International Journal of Celiac Disease, 2021, Vol. 9, No. 1, 16-22
Available online at http://pubs.sciepub.com/ijcd/9/1/3
Published by Science and Education Publishing
DOI:10.12691/ijcd-9-1-3

Gluten-free Foods and Their Contribution to Total Diet in Patients with Celiac Disease

Agustina Norambuena[1,2], Daiana Quintiliano[2], Magdalena Araya[1,*]

[1]Institute of Nutrition and Food Technology (INTA), University of Chile, Santiago, Chile
[2]Facultad de Medicina, Clínica Alemana, Universidad del Desarrollo, Santiago, Chile
*Corresponding author: maraya@inta.uchile.cl

Received January 05, 2021; Revised January 18, 2021; Accepted January 21, 2021

Abstract *Background.* Gluten-free diet continues being the most effective treatment of celiac disease but current evidence on its nutritional characteristics and metabolic effects rises concerns. *Objectives.* To assess the total diet of adult celiac patients and the contribution of gluten-free foods to it, in Chilean celiac patients. *Methodology.* Sociodemographic and clinical characteristics were registered and a food frequency questionnaire including detailed data about gluten-free foods was applied to 71 celiac patients older than 12 years of age receiving medical care at INTA, University of Chile, in Santiago. Total food intake, dietary adequacy and diet nutritional quality was calculated using descriptive statistics. *Principal Findings.* Of 71 patients, 81.6% were female, 93% were 19-65 years of age and 65% were on GFD for 2 years or more. Nutritional status classified in underweight and overweight/obesity in 2.9% and 35.7%, respectively. 2.8% patients declared to consume willingly gluten containing bread. The whole diet was normocaloric, normoproteic, hyperlipidic and hypoglucidic (FAO/WHO); when calculations were based for individuals' requirements, 65% of cases consumed excess calories, proteins, and carbohydrates. Gluten-free foods contributed to 17.7%, 11.6%, 11.5% and 23.9% of the total daily intake of calories, protein, lipids, and carbohydrates, respectively. GFF were characterized by having a low protein content. *Conclusions.* Although the whole diet appeared close to WHO/FAO recommendations when calculated as average for the study group, 65% of participants consumed excess calories, proteins, lipids, and carbohydrates when calculations were made on individual basis. There was neither moderate-severe undernutrition nor overweight/obesity in the group studied. It is interesting that both the total diet quality and the nutritional status of the celiac patients assessed were better than those described in the general local population.

Keywords: *adult, celiac disease, gluten-free diet, gluten-free food, nutritional status, dietary adequacy*

Cite This Article: Agustina Norambuena, Daiana Quintiliano, and Magdalena Araya, "Gluten-free Foods and Their Contribution to Total Diet in Patients with Celiac Disease." *International Journal of Celiac Disease*, vol. 9, no. 1 (2021): 16-22. doi: 10.12691/ijcd-9-1-3.

1. Introduction

Celiac disease (CD) has become one of the most common autoimmune gastrointestinal diseases, affecting ~1% of the population worldwide [1]. Neurological manifestations of gluten sensitivity and dermatitis herpetiformis [2,3] represent other manifestations associated with gluten consumption; more recently, non-celiac gluten/wheat sensitivity (NCG/WS) and wheat allergy are also described and might be also increasing [4,5]. Until now, the only effective treatment of CD is a strict lifelong gluten-free diet (GFD) [6], which requires the exclusion of foods naturally containing gluten and processed products that contain it as ingredient or additive or are contaminated during processing and distribution [7]. Gluten refers to a group of storage proteins present in wheat, barley and rye (main components of common foods, bread and pasta) and is the trigger of CD [8]. When consumed by patients with celiac disease, gluten leads to gastrointestinal and extra-intestinal manifestations, together with typical small intestine mucosal damage, in genetically predisposed individuals [1]. An increasing group of healthy population currently follows gluten-free diet (GFD) as an option of healthy lifestyle or fear of toxic gluten effects, without having a diagnosis justifying the restrictive diet [9]. In this case, the diet is based on the person's choice and gluten-free foods do not provide additional benefits to them [10], but they will experience the effects of it.

Maintaining strict and permanent GFD is a challenge for celiac patients, especially at school, at work and during social interactions [11]. This is a challenge that includes psychological issues and the need to have adequate knowledge about what to buy and eat [12]. There are many obstacles to maintain GFD, including availability, cost, safety of gluten-free food and gluten cross-contamination [11]. Unintentional gluten consumption is common, due to the presence of gluten in many foods [13] that do not declare it in the package labels. Also, it may be present as a hidden ingredient, because of its technological properties is used as a flavor enhancer, thickener, emulsifier, filler and fortifier, and may be hidden under the terms “flavorings”, or hydrolyzed vegetable proteins [14]. For these reasons, patients on GFD usually must spend some time reviewing their daily options of diet and environmental exposures [15], and often this lead to experiencing anxiety and/or depression, especially in social situations [13].

