Gluten-free food database: The nutritional quality and cost of packaged gluten-free foods

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Notwithstanding a growth in popularity and consumption of gluten-free (GF) food products, there is a lack of substantiated analysis of the nutritional quality compared to their gluten-containing counterparts. The objective of this study is to develop a food composition database for 7 discretionary food categories of packaged GF products available on the Austrian market and determine their cost range with the goal to support individuals with celiac disease in their dietary choices. Nutrient composition, nutritional information and cost of foods marked with the European GF declaration and non-GF, gluten-containing counterparts were systematically obtained from 12 different supermarkets. The nutrition composition (macro and micronutrients) of 63 GF and 126 gluten-containing food was analysed by using two nutrient composition databases in a stepwise approximation process. A total of 63 packaged GF foods were included in the analysis representing a broad spectrum of different GF categories (flour/bake mix, bread and bakery products, pasta and cereal-based food, cereals, cookies and cakes, snacks and convenience food were identified). Our results show, that on average GF product's protein content is >2 fold lower across 57% of the food categories. In 65% of all GF foods, low sodium content (defined as <120mg/100g) was observed. Across all GF products, 19% can be classified as source high in fiber (defined as >6g/100g). On average, GF foods were substantially higher in cost ranging from +205% (cereals) to +267% (bread and bakery products) compared to similar gluten-containing products. In conclusion, for individuals with celiac disease, the database provides a helpful tool to identify the food composition of GF food and it gives researchers a useful measure for dietary surveys. From a nutritional quality perspective, no predominant health benefits for GF foods are indicated.

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Abstract

Notwithstanding a growth in popularity and consumption of gluten-free (GF) food products, there is a lack of substantiated analysis of the nutritional quality compared to their gluten-containing counterparts. The objective of this study is to develop a food composition database for 7 discretionary food categories of packaged GF products available on the Austrian market and determine their cost range with the goal to support individuals with celiac disease in their dietary choices. Nutrient composition, nutritional information and cost of foods marked with the European GF declaration and non-GF, gluten-containing counterparts were systematically obtained from 12 different supermarkets. The nutrition composition (macro and micronutrients) of 63 GF and 126 gluten-containing food was analysed by using two nutrient composition databases in a stepwise approximation process. A total of 63 packaged GF foods were included in the analysis representing a broad spectrum of different GF categories (flour/bake mix, bread and bakery products, pasta and cereal-based food, cereals, cookies and cakes, snacks and convenience food were identified). Our results show, that on average GF product's protein content is >2 fold lower across 57% of the food categories. In 65% of all GF foods, low sodium content (defined as <120mg/100g) was observed. Across all GF products, 19% can be classified as source high in fiber (defined as >6g/100g). On average, GF foods were substantially higher in cost ranging from +205% (cereals) to +267% (bread and bakery products) compared to similar gluten-containing products. In conclusion, for individuals with celiac disease, the database provides a helpful tool to identify the food composition of GF food and it gives researchers a useful measure for dietary surveys. From a nutritional quality perspective, no predominant health benefits for GF foods are indicated.

Introduction

Individuals with celiac disease (CD) show high levels of intestinal inflammation when exposed to gluten-containing foods (Ludvigsson et al. 2013; Rubio-Tapia et al. 2013). In western countries, the prevalence for CD is estimated at approximately 1% (Gujral et al. 2012). Clinically, as direct response to gluten and related prolamines in a diet, immunological processes damage intestinal mucosa and lead to villous atrophy, crypt hyperplasia and nutrient malabsorption (Dickson et al. 2006; Husby et al. 2012). To get full remission of the symptoms, a strict lifelong gluten-free (GF) diet is indicated (El-Chammas & Danner 2011; Green 2009), excluding gluten-containing cereals from their diet (e.g. wheat, rye, barley). The nutritional quality of GF products replacing cereal-based foods is pivotal for patients with CD. Previous research showed that GF food differs in its nutrient content compared to its gluten-containing counterparts, as depicted in databases developed to support dietary choices for individuals with CD (Mazzeo et al. 2015; Miranda et al. 2014). In addition, a recent evaluation of more than 600 GF foods in an Australian dataset showed that it is unlikely that GF foods have additional health benefits for individuals without CD, in particular due to the reported lower protein content in GF compared to non-GF products (Wu et al. 2015). To the best of our knowledge, no database on the nutritional quality for packaged GF food is available in a German-speaking country to this date.

For CD patients, adhering to a GF diet can be challenging: First, food choices are essentially limited because cereal products (e.g bread or pasta) are staple foods in western countries and play a predominant role in a regular diet. Second, a wide range of processed foods contain gluten-based products as additional ingredients. Prior to consumption of these foods, a detailed examination of the ingredient list has to be carried out to avoid being exposed to gluten. This requires fundamental nutritional knowledge and a high level of self-discipline (Mulder et al.

2015). Third, 20–38% of individuals with CD have some nutritional deficiencies due to their medical condition (Kinsey et al. 2008; Saturni et al. 2010); e.g iron deficiency, deficiency in B vitamins (B_6, B_{12}) and trace minerals (e.g zinc) (Harris et al. 2012; Theethira & Dennis 2015). In a nutshell, individuals with CD are in need to structure their diet in a strict manner to maintain a positive long-term health outcome.

To assist individuals with CD, GF products have been developed as alternatives to cereal-based formulations. A wide range of products based on teff, amaranth, buckwheat or quinoa is now available for consumers. Formulations of GF products explore different alternatives to enhance sensory properties and shelf-life (Gallagher et al. 2004; Pellegrini & Agostoni 2015).

In addition, it is important to note that GF products are very popular among non-CD consumers, which has led to almost exponential rise in sales for GF products over the last decade (Marketsandmarkets, 2013; Strom, 2014). Many misconceptions circulate about the nutritional quality of GF foods. For instance, Mardini et al. (2015) report updated data from the National Health and Nutrition Examination Survey (NHANES) from 2009-2012. The survey shows that in the US 0.9% of 14.701 participants adhere to a GF diet, even though 85% of this group was not diagnosed with CD. For many consumers, GF products are perceived as healthier than conventional products (Marcason 2011). While evidence for this belief is not based on solid data (Gaesser & Angadi 2012), food companies may market GF foods as healthier and charge a premium price (Singh & Whelan 2011; Stevens & Rashid 2008). Still, information about the nutritional quality and costs of GF products are scarce.

