

We are IntechOpen, the world's leading publisher of Open Access books Built by scientists, for scientists

4,800

Open access books available

122,000

International authors and editors

135M

Downloads

Our authors are among the

154

Countries delivered to

TOP 1%

most cited scientists

12.2%

Contributors from top 500 universities



WEB OF SCIENCE™

Selection of our books indexed in the Book Citation Index
in Web of Science™ Core Collection (BKCI)

Interested in publishing with us?
Contact book.department@intechopen.com

Numbers displayed above are based on latest data collected.

For more information visit www.intechopen.com



Are Gluten-Free Foods Just for Patients with a Gluten-Related Disease?

Ana María Calderón de la Barca and
Maria Esther Mejía-León

Additional information is available at the end of the chapter

<http://dx.doi.org/10.5772/67523>

Abstract

Gluten, the set of wheat proteins that gives properties for food processing, is the cause of celiac disease (CD), and patients require a gluten-free diet lifelong. There are other bad-called gluten-related diseases as non-celiac gluten sensitivity and irritable bowel syndrome, for which triggering compounds are unknown, while wheat allergies and carbohydrate intolerances are associated with other wheat proteins and fructans, respectively. The boundaries of each disease are not clear, inducing confusion for diagnosis and dilemma about the right diet. Nowadays, the people who are currently in a gluten-free diet exceed several times the expected number of those requiring dietary gluten exclusion. It is because people consider themselves as affected and dangerously decide to self-diagnose as gluten intolerant and adopt a gluten-free diet. The alternative compounds used in gluten-free foods to obtain the technological properties given by gluten could induce problems in some disease conditions or lead to undernutrition especially in children and adolescents. It is because some gluten-free foodstuffs are limited in vitamins and minerals and contain more fat and sodium than their conventional wheat analogues. Therefore, gluten-free is not a good option for persons without diagnosis; it should be understood as a therapy, prescribed and followed by specialists.

Keywords: gluten-free, celiac disease, gluten-/wheat-related diseases, industrialized food products

1. Introduction

Gluten, the set of proteins that gives technological properties for bread making and other multiple processes, has been recognized since more than 60 years as the cause of celiac disease (CD).

Gluten/wheat is also the cause of other disorders such as wheat allergies and more recently non-celiac gluten/wheat sensitivity [1]. Treatment of these conditions requires gluten/wheat dietary restriction. Gluten-/wheat-related disorders are more frequent now than a couple of decades ago; nowadays, their global prevalence is estimated by 5% [2]. However, due to their highly variable clinical expression, an important proportion of patients could be undetected. Considering this prevalence, the proportion of people who are currently on a gluten-free diet exceeds in more than five times the number of those who require gluten exclusion as a treatment for a diagnosed medical reason [3].

There are reports that about 30% of American people would like to eliminate gluten from their diet and the reasons are wide, perhaps influenced by misunderstood propaganda. Consumers stand out the idea that gluten-free products are healthier or that gluten-free diet would help them to lose weight and to improve their mental health or because symptoms they attribute to ingestion of wheat-containing foods [4, 5]. However, does the intake of gluten-free products really offer those benefits? And especially, is the gluten-free diet safe if auto-administered, or is it an adequate food regimen to be adopted by healthy people in the long term?

In this chapter, we discuss the main indications for a gluten-free diet and refer the current trends in food industry related to gluten-free foods market. Finally, we try to clarify the main benefits, disadvantages and metabolic risks that a gluten-free diet represents for patients with different bowel inflammation diseases or for other way healthy people without a medical diagnosis.

2. The gluten-free diet and the gluten-/wheat-related diseases

2.1. The intricate spectrum of gluten-/wheat-related diseases

Celiac disease is an immune-mediated disease that affects the small intestine, precipitated by dietary gluten in genetically predisposed persons [6]. Patients suffering from this condition develop flattening and atrophy of intestinal villi, decreasing the absorption surface, and therefore there are reduction of digestive enzymes bound to membrane and poor absorption of vitamins and minerals. As a result, in addition to gastrointestinal manifestations, extra-intestinal alterations such as iron deficiency anaemia, loss of bone density and hormonal and skin disorders can be common components of celiac disease [7].