From the foods perspective, GFD is often deficient in protein, fiber, iron and B vitamins [6,14,16] and may favor nutrient deficiencies [17]. Additionally, there is recent evidence suggesting that celiac patients on GFD accumulate heavy metals [9], associated with higher metalloprotein expression in enterocytes [13] and a recent study describes that non-alcoholic fatty liver is more frequent among persons on GFD [18]. Also, changes of the intestinal microbiota with low Bifidobacterium and high Enterobacteriaceae and Escherichia coli levels, have been described in patients on GFD [19].

Most frequently, studies describe the quality of gluten-free foods (GFF) (mainly breads and bakery products) and the role they may play in patients’ diet and health [10,20]. In this study, we set as objective to assess the total daily consumption of foods, the nutritional quality of the whole diet and the contribution of gluten-free foods to daily diet, in Chilean celiac patients.

2. Materials and Methods

2.1. Study Group

Celiac patients older than 12 years of age, on GFD for more than 6 months, diagnosed by blood antibodies and duodenal biopsy [21,22], evaluated at the outpatient’s clinic of INTA, University of Chile, were included. Exclusion criteria were to suffer cognition impairment, conditions that interfere with feeding patterns or food intake and individuals on vegetarian or vegan diets. The IRB of the INTA, University of Chile, approved the study protocol.

2.2. General Data and Nutritional Status

Age, sex, years of schooling, socioeconomic level, number of family members, year of diagnosis, comorbidities, and duration of GFD were registered. Weight and height were obtained, and BMI calculated. Waist circumference was assessed in those participants that accepted to be measured.

2.3. Foods Intake

A Food Frequency Questionnaire (FFQ) [23,24,25] was adapted to discriminate gluten containing and gluten-free foods/processed products, including foods consumed, their brands, portions size and presence of gluten-free labels. Food items were considered gluten-free when the package declared the gluten-free status following the requirements of the Ministry of Health, Chile. Items without an explicit declaration were classified as gluten containing items. Nutritional information registered included energy per portion, energy (kcal) per 100 g and macronutrients recorded in g per 100 g. Other nutrients like calcium, folic acid, iron, niacin, omega-3 fatty acids, riboflavin and thiamin were systematically sought in packages, but could not be analyzed due to lack of information in all cases. A list of consumed foods was built, and weekly consumption calculated. Foods consumed were expressed as daily portions of cereals, vegetables, fruits, dairy products (high, medium and low fat), meat (high and low fat), legumes, oils and fats, and foods with high content of fat or sugar. Gluten-free processed foods/products were classified in 14 categories; bread, pasta, breakfast cereals, sweets, snacks (salted), bakery products, chocolates, ice cream, hamburgers, and food supplements. Based on this information energy and macronutrients was calculated per portion. For GFF, calculations were made using the mean value that different brands declared.

2.4. Dietary Nutritional Quality

Based on the number of portions ingested and their frequency of consumption, the total diet and the contribution of GFF to it was calculated. Percentage of adequacy against the Chilean National Food Guidelines was assessed and compared with information available for general Chilean population and the National Health Questionnaire, ENS 2017 [26,27]. Adequacy of the diet was classified into normal calories (90-110%), hypocaloric (<90%) and hypercaloric (>110%). In addition, individual requirements were calculated by age and sex [28] and the actual intake was classified according these pre-defined categories.

2.5. Statistical Analysis

Qualitative variables were expressed in absolute and relative frequencies and compared by chi- square test. Distribution of quantitative variables was tested by the Shapiro Wilk’s test. Results were expressed as median and interquartile rank. Analyses were carried out using Stata 13.1; a P level <0.05 was considered statistically significant.

3. Results

3.1. General Characteristics and Nutritional Evaluation

Of 71 participants analyzed, 58 (81.6%) were female and 93% were 19-65 years of age; 65% were active workers with ≥15 years of schooling and 35.2%, 46.5% and 18.3% belong to the low, medium and high socioeconomic status, respectively. In 65% of cases, participants were on GFD for 2 years or more and 62% of patients reported additional diagnoses (mainly thyroiditis 16.9%, osteoporosis 23.9% and anemia 21.2%). Comparison of the nutritional characteristics in the study group against the national general population is shown in Figure 1.

No morbid obese were detected, 52.8% patients had cardiovascular risk.