To provide better consumer information, the present work is the first attempt to build a nutrient composition database for packaged GF products available in a German-speaking country (Austria). The aim of the current study is to present data from a large number of identified GF

93 foods representing the main sources of cereal-based food and analyze their nutrient content and
94 cost.
95
96 **Materials & Methods**
97 *Food products included*
98 We used a matched food sample procedure to analyze the nutrient content of packaged GF foods
99 available on the Austrian Market. We grouped packaged GF foods with matching gluten-
100 containing foods from two nutrition databases, estimated their nutrient content by using a step-
101 by-step estimation process and compared the nutritional quality. Our primary outcome parameter
102 was macronutrient and energy content. As secondary outcome parameter we defined
103 micronutrients and cost.
104 First, we selected 162 packaged GF foods from 7 different food categories representing the
105 majority of consumed processed foods by celiac patients in German-speaking countries (Martin
106 et al. 2013). Packaged GF foods from 19 brands were obtained from 12 different supermarkets
107 available in Austria between fall 2014 and spring 2015. We only used packaged GF foods which
108 are marked with the European gluten-free label (Commission Regulation (EC) No 41/2009
109 2009). We did not include not verified gluten-free labels or non-packaged foods as well as foods
110 from categories which not gluten-based on their original formulation (e.g . All food categories
111 included different food items and sub-categories. Following food categories were used:
112 flour/bake mix, bread and bakery products, pasta and cereal-based food, cereals, cookies and
113 cakes, snacks and convenience food (for detailed listing, see supplementary material).
114 Additionally, we assessed the cost for each product. Both, food quality as well as cost ranged
115 widely within individual food products. To minimize this within-product range and provide more
116 homogenous data in both target variables (nutritional quality; product cost), we matched two

gluten-containing foods differing in cost range (one budget and one pricier article) for each GF food.

From originally 162 identified packaged GF foods, we excluded duplicates (86) and foods for which the nutrient information was incomplete or not available in both databases (13 foods) (see flow diagram and detailed list of exclusion in the supplementary material). Our final sample consists of 63 GF and 126 similar gluten-containing foods for subsequent nutrient content matching procedure.

Step-by-step estimation process for nutrient content

The selected GF foods were matched with two similar gluten-containing foods available in two different databases used in the Austrian Nutrition Surveys (BLS 3.02 Max Rubner Institute, Germany; Austrian Nutrient Database: ÖNWT, dato denkwerkzeuge, Vienna, Austria). We used a Microsoft Excel worksheet to compile the composition in macro- and micronutrients of the GF foods per 100 g in its raw form. We imputed the quantity for each ingredient in a descending order. In a second step, we estimated the quantity of each ingredient for every product based on the percentage of the final recipe and its rank order reported on the label (theoretical nutrient composition). Furthermore we compared the theoretical macronutrient composition of the food with the given information on the food label. The process was reiterated by adjusting the percentage of the different ingredients until the final results reflected the values of energy content and macronutrients reported on the food label. To assess the precision of this procedure we calculated the estimation precision (theoretical nutrient content/nutrient content on the food label in %). The precision for the estimation of all macronutrients was very good and within a overall variation range of 7%; precision estimates for energy content: - 2.3% ± 2.8%; precision

140 estimates for carbohydrate content: + 0.5% ± 1.5%; precision estimates for protein content: +
141 6.4% ± 4.6%.
142 As a result of this process we could estimate the amount of ingredients available in the GF
143 products and extrapolate the nutritional components for following ingredients and nutrients:
144 water (g/100g), sugar (g/100g), energy content (in kcal/100g), macronutrients (carbohydrates,
145 proteins, total fat, saturated fatty acids, monounsaturated fatty acids (MUFA), polyunsaturated
146 fatty acids (PUFA), fibre; all in g/100g), cholesterol (mg/100g), minerals (i.e. Iron, Calcium,
147 Sodium, Potassium, Phosphorous and Zinc; all in mg/100g) and vitamins (Vitamin E, Thiamin,
148 Riboflavin, Niacin, and Vitamin C; all in mg/100g; Vitamin D, Retinol, β-carotene equivalents in
149 µg/100g).
150
151 *Statistical Analyses*
152 Statistical analyses were conducted using IBM SPSS Statistics 22. Unpaired t-test was used to
153 compare means; bivariate comparisons were tested by χ^2 test. The Bonferroni post-hoc test was
154 used to correct for multiple comparisons; p-values < 0.05 were classified as significant. Post-hoc
155 power analysis was calculated by the difference between two independent means with G*Power
156 3.1.9 (Erdfelder et al. 2009).
157
158 **Results**
159 The database provides quantitative information of macro- and micronutrients of the GF product.
160 It contains nutrient data present in the traditional databases of gluten-containing foods (see Table
161 1 and Table 2).
162 *Primary Outcome* Parameter*: Macronutrient and energy content*

Across all food categories, energy content ranged between 270.5 ± 13.5kcal/100g (category: bread and bakery products) to 398.8 ± 25.4kcal/100g (category: snacks). GF foods did not differ in their energy content compared to their gluten-containing products ($F < 1$; $p > 0.05$). Alike, carbohydrate, total fat, saturated fatty acids, fiber and sugar did not differ between GF and products gluten-containing products. Protein content was significantly lower in GF foods (5.8 ± 3.7g/100g) than gluten-containing foods (8.6 ± 2.9g/100g); $F = 31.9$; $p < 0.01$ (see Figure 1). Lower protein content was present in 4 out of 7 food categories (flour/bake mix, bread and bakery products, pasta and cereal-based products and snacks). In flour/bake mix products, the average protein content was 4.6 ± 3.4g/100g for GF and 9.9 ± 2g/100g for their gluten-containing counterparts (see Table 3).

Secondary Outcome Parameter: Micronutrients and cost

Overall, sodium content in gluten-containing (448.9 ± 704.6mg/100g) did not differ to GF foods (373.5 ± 569.2mg/100g; $F < 1$, $p > 0.05$). Only in one category (cereal products), sodium content was higher in GF foods. Across all three analyzed GF cereal products, sodium content was 491.3 ± 91.6mg/100g while in gluten-containing foods, sodium content was 160.7 ± 139.3mg/100g ($F = 13.4$; $p < 0.01$). For bread and bakery products, sodium content was lower in GF products (388.4 ± 206.4mg/100g) compared to gluten-containing foods (581.9 ± 290.3mg/100g; ($F = 4.5$; $p < 0.05$). Across all other categories, sodium content did not differ significantly. 27% of all products showed high sodium content (defined as >500mg/100g, Nutrition and Health Claim N°1924/2006 (2006), this did not differ between GF and gluten-containing foods (χ^2 [1] = 1.94; $p > 0.05$). In contrast, 65% of GF and 61% of gluten-containing foods showed low sodium content (defined as <120mg/100g, Nutrition and Health Claim N°1924/2006 (2006).

Potassium content was significantly lower in GF products (190.4 ±160mg/100g) than in products

containing gluten (247.5 ± 130mg/100g); $F = 6.9$; $p < 0.05$. This difference was observable in 2 out of 7 food categories (pasta and cereal-based products; snacks), while all other categories did no show significant differences. Moreover, zinc content was significantly lower in GF pasta products (1.9 ± 0.9mg/100g vs. 4.6 ± 0.4mg/100g; $F = 82.1$; $p < 0.01$), GF Pasta products therefore showed higher fiber content (7.9 ± 4.2g/100g) when compared to gluten-containing products (3.7 ± 0.7g/100g); $F = 13.6$; $p < 0.01$. Across all GF products, 19% can be classified as source high in fiber (defined as >6g/100g, Nutrition and Health Claim N°1924/2006 (2006).

The cost for GF products ranged from 2.95€ (white flour) to 80.80€ per kg (Wafer, Oblaten) and was significantly higher in GF products (11.58 ± 11.43€) compared to gluten-containing products (6.62 ± 5.36€), $F = 53.1$; $p < 0.01$. In bread and bakery products, GF food were +267% more expensive than similar conventional products containing gluten, while cereals showed the lowest difference in cost (+205% higher cost) (Figure 2).