In spite of the recognition since so many years, until recently celiac disease was considered rare in the South American population and even inexistent in the Asian population. It is because of its association with the HLA-DQ2 genotype that is present in more than 95% of white European celiac patients, in which the expressed molecule is needed, but not sufficient for developing the enteropathy. Currently, it is well known that the Amerindian people expressing HLA-DQ8 haplotype alone or in combination with an HLA-DQ2 allele could suffer celiac disease [8, 9]. More recently, Wang et al. [10] found that Asian individuals with HLA-DQ9.3 are also prone to celiac disease.

Celiac disease prevalence has increased worldwide between 1 and 2% in general population during last decades, possibly due to that is better known and diagnosed and/or to changes in lifestyles, including more acceptance of the high wheat content of the occidental diet, in the last years [7].

In addition to celiac disease, there are wheat allergies with pathogenesis mechanisms well studied, and they have been characterized since long time ago [1]. According to the route of wheat exposure, they are classified as occupational asthma, rhinitis, hives, wheat-dependent exercise-induced anaphylaxis as well as food allergy that can manifest at the skin, gastrointestinal or respiratory level [1]. The common feature of wheat allergies is that they are IgE-mediated conditions and that their symptoms appear in minutes or up to 2 h after ingestion of wheat. It usually occurs in young children with a history of atopy, in whom gastrointestinal symptoms dominate, while in older people, the expression is dermatitis, respiratory disorders and, in extreme cases, anaphylaxis [11].

Since 2012, a new clinical entity related to the ingestion of gluten-containing food emerged as non-celiac gluten sensitivity, characterized by intestinal and extra-intestinal symptoms [12]. Because of the unknown pathogenesis of such gluten sensitivity, there are no biomarkers for diagnosis but exclusion of either celiac disease or wheat allergy [13]. The terminology non-celiac gluten sensitivity is a matter of debate because patients describe symptoms after ingestion of wheat products but the causative compound is unknown; therefore, it should be called non-celiac wheat sensitivity or just wheat sensitivity or wheat intolerance.

To identify specific sensitivity to wheat compounds, a strict exclusion of dietary wheat (including gluten) should be done and then two different challenges using purified wheat without gluten or gluten alone, to evaluate symptoms [13, 14]. However, an additional trouble for result interpretation could be that some non-gluten wheat proteins such as serpins, purinins, α -amylase/protease inhibitors, globulins and farinins are also antigens involved in the celiac disease humoral immune response [15].

On the other hand, irritable bowel disease, considered the prototype of all functional intestinal disorders, has a high prevalence among adults. Its diagnosis relies upon symptoms evaluation according to the Rome III criteria, because there are no specific biomarkers identified yet [14]. Its symptoms are exacerbated by food ingestion especially wheat, recognized as one of the relevant triggers. However, the responsible component among gluten, non-gluten proteins or fructans is unknown because all of them coexist in wheat and may induce symptoms associated with intestinal inflammation in human beings. Fructans belonging to fermentable oligo-, di- and monosaccharides and polyols (FODMAP) are compounds that elicit the clinical picture of irritable bowel syndrome, found in addition to wheat, in several dietary items, as some vegetables and fruits [14].

Therefore, as related to gluten- and/or wheat-related diseases, there are a wide spectrum including celiac disease, non-celiac gluten (or wheat) sensitivity, wheat allergies, FODMAP intolerance and other functional bowel diseases. The boundaries of each wheat-related disease are not always clear, inducing confusion regarding diagnosis [6] and dilemma on which diet and treatment should be applied [14]. In that way, it is not surprising that many people

in developed countries decide by themselves to follow a gluten-free diet; only 15–16% of such diet followers have a medical diagnosis and prescribed treatment of gluten or wheat exclusion [16].