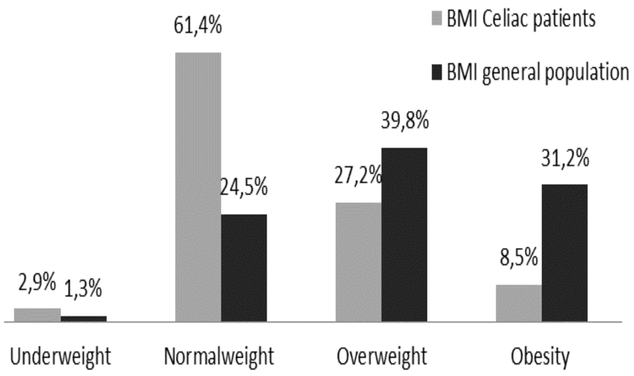


Figure 1. BMI in celiac patients and healthy population

3.2. Foods Consumed and Frequency of Consumption

Table 1 shows foods consumption. Although all patients were advised GFD, 2.8% declared to consume voluntarily gluten containing bread; 35.2% consumed non-traditional pseudo cereals at least once a week and only 11.2% declared consuming gluten-free pasta (mainly due to their high cost). White and red meats and legumes were the main proteins consumed. Among gluten-free foods, 53.6% declared consumption of gluten-free bread daily and 35.1% gluten-free cereals at least once per week. Ninety-three percent consumed 1-3 times weekly high sugar gluten-free products.

Table 1. Foods consumed and frequency of total consumption

Food groups		1 per day n (%)	1-3 per week n (%)	4-6 per week n (%)	1-2 per month n (%)	Never n (%)
Dairy	Milk (full)	6 (8.5)	5 (7.0)	0	0	59 (83.1)
	Yoghourt (full milk)	4 (5.6)	8 (11.3)	6 (8.5)	0	53 (74.6)
	Cheese	0 (0.0)	26 (36.6)	13 (18.3)	2 (2.8)	24 (33.8)
	Half-fat milk Skim milk	14 (19.7)	12 (16.9)	8 (11.3)	0	30 (42.3)
	Yoghourt (diet)	8 (11.3)	14 (19.7)	10 (14.1)	0	38 (53.5)
	Fresh cheese	1 (1.4)	16 (22.5)	4 (5.6)	3 (4.2)	47 (66.3)
Fruits & vegetables	Fruits	7 (9.9)	12 (16.9)	13 (18.3)	0	2 (2.8)
	Fruit juice (natural)	3 (4.2)	19 (26.8)	9 (12.7)	1 (1.4)	36 (50.7)
	Vegetables	21 (29.6)	9 (12.6)	18 (25.4)	0	0
Bread & Biscuits	Bread (White)	0	1 (1.4)	0	1 (1.4)	69 (97.2)
	Gluten-free bread	19 (26.8)	13 (18.3)	13 (18.3)	1 (1.4)	6 (8.4)
	Cereals (breakfast) (with wheat)	0	0	0	1 (1.4)	70 (98.6)
	Cereals (breakfast) (gluten-free)	5 (7.1)	19 (26.8)	4 (5.6)	2 (2.8)	40 (56.3)
	Biscuits (with wheat)	0	0	0	0	71 (100.0)
	Biscuits (gluten-free)	8 (11.3)	32 (45.1)	9 (12.7)	4 (5.6)	14 (19.7)
Cereals	Potatoes	5 (7.0)	53 (74.7)	9 (12.7)	0	3 (4.2)
	Rice	5 (7.0)	32 (45.1)	28 (39.5)	0	1 (1.4)
	Pasta (gluten-free, n=10)	0	8 (100.0)	0	0	0
	Quinoa/ Amaranth	1 (1.4)	23 (32.4)	1 (1.4)	10 (11.3)	37 (52.1)
Meats, eggs & legumes	Legumes	0	55 (77.5)	1 (1.4)	3 (4.2)	12 (16.9)
	Meat (white)	1 (1.4)	56 (78.9)	11 (15.5)	1 (1.4)	0
	Meat (red)	0	54 (76.0)	8 (11.3)	1 (1.4)	8 (11.3)
	Fish	0	45 (63.4)	1 (1.4)	9 (12.7)	16 (22.5)
	Eggs (n=62)	3 (4.8)	29 (46.7)	21 (33.9)	1 (1.6)	4 (6.5)
	Ham & sausages	5 (7.0)	23 (32.4)	14 (19.7)	2 (2.8)	24 (33.9)
Oils & fat	Mayonnaise & butter	12 (16.9)	30 (42.3)	11 (15.5)	4 (5.6)	9 (12.7)
	Oil	61 (85.9)	1 (1.4)	1 (1.4)	0	0
	Fat rich foods	19 (27.1)	22 (31.4)	20 (28.6)	2 (2.8)	1 (1.4)
Sugars	Soda drinks (with sugar)	2 (2.8)	14 (19.8)	5 (7.0)	1 (1.4)	47 (66.2)
	Soda drinks (diet)	1 (1.4)	18 (25.4)	1 (1.4)	1 (1.4)	49 (69.0)
	Other sugary drinks	7 (9.9)	7 (9.9)	4 (6.6)	0	52 (73.2)
	Other diet drinks	0	6 (8.5)	2 (2.8)	0	60 (84.5)
Gluten-free foods	Hotdogs	0	8 (11.3)	0	5 (7.0)	58 (81.7)
	Hamburgers	0	12 (16.9)	0	4 (5.6)	55 (77.5)
	Wheat fried bread	0	3 (4.2)	0	4 (5.6)	65 (91.6)
	French fries (homemade)	0	30 (42.3)	1 (1.4)	18 (25.3)	22 (31.0)
	Snacks (salty)	0	25 (35.2)	1 (1.4)	12 (16.9)	33 (46.0)
	Candies	1 (1.4)	23 (32.4)	2 (2.8)	2 (2.8)	42 (59.3
	Chocolate (gluten-free)	0	23 (32.4)	3 (4.2)	14 (19.7)	31 (43.7)
	Ice cream (gluten-free)	1 (1.4)	22 (31.0)	0	8 (11.3)	40 (56.3)
	Gluten-free bakery	0	21 (29.6)	4 (5.6)	18 (25.4)	28 (39.4)
Other	Tea	14 (19.7)	9 (12.7)	2 (2.8)	0	10 (14.1)
	Coffee	5 (7.0)	6 (8.5)	4 (5.6)	2 (2.8)	41 (59.2)
	Spices	29 (40.9)	16 (22.5)	16 (22.5)	0	10 (14.1)
	Supplements	9 (12.7)	1 (1.4)	2 (2.8)	0	59 (83.1)