199 **Discussion**

200 The present study is the first to present a large dataset comparing GF foods and gluten-
201 containing products available in a German-speaking country (Austria). The data showed that
202 there is great variability between GF foods and gluten-containing products for specific nutrients.
203 A key finding of this study is that protein content was significantly lower in GF foods across all
204 staple foods. In flour/bake mix products, the average protein content was > 2 fold lower
205 compared to their gluten-containing counterparts. This finding is in line with previous findings
206 (Wu et al. 2015), except that we did not observe significant differences in total fat, saturated fat,
207 PUFA and MUFA in our products (Kulai & Rashid 2014; Matos Segura & Rosell 2011; Miranda
208 et al. 2014). Only in pasta and cereal-based products, MUFA content was significantly higher in
209 GF foods. The low amount of proteins in GF foods may be explained by their formulation. In GF
210 formulations, the administration of carbohydrate-rich, but protein-poor ingredients (e.g. white
211 rice flour, tapioca or potato starch) is a reasonable explanation for this phenomenon (Mezaize et
212 al. 2009).
213 Data about the protein intake and clinical relevance for celiac patients is conflicting. In a
214 prospective study comparing dietary intake from 88 celiac patients (7-day dietary record) with
215 data from non-celiac individuals from the German National Diet and Nutrition Survey (NVS II),
216 differences in protein intake for males or females were not observed (Martin et al. 2013). On the
217 other hand, Miranda et al. (2014) analyzed 58 adults with CD and showed that protein intake was
218 lower in women who were on a GF diet compared to a diet containing gluten. In this study,
219 breads contained almost a third less protein than their equivalent with gluten. In our dataset GF
220 breads contained half the protein compared to regular breads with gluten. Addtionally, in a cross-
221 sectional study, van Hees et al. (2015) compared dietary intake of amino acids in 77 CD patients

222 contrasted by 33 healthy controls. They found that a GF diet with good adherence resulted in
223 significantly lower amino acid concentrations in blood (tyrosine, phenylalanine and tryptophan)
224 compared to healthy controls. The authors argue that both, a reduced intake of vegetable protein
225 and malabsorption as a results of CD may be resposible for this result. Although, decreased
226 amino acid concentrations did not result in increased depressive symptoms in CD patients, the
227 findings of our study suggests that reduced protein content in GF products may facilitate
228 problematic protein intake in CD patients and should be considered in dietary counseling.
229 In 65% of all GF foods, low sodium content (defined as <120mg/100g, Nutrition and Health
230 Claim N°1924/2006 (2006) was observed. Interestingly, in bread and bakery products, sodium
231 content was lower compared to gluten-containing foods. The lower amount of sodium in GF
232 bread may be accounted for the joint initiative „Weniger Salz is g'sünder" with the aim to reduce
233 salt in bread and bakery products by 15% by 2015 initiated by the Austrian Ministry of Health
234 (2011) and the Industrial Bakers of Austria (Lloyd-Williams et al. 2014). Foods from the datasets
235 used in this study contained nutrient information that were assessed prior to this initiative (started
236 2011), which may be a possible explanation for this discrepancy.
237
238 **Limitations**
239 Some limitations of the present study should be taken into account. First, we only analyzed a
240 small sample of products. Due to our rigid exclusion steps and criteria, we only analyzed 63 from
241 originally 162 identified foods. In some categories, low numbers of GF foods were included (e.g.
242 category cereals: three items; category flour/bake mix: five items). Hence, post-hoc power
243 analysis revealed that in the case of e.g protein content in GF and gluten-containing food groups
244 in flour/bake mix products, statistical power (1- β) was still high at 95.7%. Nevertheless, this is

245 only the first step to build a database for GF products in Austria, and we will be extending the
246 database for future investigations.
247 Second, we did not analyze the nutritional composition of GF foods through direct chemical
248 analysis, but estimated their amount. Food label data are provided by the food industry which are
249 mostly based on estimation of nutrient content of the ingredients rather than analysing the food
250 products (Pennington 2008). Hence, comparing these data with nutrient compositions obtained
251 by direct analysis may be limited in some cases.
252 Finally, it should be noted that we only included data from products sold in one German-
253 speaking country (Austria), while a majority of GF products are well distributed across European
254 countries, translating our findings to other countries should be interpreted with care.
255 Nevertheless, this study improves our knowledge about the nutritional quality of GF foods and
256 secondly, the applied methodological strategy holds a great potential to consolidate data from
257 other countries to form a transnational database on GF products.
258
259 *Implications of the present research*
260 To put our findings into perspective, it is important to note that GF products are very popular
261 among consumers without CD. In fact, GF foods are increasingly purchased by individuals
262 without CD (Silvester et al. 2015). Dunn et al. (2014) showed that only 57% consume GF foods
263 for medical reasons, while for almost half of the consumers other factors e.g. lifestyle and
264 positive health association are important for purchasing GF foods. This trend is reflected in
265 worldwide sales numbers as well. Between 2004 and 2011 the market for GF products grew at an
266 annual growth rate of 28% (Sapone et al. 2012). The global GF product market is projected to
267 reach a value of $6206 million, growing at a compounded annual growth rate of 10.2% by 2018

(Marketsandmarkets, 2013). This implies that the GF product market represents a very prosperous markets in the field of food and beverages. In addition, the prevalence of nonceliac gluten sensitivity (NCGS) in the general population are still unknown, but recent research suggests that NCGS prevalence could well be higher than CD (Fasano et al. 2015). For individuals suffering from NCGS, adhering to a GF diet could also be beneficial in the remission of their symptoms (El-Chammas & Danner 2011). Overall, clinical evidence on the NCGS remain inconsistent (Biesiekierski et al. 2013).

Another important reason to purchase GF products is that they are perceived to be healthier than their gluten-containing counterparts (Dunn et al. 2014). On a behavioral level, the increased perceived healthfulness can be explained by the 'health halo' effect, which states that products that are labelled as 'healthier' (e.g. low-fat label) can mislead consumers about other important nutritional elements, e.g energy content and portion sizes (Faulkner et al. 2014). The 'health halo' effect can also lead to some undesired behavioral effects such as increased consumption and poor caloric estimates (Ebneter et al. 2013).

Marketers may tap into the perceived healthfullness which reflects, besides the increased production cost of GF products, in the overall higher cost of GF products. In our dataset, the cost for all analyzed GF products was 205 – 267% higher than for conventional foods. This finding is in line with previous findings (Kulai & Rashid 2014; Lee et al. 2007; Singh & Whelan 2011; Stevens & Rashid 2008). In fact, Singh & Whelan (2011) report higher cost for GF foods ranging from 70-510%.

Conclusions

In conclusion, this study presents the first findings for a thorough analysis of GF products in a

German-speaking country. There are some marked differences between GF and gluten-containing foods. Based on the nutrient composition of GF foods, our findings indicate that GF foods do not have particular health benefits, but rather critical nutrients which should be considered in future formulations. The findings of our study indicate that re-thinking the health aspects ascribed to GF products, at least based on nutrient content of GF foods, should be considered and publicly communicated. Especially in the face of a growing market share common health misconceptions should be kept in mind when discussing GF products.

