that in a general sense such products present comparable nutritional content. Clusters 2 and 3 reinforced the results found via *t*-test. Cluster 2 gathered 21.8 per cent of products (69 per cent of which were gluten-free) with lower amounts of dietary fibre, protein, total fat, saturated fat, carbohydrates, and calories. Cluster 3 gathered 21.2 per cent of products (62 per cent conventional) with elevated total fat, saturated fat, calories, and dietary fibre, as well as low carbohydrates and sodium.

The way in which foods affect health depends on the relative importance of foods in diet, among other factors (Monteiro, 2009). The fact that 57 per cent of products presented similarities in nutritional content shows that the main difference between gluten-free and conventional products is related to the substitution of gluten sources as raw materials; after such substitution, most products present the same patterns in nutritional contents. Ohlund *et al.* (2010) compared the diet of coeliac and non-coeliac children and adolescents, observing that both follow the same diet pattern, with elevated saturated fat and sugar intake as well as low amounts of dietary fibre, vitamin D, and magnesium when compared to recommendations.

Observations on Clusters 2 and 3 indeed present evidence that a part of gluten-free products presented smaller amounts of total fat, saturated fat, dietary fibre, and protein, as previously discussed. However, it is important to note that if, on the one hand, such products present benefits regarding fat and calorie amounts, on the other

hand little importance is being devoted by the food industry regarding dietary fibre values in such products. There is a vast amount of literature reporting the benefits of utilising pseudocereals such as buckwheat, amaranth, and quinoa, which represent a safe option that would improve the nutritional value in gluten-free food products as they are rich in dietary fibre, protein, and unsaturated lipids (Saturni *et al.*, 2010; Alvarez-Jubete *et al.*, 2010).

5. Conclusions

Amount and variety of gluten-free food products were limited in stores; in addition, their prices were high. This situation may have a negative impact over diet adherence and stimulate the intake of conventional products, with harmful consequences to the quality of life and health of the coeliac patient population. Cluster analysis found similarities in the nutritional content of gluten-free and conventional food products, suggesting that although raw materials different than wheat are being employed, the composition patterns are the same. Certain advantages in the composition of gluten-free products were observed, regarding mainly calories and sodium; however, protein and dietary fibre values were significantly inferior. This calls attention to the need of better care in product formulation and dietary guidance for the coeliac patient population.

References

Alvarez-Jubete, L., Arendt, E.K. and Gallagher, E. (2010), "Nutritive value of pseudocereals and their increasing use as functional gluten-free ingredients", *Trends in Food Science & Technology*, Vol. 21 No. 2, pp. 106-113.

Araújo, H.M. and Araújo, W.M. (2011), "Coeliac disease. Following the diet and eating habits of participating individuals in the Federal District, Brazil", *Appetite*, Vol. 57 No. 1, pp. 105-109.

BRASIL (2003a), *Obriga a que os produtos alimentícios comercializados informem sobre a presença de glúten, como medida preventiva e de controle da doença celíaca*, Diário Oficial da União, Brasília.

BRASIL (2003b), *Regulamento técnico sobre rotulagem nutricional de alimentos embalados*, Diário Oficial da União, Brasilia.

Caperuto, L.C., Amaya-Farfan, J. and Camargo, C.R.O. (2001), "Performance of quinoa *(Chemopodium quinoa* Willd) flour in the manufacture of gluten-free spaghetti", *Journal of the Science of Food and Agriculture*, Vol. 81 No. 1, pp. 95-101.

Caponio, F., Summo, C., Clodoveo, M.L. and Pasqualone, A. (2007), "Evaluation of the nutritional quality of the lipid fraction of gluten-free biscuits", *European Food Research and Technology*, Vol. 227 No. 1, pp. 135-139.

Catassi, C. and Cobellis, G. (2007), "Coeliac disease epidemiology is alive and kicking, especially in the developing world", *Dig Liver Dis*, Vol. 39 No. 10, pp. 908-910.

De La Barca, A.M., Rojas-Martinez, M.E., Islas-Rubio, A.R. and Cabrera-Chavez, F. (2010), "Gluten-free breads and cookies of raw and popped amaranth flours with attractive technological and nutritional qualities", *Plant Foods for Human Nutrition*, Vol. 65 No. 3, pp. 241-246.