Table 2. Nutritional characteristics of gluten-free diet and its contribution to the total caloric value (given by all macronutrients)

	Total energy, macronutrients and PTCI[1]	Nutritional Contribution of GFD to total diet[2]
	Median and Interquartile Rank	Median and Interquartile Rank
Energy (Kcal/d)	2214.8 (1680- 2641)	376 (264.8- 510.2)
Gluten-free foods (%)[2]	---	17.7 (13.3- 21.3)
Proteins (g/d)	76.5 (62.1- 99.9)	8.2 (5.9-12.4)
P (%)[1]	14.1 (12.3- 15.7)	11.6 (7.3- 15.8)
Lipids (g/d)	84.5 (60.9-107.2)	8.6 (5.9- 14.6)
L (%)[1]	35.6 (31.2- 39.4)	11.5 (8.5- 15.7)
Carbohydrates (g/d)	263.4 (219.5 -328.4)	63.2 (43.2- 80.0)
CHO%[1]	49.2 (45.4- 54.8)	23.9 (18.5- 26.7)

[1]PTCI = percentage of each nutrient consumption in relation to total calorie intake, protein (P), lipid (L) and carbohydrate CHO. [2]= percentage of calories given by gluten-free foods to total calorie intake.

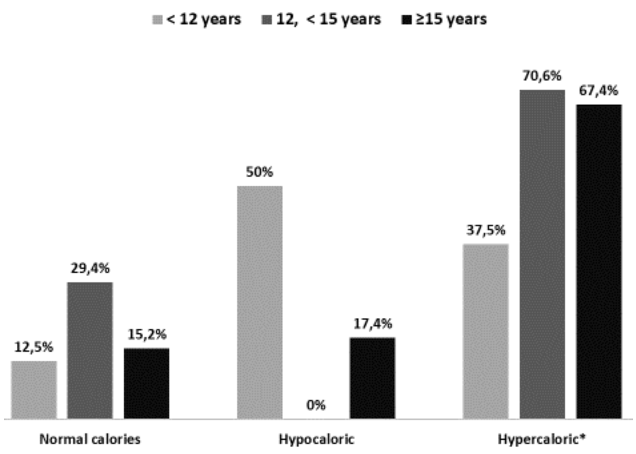
Table 3. Percentage of celiac patients failing to meet recommendations of national alimentary guidelines, calculated based on declared portions of food ingested daily

Recommended intake[1]	patients (%)
Vegetables (3 portions/day)	69 (97.2%)
Fruits (2 portions/day)	28 (39.4%)
Vegetables & fruits (5 portions/day)	49 (69.0%)
Dairy products (3 portions/day) (Skim Milk and half-fat milk)	63 (88.7%)
Fish (twice per week)	52 (73.2%)
Legumes (twice per week)	23 (31.4%)

[1] Comparison to Reference Nutritional Intake (RNI).

3.3. Diet Nutritional Quality

Table 2 shows the energy and macronutrients intake and the gluten-free foods contribution to the total diet. Comparisons of specific foodstuff against the National Nutritional Guidelines showed that few were close to meet recommendations (Table 3); for example, less than 3% and 15% consumed at least three portions daily of vegetables and dairy products, respectively. Legumes consumption (68.6%) was the closest to recommendations while for vegetables and fruits, only 31% declared consuming 5 portions per day as suggested by WHO [29,30].



* Statistical significance= P< 0.05.

Figure 2. Caloric intake by years of education

When each individual mean daily intake was compared to his/her individual requirements, in 65% of the study group the dietary intake was over 110% for calories, proteins, lipids and carbohydrate individual requirement. Analysis of the relation between caloric intake and educational levels showed that the greater educational level the higher caloric intake ($P<0.05$, Figure 2). Analysis of macronutrients' intake by nutritional status showed differences only in the obese group, where individuals had significantly higher frequency of hyperproteic intake ($P<0.05\%$).