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401

Figure 1(on next page)

Nutrient content in g/100g between gluten-free and gluten-containing foods across seven different food categories

* Significant differences ($p<0.05$) between gluten-free and gluten containing foods

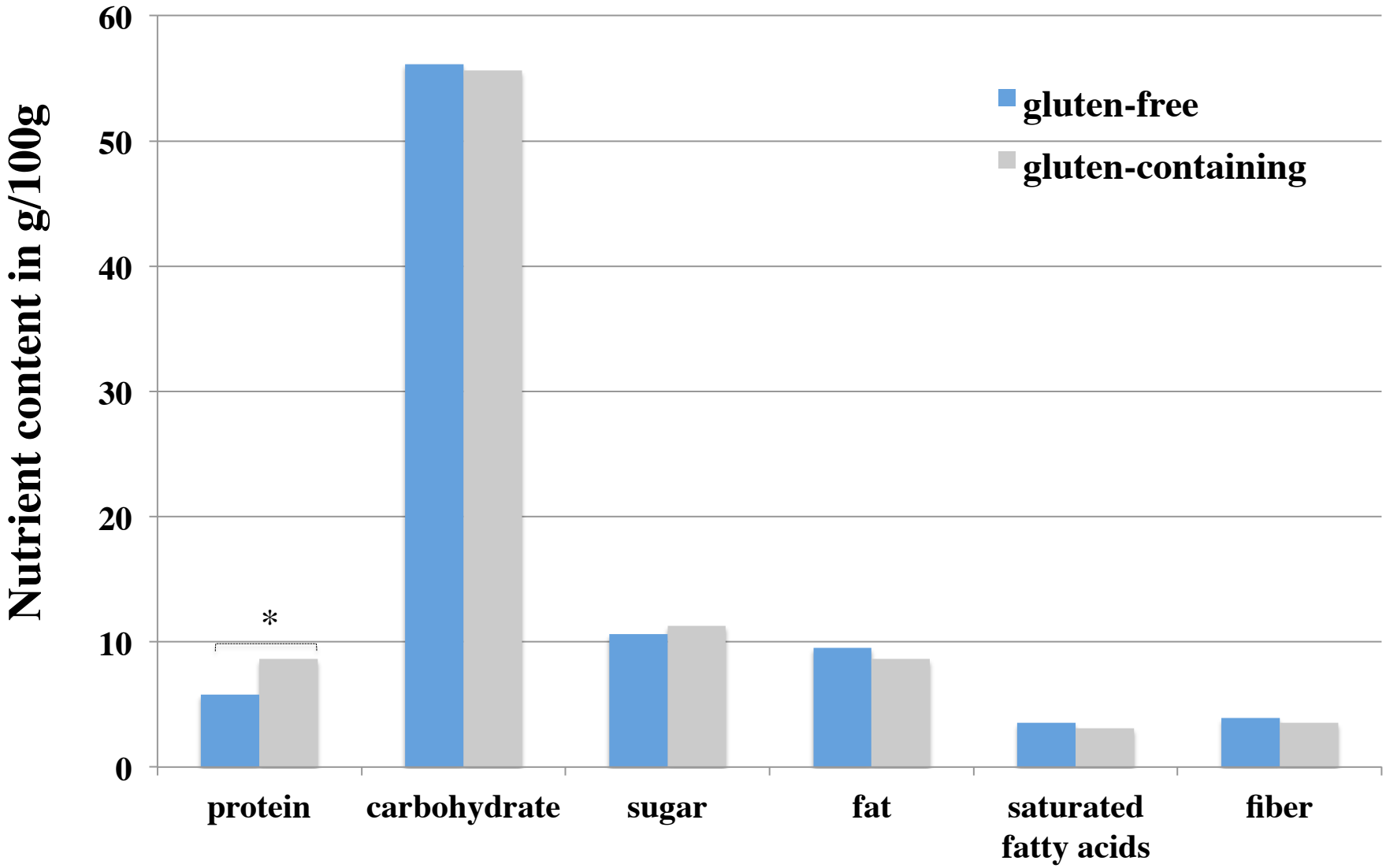
Nutrient content in g/100g
60
50
40
30
20
10
0
*
gluten-free
gluten-containing
protein
carbohydrate
sugar
fat
saturated fatty acids
fiber

Figure 2(on next page)

Cost in €/kg between gluten-free and gluten-containing foods across seven different food categories

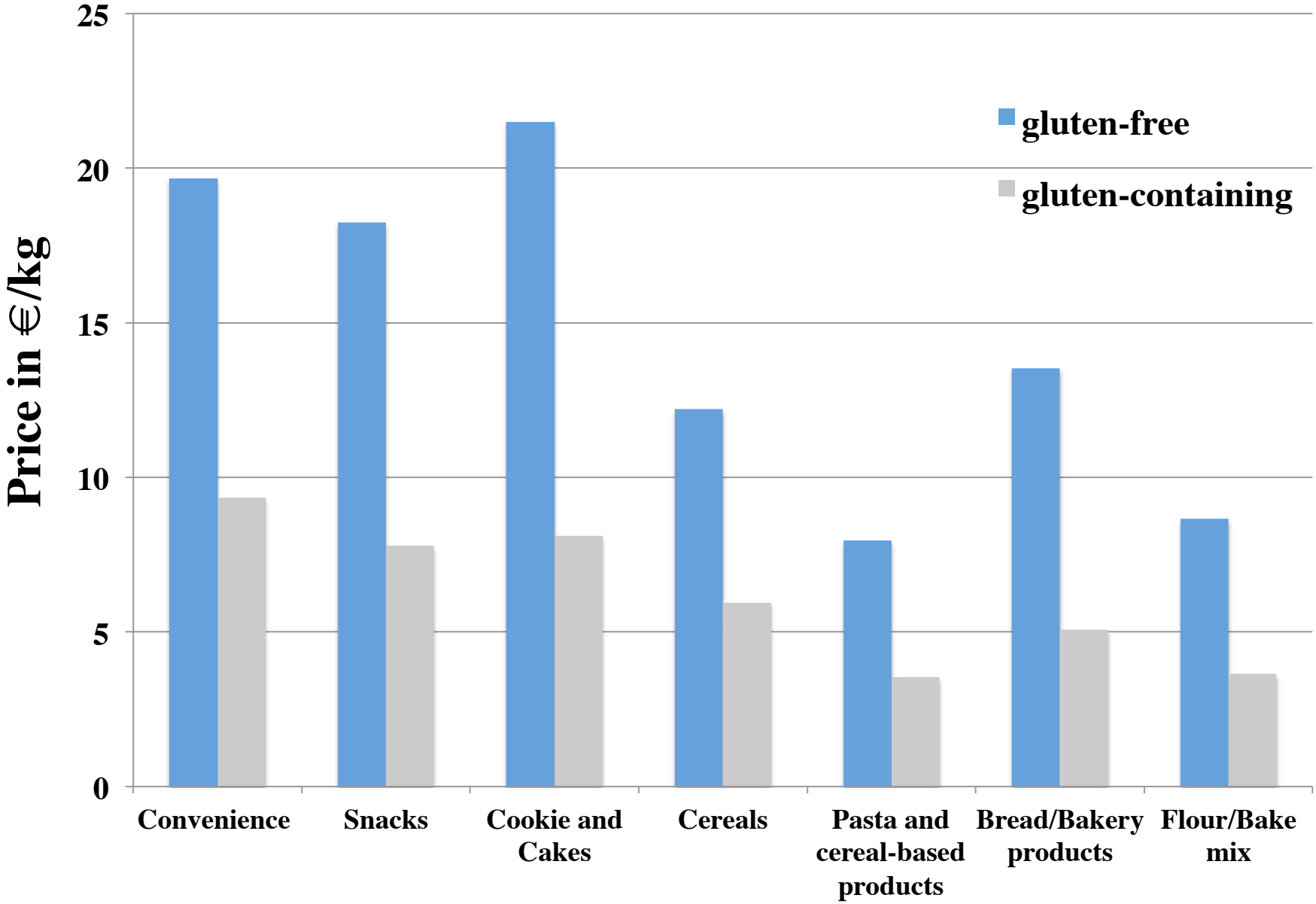
Price in €/kg
25
20
15
10
5
0
gluten-free
gluten-containing
Convenience
Snacks
Cookie and Cakes
Cereals
Pasta and cereal-based products
Bread/Bakery products
Flour/Bake mix