2.2. Gluten-free market and regulation of gluten-free foods

According to the *Codex Alimentarius* [17], the International Food Standards, foods for special dietary uses are “those foods which are specially processed or formulated to satisfy particular dietary requirements which exist because of a particular physical or physiological condition and/or specific diseases and disorders and which are presented as such” (Codex standard 146-1985; last modified: 2009). Additionally, there is a special standard for gluten-free foods defined as “foods for special dietary uses that have been formulated, processed or prepared to meet the special dietary needs of people intolerant to gluten” (Codex standard 118-1979; last modified 2015).

The former definitions mean that unlike foods for special medical purposes, which should be prescribed and supervised by medical doctors, gluten-free foods for special dietary uses do not need any prescription to buy them. They are commercially available, not only for gluten-intolerant individuals but also for any consumer which voluntary follows a gluten-free diet or eventually buy some of these popular products [18]. Nowadays, due to marketing strategies and trends related to healthy foods, as well as self-diagnosis of gluten-/wheat-related disorders, an important part of the population in developed countries is following a gluten-free diet. This diet is currently one of the three most popular food regimen in the world along with the low-carbohydrate and fat-free diets [5].

The trends have boosted the gluten-free and reduced-gluten foodstuffs market over the world. However, the boost of gluten-free foods is peaking because sales of gluten-free products grew more than 30% annually between 2010 and 2014. In the United States (USA), sales increased 47–86% (according to the source) between 2012 and 2013 [19, 20], while the growth was just 6% from 2015 to 2016 [19]. More than two years ago, the reason for eating gluten-free foods were 51% for improved health, 38% to feel better and 27% to lose weight; only 6% followed a medical-prescribed gluten-free diet [20]. In 2016 just 10% think gluten-free foods help to manage their weight, and few people consider that gluten-free foods are higher in quality than those with gluten, probably because people are better informed [19]. However, the market cost of gluten-free foods is still very important, reaching \$1328 million of American dollars in 2016 [19].

Additionally, the *Codex Alimentarius* [17] indicates that foods made from naturally gluten-free ingredients or ingredients specially processed to remove gluten should contain no more than 20 mg/kg of gluten and foods specially processed to reduce gluten should content between 20 and 100 mg/kg, which is a decision determined at the national level. Thus, the actual gluten intake in a strict gluten-free diet, consuming 0.5–1.0 kg of labelled foods, is about 10–20 mg/day, while eating a reduced-gluten diet can accomplish up to 100 mg/day. It is not expected to eat more than 1 kg/day of labelled gluten-free foods because dietary intake includes other non-labelled as gluten-free as fresh fruits and vegetables.

The complete exclusion of dietary gluten is almost impossible due to the ubiquitous nature of gluten in industrialized foods, cross-contamination and inadequate food labelling. Therefore, the actual problem of celiac disease patients sometimes diagnosed as refractory to treatment, because symptoms do not abate, is the consumption of unknown gluten content of some called gluten-free foods. For instance, a study was carried out in the USA analysing 275 gluten-free-labelled foods and 186 non-labelled as gluten-free without wheat, rye or barley. Three of the gluten-free labelled (1.1%) were mislabelled, meaning almost 99% of compliance, while 36 out of 186 of non-wheat containing had more than 20 ppm of gluten, and 19 of them were higher than 100 mg/kg of gluten [21].

According to the Food and Drug Administration (FDA) of the USA [22], the labelled gluten-free foods that include “wheat” in the ingredient list as wheat starch, either before or after hydrolysis (glucose syrup or maltodextrin), should specify in the label that wheat has been processed to remove gluten according to the FDA regulation. This is because while these products are safe for celiac disease patients, these could be risky for people with any other wheat-related disease.

2.3. Health effects and safety considerations of gluten-free products

Currently, to prepare gluten-free bakery products, ingredients such as rice and corn flour, mixed with hydrocolloids and enriched with milk, egg or soybean proteins, are used [23]. In addition, there are alternative grains used as buckwheat, amaranth, quinoa and teff, as well as different starch sources as these of potato and cassava. To improve the overall quality of the products, enzymes as microbial transglutaminase and proteases are used [24]. The European Food Information Council (EUFIC) and the FDA of the USA recognize all of the cited food additives as safe; also, different regulations accept them as gluten-free. However, some of them could affect the health of patients with gluten-/wheat-related and/or other gastrointestinal diseases.