3.4. Food Security

When asked how they chose what to buy, 89% of patients declare to look for the gluten-free logo or a statement explicitly declaring the gluten-free condition of the product, while 11% based their decision by only reading the ingredients appearing in the package. Despite these answers, during the interview that collected FFQ data, the stated behaviors proved correct only in 64.6% of cases. In view of this discrepancy, we analyzed separately the percentage of times that those most frequently naturally gluten-free foods were consumed safely (Table 4).

Table 4. Percentage of times of safe food consumption

Foods[1]	Intake n (%)	Safe[2] consumption n (%)
Legumes	(54)76.1	9 /54 (16.7)
Meat	70 (98.6)	52/70 (74.3)
Ham & sausages	48 (67.6)	39/48 (81.3)
Bakery	49 (69.0)	38 /49 (77.5)
Nuts	45 (63.4)	20/45 (44.4)
Spices	45 (63.4)	20/45 (44.4)
Tea	62 (87.3)	34/62 (54.8)
Coffee	30 (42.3)	4/30 (13.3)

[1] Eight most frequently consumed naturally gluten-free foods, which may be contaminated during processing, distribution or preparation. [2]Safe consumption defined as looking for the gluten-free logo or a statement explicitly declaring the gluten-free condition.

4. Discussion

The mean daily diet consumed by the participants classified as hypoglucidic and hyperlipidic following FAO/OMS (2003) criteria, but it was over 110% for calories, proteins, lipids and carbohydrate in 65% of cases when calculated according to each individual's requirements. Data on complete diet reported from

Slovenian celiac women and Spanish celiac men, also describe their diets as hypoglucidic and hyperlipidic

[31,32]. Our results are relevant considering that they refer to the total diet consumed and not only the gluten-free foods, as assessed by most studies [10,11,33]. For example, Wu et al assessed breads and flour based on foods availability [33]. Misbach et al reported consumption of bread and gluten-free flours among celiac patients and apparently healthy population [10] while Valitutti et al gluten-free cereals consumed by celiac patients versus gluten containing cereals consumed by non-celiac controls [11].

It is interesting that gluten-free foods, contributed 17.7% to the total dietary energy, with 11.6%, 11.5% and 63.2% corresponding to protein, lipids and carbohydrates, respectively. Except for carbohydrates, results of this study suggest that gluten-free foods do not have a prominent influence in the celiac patient's diet. Higher cost of GFF may contribute to these findings, but unfortunately, this protocol does not allow analyzing this issue any further. The higher representation of carbohydrates may be related to the high consumption of bread described in Chile [34], where mean annual bread consumption is described at 90-96 kg per person per year [35]. Quantitative analysis of energy shows that while total daily energy intake was 11% over recommendation (2214 vs 2000 Kcal/day) [36], GFF contributed 16.9% (376 kcal) to the total diet. This means that Chilean women would consume 19.8% more energy than Spanish women [37]. Protein intake represented 14.1% (76.5 g/day) of total calorie intake, figure not different from that reported for Chilean general population [38] and in Spanish women [37]. GFF provided 10.7% of the total daily protein intake, but it is relevant that these proteins were of poor biologic quality, a characteristic also reported in previous studies [10]. Gluten-free bread deserves an especial comment. It provides a mean 2.4g protein per portion, equivalent to 54.5% less protein than that provided by gluten containing bread (data not shown). A recent study in the UK describes that protein content was significantly lower in gluten-free white and brown breads ($p<0.001$) and pasta ($p < 0.001$) [13], which coincides with reports from Australia that describe 32% and 52% less protein in breads and pasta, respectively [33]. Mean daily lipid intake was high (84.5 g/day or 35.6% of the total calorie intake) and GFF corresponded to 8.6g/day, (11.5% of the total calorie intake), which concurs with data by Churruca [37] and Gonzalez in Spanish women and men, respectively [32]. As for carbohydrate intake, if we consider that FAO/WHO criteria define 55-75% of the total calorie intake as adequate, our results classify as hypoglucidic (49.2%), but they are 36.9% higher than Churruca's findings in Spain. In addition, although GFF represents only 11.4% of the total calorie intake, this finding is higher than in that of the Spanish study mentioned (3%).

Comparison against the national data available [26,27] shows that dairy products are poorly consumed both by celiac patients and healthy Chilean population, especially defatted dairy products (21.8% and 44.1%, respectively). Dairy consumption appears low too when compared with data by Churruca [37] and Gonzalez [32]; this latter found that 87% consumed dairy products and nearly half fulfilled dietary recommendations. Fruits, legumes and vegetables show higher consumption among celiac patients when compared with general local population data [32]. We may speculate that, being chronic patients, celiac persons are under periodic medical control and this may favor better education on nutrition. As expected, our data differ in some aspects from some reported from other countries [31,32,37], showing that diverse cultural dietary habits indeed influence daily diets, including a gluten-free diet.