Table 1(on next page)

Macronutrient composition of gluten-free products in Austria. Values expressed as g/100g of the product.

*Notes. *mean values of two very similar products were pooled.*

1 Table 1: Macronutrient composition of gluten-free products in Austria. Values expressed as g/100g of the product.
2

	Energy (kcal)	Protein (g)	Carbohydrates (g)	Sugar (g)	Total Fat (g)	Saturated fatty acids (g)	MUFA (mg)	PUFA (mg)	Fiber (g)
Flour/Bake mix									
Flour *	345.5	3.7	77.6	1.0	1.7	0.2	0.3	1.0	3.8
Bake mix white (cake)	338.4	3.2	77.5	17.8	1.2	0.3	0.5	0.5	2.3
Bake mix brown (cake)	394.7	2.6	82.9	52.5	5.4	3.1	1.8	0.4	2.8
Bake mix (Pizza) *	322.7	5.9	70.3	1.5	1.9	0.4	0.8	0.7	3.9
Breadcrumbs *	350.8	5.9	70.1	0.4	4.8	1.3	1.9	1.2	6.0
Bread/Bakery products									
Rustic bread	238.4	3.7	51.0	0.7	1.9	0.3	0.8	0.6	1.4
Whole-grain bread	263.6	8.5	40.8	5.1	7.2	1.0	2.2	3.9	8.4
Toast *	224.8	4.8	39.0	2.1	5.3	1.4	2.0	1.5	6.3
Bun	259.2	1.4	48.7	5.2	6.2	3.0	1.6	1.2	1.6
Ciabatta	213.4	3.3	44.9	2.9	2.0	0.3	2.3	0.7	8.3
Raisin bread	261.0	4.0	49.1	18.6	4.2	1.5	0.8	0.8	1.6
Scone	293.2	3.7	52.2	13.8	7.5	2.2	1.4	1.1	2.7
Baguette	270.1	4.5	56.7	6.4	2.5	0.4	1.9	3.0	5.3
Lye Pretzel	343.8	4.8	59.2	7.8	9.4	4.7	1.0	0.9	2.2
Rusk	343.9	0.3	82.5	0.8	0.9	0.3	3.2	0.7	0.7
Crispbread	351.6	6.9	77.8	6.0	0.9	0.2	0.4	0.2	2.9
Wraps	228.7	3.1	38.8	0.4	7.5	2.2	0.3	0.4	2.8
Pasta and cereal-based products									
Fusilli	335.9	8.2	69.9	1.0	2.2	0.3	0.7	1.1	7.2
Spaghetti	329.0	8.7	66.3	1.3	2.8	0.4	0.9	1.4	9.4
Penne	338.4	6.9	72.4	4.3	1.9	0.3	0.5	0.9	4.9
Lasagne sheets	373.0	7.0	76.3	0.8	4.0	1.1	1.6	0.8	2.4
Vermicelli	371.2	12.5	71.6	2.0	3.4	0.4	1.0	1.7	13.5
Tagliatelli	370.9	12.1	72.0	1.9	3.3	0.4	1.0	1.7	13.1
Cous Cous	345.0	8.8	73.8	1.5	1.1	0.1	0.4	0.4	5.0
Cereals									
Granola (chocolate)	392.3	5.5	72.6	34.0	8.5	4.7	3.1	0.6	4.6
Granola (nuts)	478.0	7.1	64.9	16.7	21.0	7.7	10.3	2.5	4.8
Cornflakes	322.4	8.5	62.9	1.4	3.7	0.6	1.1	1.6	7.6
Cookie and Cakes									
Shortbread	385.3	3.3	73.6	13.8	8.3	2.7	3.9	1.5	1.2
Neapolitan wafers (original)	236.0	2.5	22.9	18.1	15.0	8.3	5.2	1.1	3.3
Cookie (chocolate)	479.2	2.0	64.3	5.7	23.8	11.9	8.5	2.5	2.3
Mignon wafers (hazelnut)	507.9	5.0	54.0	41.7	30.4	13.9	11.9	3.7	5.6
Marble cake	403.7	5.4	48.1	20.7	22.6	3.8	10.2	7.4	0.8
Ladyfinger	356.9	5.7	74.6	33.1	3.5	1.0	1.4	0.6	2.5
Cookie (whole-grain)	471.1	4.6	71.8	21.1	18.2	7.8	6.8	2.8	3.6
Granola bar	400.8	7.2	59.2	25.0	14.8	7.0	5.3	1.7	12.9
Cookie (orange)*	433.0	6.2	60.2	49.7	18.3	10.5	5.5	1.4	2.6
Apple strudel	270.9	4.2	43.2	18.1	8.7	3.4	2.9	2.2	1.6
Muffin	371.6	5.2	55.8	30.0	14.6	4.1	3.4	2.2	3.5