Fasano, A., Araya, M., Bhatnagar, S., Cameron, D., Catassi, C., Dirks, M., Mearin, M.L., Ortigosa, L. and Phillips, A. (2008), "Federation of international societies of pediatric gastroenterology, hepatology and nutrition consensus report on celiac disease", *Journal of Pediatric Gastroenterology and Nutrition*, Vol. 47 No. 2, pp. 214-219.

Furst, T., Connors, M., Bisogni, C.A., Sobal, J. and Falk, L.W. (1996), "Food choice: a conceptual model of the process", *Appetite*, Vol. 26 No. 3, pp. 247-266.

Gallagher, E., Gormley, T.R. and Arendt, E.K. (2004), "Recent advances in the formulation of gluten-free cereal-based products", *Trends in Food Science & Technology*, Vol. 15 Nos 3/4, pp. 143-152.

Husby, S., Koletzko, S., Korponay-Szabo, I.R., Mearin, M.L., Phillips, A., Shamir, R., Troncone, R., Giersiepen, K., Branski, D., Catassi, C., Lelgeman, M., Maki, M., Ribes-Koninckx, C., Ventura, A. and Zimmer, K.P. (2012), "European society for pediatric gastroenterology, hepatology, and nutrition guidelines for the diagnosis of coeliac disease", *Journal of Pediatric Gastroenterology and Nutrition*, Vol. 54 No. 1, pp. 136-160.

Husson, F., Josse, J., Le, S. and Mazet, J. (2010), *FactoMineR: Multivariate Exploratory Data Analysis and Data Mining with R. R package version 1.14 ed*, Saint-Brieuc.

İbanoglu, Ş., Ainsworth, P., Özer, E.A. and Plunkett, A. (2006), "Physical and sensory evaluation of a nutritionally balanced gluten-free extruded snack", *Journal of Food Engineering*, Vol. 75 No. 4, pp. 469-472.

Lee, A.R., Ng, D.L., Zivin, J. and Green, P.H.R. (2007), "Economic burden of a gluten-free diet", *Journal of Human Nutrition and Dietetics*, Vol. 20 No. 5, pp. 423-430.

Lee, A.R., Ng, D.L., Dave, E., Ciaccio, E.J. and Green, P.H. (2009), "The effect of substituting alternative grains in the diet on the nutritional profile of the gluten-free diet", *Journal of Human Nutrition and Dietetics*, Vol. 22 No. 5, pp. 359-363.

Ludvigsson, J.F. and Green, P.H. (2011), "Clinical management of coeliac disease", *Journal of Internal Medicine*, Vol. 269 No. 6, pp. 560-571.

Monteiro, C.A. (2009), "Nutrition and health. The issue is not food, nor nutrients, so much as processing", *Public Health Nutrition*, Vol. 12 No. 5, pp. 729-731.

Montgomery, D.C. (2001), *Design and Analysis of Experiments*, John Wiley & Sons, New York, NY.

Ohlund, K., Olsson, C., Hernell, O. and Ohlund, I. (2010), "Dietary shortcomings in children on a gluten-free diet", *Journal of Human Nutrition and Dietetics*, Vol. 23 No. 3, pp. 294-300.

Pagliarini, E., Laureati, M. and Lavelli, V. (2010), "Sensory evaluation of gluten-free breads assessed by a trained panel of celiac assessors", *European Food Research and Technology*, Vol. 231 No. 1, pp. 37-46.

Rewers, M. (2005), "Epidemiology of celiac disease: what are the prevalence, incidence, and progression of celiac disease?", *Gastroenterology*, Vol. 128 No. 4, pp. S47-S51.

Roma, E., Roubani, A., Kolia, E., Panayiotou, J., Zellos, A. and Syriopoulou, V.P. (2010), "Dietary compliance and life style of children with coeliac disease", *Journal of Human Nutrition and Dietetics*, Vol. 23 No. 2, pp. 176-182.

Saturni, L., Ferretti, G. and Bacchetti, T. (2010), "The gluten-free diet: safety and nutritional quality", *Nutrients*, Vol. 2 No. 1, pp. 16-34.