A limitation to this study is that due to lack of nutritional information provided in package labels, only sodium could be analyzed among the minerals and vitamins section. Of the processed foods analyzed, only hamburgers provided high sodium content (>400 mg per portion), while biscuits, cereals, sweets, snacks, chocolates and ice creams were low in sodium (< 35 mg per portions) [39] (data not shown). As for gluten-free breads, these contributed with a mean 255.6±166,9mg Na/day (320± 71,7mg/100g), representing 50.7% less than the mean sodium content in regular local breads ($p<0.000$) [40]. These results concur with data by Missbach et al, who found 388,4 ± 206,4 mg /100g in gluten-free bread vs 581,9 ± 290,3 mg/100 g in gluten containing breads ($p <0,05$) [10]. Tres et al found sodium content of gluten-free bread was higher and more variable than that present in gluten containing bread. The values of this latter group ranged from 0.34 to 0.57 g Na/100 g while in the former these values ranged from 0.28 to 0.75 g Na/100 g. Interestingly, in the gluten-free group there were both the highest and the lowest sodium contents [41].

It is relevant to emphasize our findings on the nutritional status in the celiac group assessed. That 35.7% were overweight defies the historical idea that celiac patients are underweight. At the same time, when compared to the general Chilean population (ENS 2016- 2017) [26,27], patients show better nutritional status, with fewer cases under and over nourished (Figure 1). These findings contrast though with those published by Churruca et al (2015), who described a higher proportion of eutrophic patients, fewer cases with overweight and no obesity [37]. Taking waist circumference as an indicator of cardiovascular risk, this risk appears lower than figures described nationwide in the local general population (50% vs 73.8%); however, this issue deserves attention considering that recently published data describe that the frequency metabolic syndrome tends to increase after one year on gluten-free diet [42] and in this study duration of GFD was variable.

5. Conclusions

Results show that GFD, expressed as the mean for the group assessed was normocaloric, normoproteic, hyperlipidic and hypoglucidic (FAO/WHO); however, when calculations were based for each individuals' requirements, 65% of cases consumed excess calories, proteins and carbohydrates.

Representation of gluten-free foods in the total diet was less than expected (17.7%, 11.6%, 11.5% and 23.9% of the total daily intake of calories, protein, lipids, and carbohydrates, respectively).

GFF was characterized by having a low protein content.

Diet quality of celiac patients assessed was better than that described in the country general population.

The nutritional status in celiac patients is better than in the general population, with absence of moderate-severe undernutrition and overweight/obesity.

Author's Statements

All authors of this paper have read and approved the final version submitted. The authors declare no conflict of interest. All authors contributed equally to this work.

References

[1] Freeman HJ. Dietary compliance in celiac disease. World J Gastroenterol [Internet]. 2017 Apr 21 [cited 2020 Sep 18]; 23(15): 2635-9.

[2] Clappison E, Hadjivassiliou M, Zis P. Psychiatric manifestations of coeliac disease, a systematic review and meta-analysis. Nutrients [Internet]. 2020 Jan 1 [cited 2020 Sep 18]; 12(1). Available from: /pmc/articles/PMC7019223/?report=abstract.

[3] Antiga E, Maglie R, Quintarelli L, Verdelli A, Bonciani D, Bonciolini V, et al. Dermatitis herpetiformis: Novel perspectives. Front Immunol [Internet]. 2019 [cited 2020 Sep 18];10(JUN):1290. Available from: /pmc/articles/PMC6579917/?report=abstract.

[4] Sapone A, Bai JC, Ciacci C, Dolinsek J, Green PHR, Hadjivassiliou M, et al. Spectrum of gluten-related disorders: Consensus on new nomenclature and classification. BMC Med [Internet]. 2012 Feb 7 [cited 2020 Sep 18]; 10: 13. Available from: /pmc/articles/PMC3292448/?report=abstract.

[5] Roszkowska A, Pawlicka M, Mroczek A, Bałabuszek K, Nieradko-Iwanicka B. Non-celiac gluten sensitivity: A review. Med [Internet]. 2019 Jun 1 [cited 2020 Sep 18]; 55(6). Available from: /pmc/articles/PMC6630947/?report=abstract.

[6] Pinto-Sanchez MI, Bai JC. Toward New Paradigms in the Follow Up of Adult Patients With Celiac Disease on a Gluten-Free Diet [Internet]. Vol. 6, Frontiers in Nutrition. Frontiers Media S.A.; 2019 [cited 2020 Oct 18]. p. 153.

[7] Muhammad H, Reeves S, Ishaq S, Mayberry J, Jeanes YM. Adherence to a gluten free diet is associated with receiving gluten free foods on prescription and understanding food labelling. Nutrients [Internet]. 2017 Jul 1 [cited 2020 Sep 18]; 9(7).