Snacks									
Cracker	340.8	10.1	43.5	0.0	13.8	9.3	3.3	0.4	0.3
Brezels	449.7	0.5	65.5	0.8	20.6	9.8	7.5	2.4	0.8
Grissini	392.5	2.0	67.4	2.6	12.6	3.9	6.1	2.4	0.7
Saltsticks	480.9	0.6	72.0	1.5	21.1	10.3	7.8	2.2	0.8
Wafers (plain)	329.7	8.6	63.8	1.4	4.1	0.6	1.2	1.8	7.7
Convenience foods									
Pizza (salami)	235.1	8.0	24.8	2.8	11.5	4.8	4.1	1.9	1.5
Pizza (margherita)	209.1	6.3	27.6	3.5	8.0	3.8	2.5	1.3	2.0
Lasagne	170.4	7.4	16.4	2.2	8.3	3.8	3.2	0.8	1.1
Chicken Nuggets	251.2	15.3	22.5	0.5	11.0	1.5	4.2	4.8	3.0
Fish sticks	216.0	9.2	28.1	4.0	7.3	0.8	1.8	3.8	1.9
Tortellini (pork)	285.3	7.7	48.1	1.3	6.6	2.5	2.5	1.0	1.7
Soup (potato and leek)	355.9	16.2	47.7	7.9	10.4	2.2	4.3	2.6	8.3
Soup (mushrooms)	431.4	15.5	43.4	13.7	21.7	2.1	10.2	5.7	1.6
Wafer-cone (icecream filling)	278.0	5.2	27.8	24.2	16.2	5.9	7.0	2.9	3.5
Pudding (semolina)	362.5	6.2	82.0	14.8	0.6	0.1	0.2	0.2	1.8
Baked pastry case	483.9	4.3	43.3	21.6	32.9	15.7	12.0	3.6	4.4
Wafer (Oblate)	329.2	1.1	79.1	0.2	0.4	0.1	0.1	0.2	1.2
Rice Drink (natural)	56.9	1.1	11.0	0.2	0.9	0.1	0.4	0.3	0.4
Flaky pastry	389.5	1.4	31.6	2.05	29.0	8.1	7.3	12.3	5.3
Frozen Cake (almond, chocolate)	405.2	7.0	25.1	24.4	31.1	10.9	13.1	4.3	2.0

*Notes. *mean values of two very similar products were pooled.*

Table 2(on next page)

Micronutrient composition of gluten-free products in Austria. Values expressed as g/100g of the product.

*Notes. *mean values of two very similar products were pooled.*

Table 2: Micronutrient composition of gluten-free products in Austria. Values expressed as g/100g of the product.

	Sodium (mg)	Cholesterol (mg)	Iron (mg)	Calcium (mg)	Potassium (mg)	Zinc (mg)	Phosphor (mg)	Vitamin C (mg)	Vitamin D (µg)	Vitamin E (mg)	Retinol (µg)	ß-Carotin (µg)	Thiamin (mg)	Riboflavin (mg)	Niacin (mg)
Flour/Bake mix															
Flour *	3.02	0.00	1.42	32.16	147.84	0.99	78.76	0.00	0.00	0.11	0.00	0.02	0.08	0.03	0.29
Bake mix white (cake)	39.67	0.00	1.17	54.73	240.21	1.08	204.11	0.12	0.00	0.04	0.00	0.00	0.03	0.02	0.29
Bake mix brown (cake)	41.71	9.47	1.23	17.52	252.71	0.79	118.76	0.32	0.00	0.06	0.00	0.00	0.02	0.02	0.29
Bake mix (Pizza) *	783.75	0.00	1.49	89.31	347.84	1.64	720.85	0.39	0.00	0.08	0.00	0.00	0.06	0.05	1.14
Breadcrumbs *	196.33	0.04	2.25	31.67	182.99	1.88	183.23	0.00	0.00	1.02	0.00	4.51	0.25	0.04	0.31
Bread/Bakery products															
Rustic bread	120.53	0.00	0.38	10.58	75.45	0.48	35.90	0.00	0.00	1.01	0.00	0.00	0.06	0.02	0.48
Whole-grain bread	685.79	0.00	2.41	96.43	304.10	1.70	208.75	0.01	0.00	0.23	0.00	0.01	0.21	0.10	1.33
Toast *	394.29	0.02	1.58	34.01	273.02	1.24	135.35	0.03	0.00	2.05	0.00	0.37	0.17	0.11	1.92
Bun	402.11	4.02	0.60	17.67	52.68	0.39	36.52	0.00	0.00	0.48	0.00	1.28	0.03	0.06	0.48
Ciabatta	355.74	0.00	1.03	17.15	117.38	0.86	91.38	1.20	0.00	1.05	0.00	0.08	0.14	0.09	0.97
Raisin bread	299.48	0.37	1.01	59.31	157.72	0.73	80.86	0.43	0.00	0.08	0.02	0.04	0.07	0.09	0.51
Scone	314.90	32.64	0.82	30.76	91.38	0.50	73.71	0.01	0.00	0.19	0.06	0.05	0.07	0.14	1.09
Baguette	336.38	0.00	0.66	13.96	120.93	0.41	48.25	0.84	0.00	1.41	0.00	0.01	0.07	0.06	0.62
Lye Pretzel	790.76	7.06	0.40	124.30	137.68	0.57	78.43	13.10	0.00	0.49	0.02	1.29	0.04	0.15	0.15
Rusk	5.52	0.01	1.06	21.34	11.95	0.40	20.24	0.00	0.00	0.08	0.00	1.00	0.00	0.01	0.09
Crispbread	547.20	0.00	0.67	11.61	99.13	0.67	109.04	0.00	0.00	0.24	0.00	0.04	0.11	0.04	1.38
Wraps	402.35	0.63	0.21	18.09	83.57	0.19	39.96	0.25	0.23	0.07	0.05	0.06	0.03	0.01	0.58
Pasta and cereal-based products															
Fusilli	1.88	0.00	1.80	14.67	114.68	1.87	205.75	0.00	0.00	0.81	0.00	0.21	0.33	0.10	1.76
Spaghetti	1.00	0.00	2.40	18.00	120.00	2.50	256.00	0.00	0.00	1.11	0.00	0.30	0.44	0.13	1.93
Penne	1.90	0.00	3.15	22.73	198.37	1.43	211.40	0.00	0.00	0.48	0.00	0.12	0.28	0.12	1.61
Lasagne sheets	55.98	146.52	1.37	30.53	91.97	1.32	144.47	0.00	0.00	0.89	0.10	0.04	0.10	0.18	0.52
Vermicelli	6.71	0.00	3.81	45.15	297.12	3.05	327.38	0.93	0.00	1.68	0.00	0.31	0.51	0.16	2.14
Tagliatelli	5.94	0.00	3.65	41.70	274.68	3.02	321.78	0.80	0.00	1.62	0.00	0.32	0.51	0.16	2.14
Cous Cous	1.00	0.00	1.00	4.00	80.00	0.41	73.00	0.00	0.00	0.52	0.00	0.26	0.13	0.04	1.20
Cereals															
Granola (chocolate)	504.01	15.77	1.51	17.98	265.98	0.52	73.86	0.13	0.00	0.25	0.00	0.51	0.05	0.06	0.96
Granola (nuts)	393.96	0.16	1.72	44.88	314.76	1.60	174.62	0.11	0.00	3.54	0.00	1.78	0.20	0.09	1.40
Cornflakes	575.88	0.00	1.52	8.61	265.44	1.45	208.76	0.00	0.00	1.47	0.00	0.90	0.35	0.20	1.47
Cookie and Cakes															
Shortbread	408.14	17.31	0.66	33.19	79.97	0.59	72.93	0.22	0.00	0.84	0.02	9.02	0.05	0.10	0.73
Neapolitan wafers (original)	16.20	21.70	0.71	8.86	259.18	0.59	61.06	0.01	0.00	0.12	0.00	0.01	0.03	0.03	0.37
Cookie (chocolate)	199.30	3.37	0.82	13.20	91.10	0.73	57.96	0.00	0.00	1.66	0.00	4.50	0.05	0.02	0.26
Mignon wafers (hazelnut)	417.91	28.84	2.70	28.12	476.92	1.16	124.82	0.02	0.00	1.31	0.00	0.03	0.09	0.06	0.68
Marble cake	54.88	138.60	1.32	22.11	103.26	0.76	98.91	0.00	0.00	12.54	0.10	0.02	0.05	0.15	0.24
Ladyfinger	98.46	141.37	1.00	37.26	79.88	0.80	100.96	0.00	0.00	0.72	0.10	0.00	0.05	0.15	0.28
Cookie (whole-grain)	295.19	5.16	1.17	15.24	68.83	0.78	89.30	0.13	0.00	0.37	0.00	0.12	0.14	0.05	0.87
Granola bar	237.91	4.24	2.14	96.16	292.51	1.37	170.55	0.45	0.00	1.00	0.01	0.16	0.19	0.19	1.23
Cookie (orange)*	190.66	23.28	1.74	103.46	389.10	0.83	120.50	4.78	0.00	0.39	0.06	0.27	0.08	0.13	0.45
Apple strudel	102.98	1.83	1.13	177.03	240.82	0.68	128.36	4.75	0.00	0.16	0.05	0.08	0.07	0.27	0.25
Muffin	247.84	79.20	2.66	29.50	219.98	0.74	102.31	0.00	0.00	3.54	0.06	0.01	0.06	0.11	0.30
Snacks															
Cracker	2416.36	47.71	1.40	434.99	83.08	2.05	305.78	0.43	0.00	0.41	0.13	0.06	0.03	0.12	0.48