Some of the food additives as emulsifiers and microbial transglutaminase could alter the integrity of tight junctions between the epithelial cells of the small intestine, increasing the paracellular intestinal permeability. Tight junction dysfunction or “leaky gut barrier” is a common feature in several autoimmune disease pathogenesis such as celiac disease and type 1 diabetes [6, 25]. It is because the opened tight junctions allow the entry of dietary antigens and trigger an immune cascade that can lead to autoimmunity in susceptible people [26]. Furthermore, leaky gut barrier function and immune activation are also important factors associated with irritable bowel disease. In this syndrome, the ingested food components can induce infiltration and activation of mast cells after passing the gut barrier, leading to the development of symptoms [14].

The problem is that a considerable proportion of the general population consider themselves as affected due to symptoms and dangerously decide to self-diagnose with gluten or wheat intolerance or sensitivity and adopt self-prescribed diets [27]. Even more, the non-celiac gluten or wheat sensitivity described in adults has little evidence in children, with no data supporting the health benefits of a gluten-free diet. If the children follow a gluten-free diet

without guidance of an experienced nutritionist or physician, it can lead to unbalanced nutrition and health complications [28].

Another additive used in gluten-free foodstuffs is inulin-type fructans because of their prebiotic properties which provide structure and gas retention during baking. Its addition to the mix dough improves the quality of gluten-free bread, enhances sensorial acceptance and increases the fibre content, reducing glycaemic response and inducing a better nutritional quality [29]. Furthermore, to help to improve the decreased calcium absorption of patients with celiac disease, the gluten-free bread can be fortified and added with inulin-type fructans increasing calcium bio-availability [30]. However, for patients with irritable bowel disease and/or FODMAP-intolerant people consuming such gluten-free bread added with fructans, its intake could be a problem.

The transglutaminase family is a set of enzymes capable to bind a protein chain with other one, through covalent bonds, inducing a net formation. If there is no amino acid residue with an amino lateral in each two neighbour chains, transglutaminases release the amino radical, producing glutamate instead glutamine, for instance, in a called deamidation process. The microbial transglutaminase (mTG) is widely used in the food industry, especially for industrially processed products that naturally do not contain gluten as well as in gluten-free bakery products for enhancing quality. Its addition simplifies the elaboration processes and reduces the production cost while improves the texture, elasticity and appearance and even reduces the caloric content. However, the products of the enzymatic activity and homology of mTG with the human tissue transglutaminase (tTG), a key component in celiac disease pathogenesis because of its deamidation capacity, could elicit the exacerbated immune response of celiac patients.

The enzyme mTG can deamidate/transamidate gluten in the same way as tTG does and can change the protein antigenicity leading to a higher antigenic load [31]. Regarding this, Dekking et al. [32] found that gluten-specific T cells recognize gluten peptides deamidated by mTG, so they recommend that patients with celiac disease should avoid the consumption of products containing it, in order to control the disease. In another study, the reactivity of IgA of celiac patients against prolamins of wheat and gluten-free breads (maize and rice flours), mTG-treated or not, was evaluated. Sera pool from celiac patients presented IgA higher titres against prolamins of mTG-treated wheat or gluten-free breads than against mTG-untreated ones. The electrophoretic pattern of gluten-free bread prolamins was modified by the mTG treatment, and a new 31 kDa band originated in maize was recognized by IgA of some patients with CD [33].

Therefore, some additives of the gluten-free foods can induce negative effects for patients with different wheat-related diseases and even for those with celiac disease depending of the added compounds. The gluten-free food formulations should be carefully designed to prevent complications as described above.