[8] Tye-Din JA, Galipeau HJ, Agardh D. Celiac disease: A review of current concepts in pathogenesis, prevention, and novel therapies. Front Pediatr [Internet]. 2018 [cited 2020 Sep 18]; 6: 350.

[9] Dieterich W, Zopf Y. Gluten and FODMAPS-sense of a restriction/when is restriction necessary? Nutrients [Internet]. 2019 Aug 1 [cited 2020 Sep 19]; 11(8).

[10] Missbach B, Schwingshackl L, Billmann A, Mystek A, Hickelsberger M, Bauer G, et al. Gluten-free food database: The nutritional quality and cost of packaged gluten-free foods. PeerJ [Internet]. 2015 [cited 2020 Sep 18]; 2015(10).

[11] Valitutti F, Iorfida D, Anania C, Trovato CM, Montuori M, Cucchiara S, et al. Cereal consumption among subjects with celiac disease: A snapshot for nutritional considerations. Nutrients [Internet]. 2017 Apr 18 [cited 2020 Sep 20]; 9(4).

[12] Yorulmaz E, Fındık N, Aksoy M, Akbayrak R, Genç G, Yorulmaz H. Perception of Disease and Coping Attitudes in Patients with Celiac Disease. Int J Celiac Dis [Internet]. 2019; 7(1): 1-8.

[13] Allen B, Orfila C. The availability and nutritional adequacy of gluten-free bread and pasta. Nutrients [Internet]. 2018 Oct 1 [cited 2020 Sep 20]; 10(10).

[14] Melini V, Melini F. Gluten-free diet: Gaps and needs for a healthier diet. Nutrients [Internet]. 2019 Jan 1 [cited 2020 Sep 19]; 11(1). Available from: /pmc/articles/PMC6357014/?report=abstract.

[15] Marshall JK. The burden of celiac disease in Canada: More work needed to lighten the load [Internet]. Vol. 27, Canadian Journal of Gastroenterology. Pulsus Group Inc.; 2013 [cited 2020 Sep 20]. p. 448.

[16] Ballestero Fernández C, Varela-Moreiras G, Úbeda N, Alonso-Aperte E. Nutritional status in Spanish children and adolescents with celiac disease on a gluten free diet compared to non-celiac disease controls. Nutrients [Internet]. 2019 Oct 1 [cited 2020 Sep 18]; 11(10).

[17] Caio G, Volta U, Sapone A, Leffler DA, De Giorgio R, Catassi C, et al. Celiac disease: A comprehensive current review. BMC Med [Internet]. 2019 Jul 23 [cited 2020 Sep 18]; 17(1). Available from: /pmc/articles/PMC6647104/?report=abstract.

[18] Tovoli F, Negrini G, Farì R, Guidetti E, Faggiano C, Napoli L, et al. Increased risk of nonalcoholic fatty liver disease in patients with coeliac disease on a gluten-free diet: beyond traditional metabolic factors. Aliment Pharmacol Ther [Internet]. 2018 Sep 1 [cited 2020 Sep 20]; 48(5): 538-46.

[19] Rinninella E, Cintoni M, Raoul P, Lopetuso LR, Scaldaferri F, Pulcini G, et al. Food components and dietary habits: Keys for a healthy gut microbiota composition [Internet]. Vol. 11, Nutrients. MDPI AG; 2019 [cited 2020 Oct 18]. Available from: /pmc/articles/PMC6835969/?report=abstract.

[20] Mazzeo T, Cauzzi S, Brighenti F, Pellegrini N. The development of a composition database of gluten-free products. Public Health Nutr [Internet]. 2015 [cited 2020 Sep 20]; 18(8): 1353-7.

[21] Rubio-Tapia A, Hill ID, Kelly CP, Calderwood AH, Murray JA. ACG clinical guidelines: Diagnosis and management of celiac disease. Am J Gastroenterol [Internet]. 2013 May [cited 2020 Oct 29]; 108(5): 656-76.

[22] Husby S, Koletzko S, Korponay-Szabó IR, Mearin ML, Phillips A, Shamir R, et al. European Society for Pediatric Gastroenterology, Hepatology, and Nutrition Guidelines for the Diagnosis of Coeliac Disease. J Pediatr Gastroenterol Nutr [Internet]. 2012 Jan [cited 2020 Oct 29]; 54(1): 136-60.

[23] Food and Agriculture O of the UN. Dietary Assessment a Resource Guide to Method Selection and Application in low Resource Settings. 2018.

[24] Escobar PC, Lerma JC, Marín DH, Aliaga ED, Simó EM, Miquel BP, et al. Development and validation of two food frecuency questionnaires to assess gluten intake in children up to 36 months of age. Nutr Hosp. 2015;32(5):2080-90.

[25] Shim J-S, Oh K, Kim HC. Dietary assessment methods in epidemiologic studies. Epidemiol Health [Internet]. 2014 Jul 22 [cited 2020 Sep 21]; 36: e2014009.