Brezels	554.28	0.20	0.67	11.72	17.23	0.45	26.93	0.00	0.00	1.48	0.00	4.26	0.01	0.03	0.21
Grissini	226.87	20.01	0.63	52.59	64.73	0.62	62.82	0.06	0.00	1.31	0.03	15.02	0.02	0.09	0.07
Saltsticks	1007.36	0.21	0.93	15.82	25.22	0.47	30.69	0.00	0.00	1.56	0.00	4.47	0.02	0.04	0.34
Wafers (plain)	119.98	0.01	1.50	8.15	268.55	1.47	211.73	0.02	0.00	1.61	0.00	0.92	0.36	0.20	1.49
Convenience foods															
Pizza (salami)	614.15	22.66	0.97	103.75	275.57	1.13	115.28	7.43	0.00	3.23	0.04	0.24	0.11	0.11	1.68
Pizza (margherita)	437.51	14.95	0.68	110.73	266.87	0.85	106.10	6.97	0.00	2.97	0.05	0.26	0.05	0.10	1.02
Lasagne	450.21	38.88	0.79	56.08	211.47	1.38	99.60	5.51	0.02	1.14	0.04	0.24	0.11	0.13	1.51
Nuggets	396.19	35.00	1.34	16.80	158.47	1.37	179.53	0.05	0.00	5.46	0.00	0.16	0.14	0.09	4.71
Fish sticks	378.34	23.54	1.19	24.87	128.33	0.49	142.50	0.24	0.00	4.04	0.00	0.11	0.12	0.22	1.62
Tortellini (pork)	628.05	72.33	1.49	51.06	118.68	1.64	122.19	1.06	0.01	0.75	0.04	0.04	0.24	0.12	1.38
Soup (potato and leek)	3801.76	1.03	2.53	80.57	1014.25	0.88	260.47	11.70	0.00	1.61	0.00	0.42	0.17	0.28	4.63
Soup (mushrooms)	472.57	0.43	0.89	17.52	104.01	0.22	34.90	0.95	0.00	3.82	0.00	0.68	0.04	0.07	0.91
Wafer-cone (icecream filling)	101.42	22.61	1.39	97.43	358.09	0.78	127.37	0.81	0.12	3.66	0.02	0.04	0.04	0.16	0.37
Pudding (semolina)	117.48	0.00	0.54	9.64	91.27	0.50	79.69	0.10	0.00	0.09	0.00	0.00	0.06	0.02	1.18
Baked pastry case	108.30	0.32	1.61	30.08	138.24	1.30	202.23	0.70	0.00	2.87	0.00	6.82	0.18	0.09	1.91
Wafer (Oblate)	6.98	0.00	1.80	31.88	26.15	0.43	35.54	0.00	0.00	0.12	0.00	0.03	0.05	0.02	0.33
Rice Drink (natural)	52.58	0.00	0.23	12.47	17.01	0.20	15.55	0.00	0.00	0.51	0.00	0.00	0.01	0.00	0.19
Flaky pastry	412.00	2.35	0.22	49.65	47.07	0.20	24.56	0.13	0.03	2.10	0.00	0.17	0.24	0.01	0.22
Frozen Cake (almond, chocolate)	120.14	170.20	1.69	39.44	219.39	0.90	126.96	0.21	0.13	4.26	0.15	2.19	0.06	0.16	0.38

*Notes. *mean values of two very similar products were pooled.*

Table 3(on next page)

Micronutrient composition of gluten-free products in Austria. Values expressed as g/100g of the product.

*Notes. *mean values of two very similar products were pooled.*

Table 3: Comparison between micro-and macronutrient composition of gluten-free and matched gluten-containing foods among categories.