Segura, M.E. and Rosell, C.M. (2011), "Chemical composition and starch digestibility of different gluten-free breads", *Plant Foods for Human Nutrition*, Vol. 66 No. 3, pp. 224-230.

Singh, J. and Whelan, K. (2011), "Limited availability and higher cost of gluten-free foods", *Journal of Human Nutrition and Dietetics*, Vol. 24 No. 5, pp. 479-486.

Song, J.-Y. and Shin, M. (2007), "Effects of soaking and particle sizes on the properties of rice flour and gluten free rice bread", *Food Science and Biotechnology*, Vol. 16 No. 5, pp. 759-764.

Stevens, L. and Rashid, M. (2008), "Gluten-free and regular foods: a cost comparison", *Canadian Journal of Dietetic Practice and Research*, Vol. 69 No. 3, pp. 147-150.

Stojceska, V., Ainsworth, P., Plunkett, A. and Ibanoğlu, Ş. (2010), "The advantage of using extrusion processing for increasing dietary fibre level in gluten-free products", *Food Chemistry*, Vol. 121 No. 1, pp. 156-164.

Sverker, A., Hensing, G. and Hallert, C. (2005), "Controlled by foods – lived experiences of coeliac disease", *Journal of Human Nutrition and Dietetics*, Vol. 18 No. 3, pp. 171-180.

Thompson, T. (1999), "Thiamin, riboflavin, and niacin contents of the gluten-free diet", *Journal of the American Dietetic Association*, Vol. 99 No. 7, pp. 858-862.

Thompson, T. (2000), "Folate, iron, and dietary fiber contents of the gluten-free diet", *Journal of the American Dietetic Association*, Vol. 100 No. 11, pp. 1389-1396.

Thompson, T., Dennis, M., Higgins, L.A., Lee, A.R. and Sharrett, M.K. (2005), "Gluten-free diet survey are Americans with celiac disease consuming recommended amounts of fiber, iron, calcium and grain foods", *Journal of Human Nutrition and Dietetics*, Vol. 18 No. 3, pp. 163-169.

Wieser, H. (2007), "Chemistry of gluten proteins", *Food Microbiology*, Vol. 24 No. 2, pp. 115-119.

Wild, D., Robins, G.G., Burley, V.J. and Howdle, P.D. (2010), "Evidence of high sugar intake, and low fibre and mineral intake, in the gluten-free diet", *Aliment Pharmacol Ther*, Vol. 32 No. 4, pp. 573-581.

Zarkadas, M., Cranney, A., Case, S., Molloy, M., Switzer, C., Graham, I.D., Butzner, J.D., Rashid, M., Warren, R.E. and Burrows, V. (2006), "The impact of a gluten-free diet on adults with coeliac disease – results of a national survey", *Journal of Human Nutrition and Dietetics*, Vol. 19 No. 1, pp. 41-49.

About the authors

Amanda Bagolin do Nascimento is a Dietitian from the Centro Universitário Franciscano (2007), Master Degree in Nutrition (2010), and Doctoral Degree Student in Food Science Postgraduate Program of the Federal University of Santa Catarina. Research Gluten-free Food Products and Consumer Behavior. Amanda Bagolin do Nascimento is the corresponding author and can be contacted at: amandabagolin@hotmail.com

Professor Giovanna Medeiros Rataichesck Fiates is a Dietitian (1992), Master (1995), and Doctor in Food Science (2006) of the Federal University of Santa Catarina and since 1995 serves as a Professor in the Nutrition Department of the same university. Since 2008 is a Permanent Professor in Nutrition Postgraduate Program. Research Consumer Behaviour and Food Choices of children's.

Adilson dos Anjos is an Agronomy (1994), Master Degree in Agronomy (1998), and Doctoral Degree Student in the Production Engineering Postgraduate Program of the Federal University of Santa Catarina. Since 1998 is a Professor in the Statistics Department of the Federal University of Paraná. Research Statistics Models and Sensometrics.

Professor Evanilda Teixeira has graduated in Pharmacy and Biochemistry (1980) and Master Degree in Chemistry (1983) from the Federal University of Santa Catarina, Doctor Degree in Food Sciences and Technology from the Universitat de Barcelona (1992). Since 1985 serves as a Professor in Food Sciences and Technology Department. Research Consumer Behaviour and Sensorial Evaluations.