[26] Ministerio de Salud. Gobierno de Chile. Encuesta Nacional de Salud 2016-2017 Primeros resultados. Departamento de Epidemiología, División de Planificación Sanitaria, Subsecretaría de Salud Pública. 2017.

[27] Ministerio de Salud. Gobierno de Chile. Encuesta nacional de salud 2016-2017 Segunda entrega de resultados [Internet]. Departamento de Epidemiología, División de Planificación Sanitaria, Subsecretaría de Salud Pública. 2018. Available from: http://www.ipsuss.cl/ipsuss/site/artic/20171122/asocfile/20171122142253/ens_2016_17_primeros_resultados.pdf.

[28] Series FF and NTR. Human energy requirements. Vol. 0. 2001.

[29] WHO. Fomento del consumo mundial de frutas y verduras [Internet]. Available from: https://www.who.int/dietphysicalactivity/fruit/es/.

[30] Asociación 5 al día. Dosier de información frutas y hortalizas frescas 5 al día [Internet]. Available from: https://www.5aldia.org/datos/60/1585207549_1584701573_DOSSIER DE INFORMACIÓN_OK_CON PRECIOS.pdf.

[31] Mijatov MAK, Mičetić-Turk D. Dietary intake in adult female coeliac disease patients in Slovenia. Zdr Varst [Internet]. 2016 Feb 1 [cited 2020 Sep 21]; 55(2): 86-93.

[32] González T, Larretxi I, Vitoria JC, Castaño L, Simón E, Churruca I, et al. Celiac male's gluten-free diet profile: Comparison to that of the control population and celiac women. Nutrients [Internet]. 2018 Nov 8 [cited 2020 Sep 21]; 10(11). Available from: /pmc/articles/PMC6266148/?report=abstract.

[33] Wu JHY, Neal B, Trevena H, Crino M, Stuart-Smith W, Faulkner-Hogg K, et al. Are gluten-free foods healthier than non-gluten-free foods? An evaluation of supermarket products in Australia. Br J Nutr [Internet]. 2015 Aug 14 [cited 2020 Sep 21]; 114(3): 448-54.

[34] Valentino G, Acevedo M, Villablanca C, Álamos M, Orellana L, Adasme M, et al. La ingesta de "once", en reemplazo de la cena, se asocia al riesgo de presentar síndrome metabólico. Rev Med Chil [Internet]. 2019 [cited 2020 Sep 22];147(6): 693-703.

[35] TVN 24 horas. Chile se consagra como el segundo país que más consume pan a nivel mundial [Internet]. 31-07-2019. Available from: https://www.24horas.cl/nacional/chile-se-consagra-como-el-segundo-pais-que-mas-consume-pan-a-nivel-mundial-3492060#:~:text=Después de Turquía%2C los chilenos,carácter artesanal y más saludable.&text=Después de Turquía%2C Chile es,de 90 kilos al año.

[36] Subsecretaría de Salud Pública D de PPS y PD de N y A. INFORME FINAL "ESTUDIO PARA REVISIÓN Y ACTUALIZACIÓN DE LAS GUÍAS ALIMENTARIAS PARA LA POBLACIÓN CHILENA " 16 de mayo 2013. Informe. 2013.

[37] Churruca I, Miranda J, Lasa A, Bustamante M, Larretxi I, Simon E. Analysis of body composition and food habits of Spanish celiac women. Nutrients [Internet]. 2015 Jul 8 [cited 2020 Sep 21]; 7(7): 5515-31.

[38] Facultad de medicina F de economía y negocios. U de C. Encuesta Nacional de Consumo Alimentario. I n forme Final. 2014.

[39] Ministerio de Salud. Gobierno de Chile. Manual De Etiquetado Nutricional De Alimentos [Internet]. Minsal. 2017. Available from: https://www.minsal.cl/wp-content/uploads/2018/01/Manual-Etiquetado-Nutricional-Ed.-Minsal-2017v2.pdf.

[40] Aguilera P X, López S C, Rodriguez F A, Sanhueza R X, Atalah S E, Parra F J. Contenido de sodio en pan elaborado en panaderia de distribución nacional y comparado con una panadería local en la ciudad de Chillán de Chile. Rev Chil Nutr [Internet]. 2014; 41(2): 161-6.

[41] Tres A, Tarnovska N, Varona E, Quintanilla-Casas B, Vichi S, Gibert A, et al. Determination and Comparison of the Lipid Profile and Sodium Content of Gluten-Free and Gluten-Containing Breads from the Spanish Market. Plant Foods Hum Nutr [Internet]. 2020 Sep 2 [cited 2020 Sep 23];75(3): 344-54.

[42] El Khoury D, Balfour-Ducharme S, Joye IJ. A review on the gluten-free diet: Technological and nutritional challenges. Nutrients [Internet]. 2018 Oct 2 [cited 2020 Sep 18]; 10(10). Available from: /pmc/articles/PMC6213115/?report=abstract.

© The Author(s) 2021. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (http://creativecommons.org/licenses/by/4.0/).