		Flour/Bake mix	Bread/Bakery products	Pasta and cereal-based products	Cereals	Cookie and Cakes	Snacks	Convenience foods
Energy (kcal)	**Gluten Free**	346.4 ± 35.5	270.5 ± 46.7	351.9 ± 17.7	397.5 ± 63.6	395.8 ± 84.4	398.7 ± 59.2	297.3 ±108.5
	Gluten-containing	335.0 ± 23.0	280.9 ± 49.8	346.5 ± 10.9	397.4 ± 56.3	416.3 ± 78.1	371.6 ± 45.3	298.2 ± 102.0
Protein (g)	**Gluten Free**	4.6 ± 3.2	4.1 ± 2.2	9.2 ± 2.1	7.0 ± 1.2	4.8 ± 1.6	4.3 ± 4.1	7.4 ± 4.8
	Gluten-containing	10.0 ± 2.0	8.3 ± 1.0	11.9 ± 0.9	9.2 ±2.4	5.8 ± 1.9	10.5 ± 1.4	8.2 ± 3.9
Sugar (g)	**Gluten Free**	9.5 ± 17.2	5.5 ± 5.2	1.8 ± 1.1	17.4 ± 13.3	27.2 ± 14.6	1.3 ± 0.8	8.2 ± 8.8
	Gluten-containing	6.0 ± 9.1	4.4 ± 5.4	0.8 ± 0.2	14.5 ± 6.4	33.7 ± 12.6	1.0 ± 0.2	9.8 ± 12.2
Total Fat (g)	**Gluten Free**	2.9 ± 2.2	4.7 ± 2.7	2.7 ± 0.9	11.1 ± 7.3	16.4 ± 8.4	14.4 ± 6.2	13.1 ± 10.5
	Gluten-containing	2.2 ± 2.3	3.8 ± 2.8	1.9 ± 1.0	14.3 ± 8.0	17.0 ± 8.4	9.0 ± 8.0	11.6 ± 9.0
Saturated fatty acids (g)	**Gluten Free**	0.9 ± 1.1	1.4 ± 1.3	0.4 ± 0.3	4.3 ± 2.9	7.1 ± 5.1	6.8 ± 3.8	4.1 ± 4.3
	Gluten-containing	0.7 ± 1.2	0.9 ± 1.0	0.4 ± 0.3	4.4 ± 3.4	6.8 ± 4.5	4.2 ± 5.3	4.0 ± 4.1
MUFA (mg)	**Gluten Free**	1.0 ± 1.1	1.5 ± 0.8	0.9 ± 0.4	4.8 ± 4.0	5.9 ± 3.2	5.2 ± 2.6	4.8 ± 4.1
	Gluten-containing	0.5 ± 0.9	1.3 ± 1.2	0.4 ± 0.4	6.4 ± 4.1	6.7 ± 3.6	2.7 ± 2.4	4.5 ± 3.7
PUFA (mg)	**Gluten Free**	0.8 ± 0.6	1.4 ± 1.1	1.1 ± 0.4	1.5 ± 0.8	2.4 ± 1.7	1.8 ± 0.7	3.0 ± 3.0
	Gluten-containing	0.6 ± 0.4	1.0 ± 0.8	0.8 ± 0.3	3.2 ± 0.9	2.6 ± 1.8	1.4 ± 1.0	1.9 ± 1.4
Fiber (g)	**Gluten Free**	4.1 ± 2.9	3.9 ± 2.7	7.9 ± 4.0	5.6 ± 1.4	3.5 ± 3.1	2.0 ± 2.8	2.6 ± 2.0
	Gluten-containing	4.0 ± 2.3	3.3 ± 1.7	3.7 ± 0.7	7.4 ± 1.9	3.5 ± 3.8	4.6 ± 3.2	2.4 ± 2.0
Sodium (mg)	**Gluten Free**	255.9 ± 326.9	388.4 ± 198.3	10.6 ± 18.6	491.3 ± 74.8	205.0 ± 122.6	856.0 ± 835.0	539.8 ± 894.2
	Gluten-containing	281.6 ± 294.6	581.9 ± 284.6	15.8 ± 18.0	160.7 ± 127.2	247.8 ± 394.0	832.1 ± 626.7	715.8 ± 1186.1
Cholestorol (mg)	**Gluten Free**	1.2 ± 3.1	3.4 ± 8.7	20.9 ± 51.3	5.3 ± 7.4	40.7 ± 49.0	13.6 ± 18.7	27.0 ± 43.1
	Gluten-containing	2.6 ± 7.0	5.5 ± 12.1	21.5 ± 42.2	1.4 ± 2.0	32.4 ± 38.4	1.5 ± 2.6	28.5 ± 41.5
Iron (mg)	**Gluten Free**	1.6 ± 0.8	1.0 ± 0.7	2.5 ± 1.0	1.6 ± 0.1	1.5 ± 0.7	1.0 ± 0.4	1.2 ± 0.6
	Gluten-containing	1.6 ± 1.1	1.2 ± 0.6	2.5 ± 0.3	6.1 ± 7.3	1.6 ± 1.3	2.2 ± 1.8	1.4 ± 1.3
Calcium (mg)	**Gluten Free**	47.3 ± 27.2	37.6 ± 33.9	25.3 ± 13.7	23.8 ± 15.4	55.6 ± 55.0	104.7 ± 165.9	48.8 ± 33.1
	Gluten-containing	24.3 ± 19.1	18.9 ± 10.8	33.6 ± 7.6	75.4 ± 117.0	37.2 ± 27.5	50.3 ± 45.1	46.4 ± 40.0
Potassium (mg)	**Gluten Free**	231.3 ± 127.5	138.3 ± 118.9	168.1 ± 82.5	282.1 ± 23.1	224.2 ± 136.7	91.8 ± 91.7	211.7 ± 234.1
	Gluten-containing	222.3 ± 86.8	201.3 ± 61.0	295.4 ± 121.2	378.3 ± 152.7	235.1 ± 124.3	309.7 ± 179.8	241.8 ± 145.4
Zinc (mg)	**Gluten Free**	1.4 ± 0.8	0.7 ± 0.5	1.9 ± 0.9	1.2 ± 0.5	0.8 ± 0.2	1.0 ± 0.6	0.8 ± 0.5
	Gluten-containing	1.2 ± 1.1	0.8 ± 0.4	4.6 ± 0.4	2.6 ± 1.0	0.8 ± 0.6	1.6 ± 1.1	1.0 ± 0.8
Phosphor (mg)	**Gluten Free**	286.1 ± 267.0	84.1 ± 61.3	220.0 ± 85.2	152.4 ± 57.3	104.0 ± 33.5	127.6 ± 111.8	111.5 ± 66.4
	Gluten-containing	194.7 ± 177.1	104.9 ± 49.2	301.3 ± 178.4	321.0 ± 222.1	109.2 ± 73.7	207.2 ± 152.4	130.7 ± 84.6
Vitamin C (mg)	**Gluten Free**	0.2 ± 0.2	1.2 ± 3.4	0.2 ± 0.4	0.1 ± 0.1	1.3 ± 2.4	0.1 ± 0.2	2.4 ± 3.5
	Gluten-containing	0.0 ± 0.0	1.6 ± 7.6	1.0 ± 3.5	22.4 ± 49.9	2.0 ± 3.4	0.0 ± 0.1	16.7 ± 56.1
Vitamin D (mg)	**Gluten Free**	0.0 ± 0.0	0.0 ± 0.1	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
	Gluten-containing	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.1
Vitamin E (mg)	**Gluten Free**	0.3 ± 0.4	0.7 ± 0.8	1.0 ± 0.4	1.8 ± 1.4	1.9 ± 3.3	1.3 ± 0.4	2.4 ± 1.6
	Gluten-containing	0.3 ± 0.4	0.8 ± 1.0	1.0 ± 0.2	2.1 ± 1.2	2.3 ± 3.2	0.9 ± 0.5	1.7 ± 1.1
Retinol (mg)	**Gluten Free**	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
	Gluten-containing	0.0 ± 0.0	0.0 ± 0.1	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.1	0.0 ± 0.0
ß-Carotin (mg)	**Gluten Free**	1.1 ± 3.0	0.4 ± 0.5	0.2 ± 0.1	1.1 ± 0.5	1.2 ± 2.7	4.9 ± 5.3	0.8 ± 1.7
	Gluten-containing	0.0 ± 0.0	0.2 ± 0.5	0.1 ± 0.3	1.2 ± 1.2	1.1 ± 1.6	0.4 ± 0.7	0.9 ± 1.5
Niacin (mg)	**Gluten Free**	0.6 ± 0.4	0.9 ± 0.7	1.6 ± 0.5	1.3 ± 0.2	0.5 ± 0.3	0.5 ± 0.5	1.5 ± 1.4

	Gluten-containing	1.5 ± 1.6	1.6 ± 0.8	3.6 ± 2.7	11.0 ± 22.0	0.7 ± 0.8	3.3 ± 3.1	1.8 ± 1.6

Notes. Numbers are depicted as mean values per unit/100g ± standard deviation.