2.4. Nutrition quality of the gluten-free diet

A recognized problem associated with gluten-free diets is that it could induce nutritional imbalance, especially in children. Gluten-free cookies and some sweet products at

the Italian market have more than 20% of fat, and 7.5% of them are saturated fat [34]. In addition, gluten-free products contain less vitamins and minerals and frequently have lower protein content than the wheat-containing food products. It is because wheat flours are fortified with vitamins and minerals in several countries; hence, alternative flours for gluten-free foods should be also fortified. Despite this, most of the gluten-free products commercially available are not fortified, and those already fortified premium products are not widely available and have higher costs that are not accessible to the majority of consumers [35].

In addition to other limiting issues, gluten-free breads had a higher glycaemic index than the conventional gluten-containing breads according to the results of a comparison of 20 commercial breads of the major European brands [24]. Formerly, Mazzeo et al. [34] published a food composition database including 60 gluten-free food representatives of different categories sold on the Italian market (more than 50% of them are distributed all over Europe). Almost all the gluten-free products were high in available carbohydrates, with approximately 50% of sugar content in cookies, breakfast and sweet products, which results in a high glycaemic load when consumed.

However, due to their hydrocolloid content, half of the Italian gluten-free foods formerly described presented a dietary fibre content at least of 3% [34]. In contrast, Vici et al. [36] in a wide review between 1990 and 2015 found gluten-free diet to be poor in fibre due to avoidance of grains and because products are usually made with starches and/or refined flours. Coinciding with them, Estevez et al. [35] found, when analysing the basic basket of gluten-free products available in Chile, that regular wheat-based foods like biscuits and noodles contain 50% more fibre than their gluten-free equivalents, which also contain 24% less protein, on average. In addition, dairy products, like gluten-free cheese and yogurts, can have up to 52.4% more sodium than the regular ones.

All these compositional characteristics of gluten-free products have a direct impact for evaluation of diet as a whole. Thus, in another study in Spain [37], the average diets of 58 adults with celiac disease were analysed, finding that women in this regimen tend to decrease the consumption of protein and fibre, increasing fat, while men increase their intake of animal protein, compensating the excluded protein from cereals. In both genres, the authors detected an increase in the total caloric intake when comparing to a similar diet composed of regular foods.

As stated by Pellegrini and Agostoni [18], the gluten-free foods should improve their nutritional quality to decrease the risk of later chronic degenerative disorders.

To follow a strict gluten-free diet is a broad dietary change, which can be associated with several risks. Nutritional inadequacy of this diet can compromise the intake of minerals, especially in children and adolescents. The gluten-free diet can be associated with reduction of fibre intake because patients elude wheat and other cereal fibre sources. The lack of fortification can affect health and quality of life, increasing the risk of anaemia, osteoporosis and constipation, mainly in patients whose disease, which includes deficient intestinal absorption, already predisposes them to these complications.

All of the previous comments together do not mean that the gluten-free diet was a bad choice. As shown in **Table 1**, for people with diagnosed celiac disease, the dietary gluten exclusions are the only treatment option to avoid and/or reduce symptoms and prevent complications in the medium and long term. Even for individuals with wheat allergy, non-celiac gluten/wheat sensitivity and intestinal bowel syndrome, except for those with FODMAP intolerance who need additional dietary changes, the gluten-free diet could be able to reduce gastrointestinal symptoms because the gluten-free foods do not contain wheat with its triggering compounds.

Figure 1 shows a hypothetical design to discriminate among the wheat components possibly related to each wheat-related disease, for dietary recommendation. Therefore, if were possible to know the type of compounds responsible or related to non-celiac gluten/wheat sensitivity and irritable bowel syndrome, the gluten-free diet could be not the best treatment for patients suffering from such diseases. In many cases, a low FODMAP diet may offer a higher chance of symptomatic response; however, the gluten-free diet involves attacking a specific pathogenic factor for celiac disease based in its pathogenesis mechanism. If the injurious nature of other wheat proteins is part of the genesis of visceral hypersensitivity or other gut-related physiological changes, it is very important to look for the key compound to design the right diet [14].

Due to the technological difficulty for obtaining high-quality gluten-free products and to their lower market demand than their conventional food counterparts, they can be up to 300% more expensive [35]. Therefore, an option for people with gluten-related disorders is the home preparation of foods from unprocessed sources to devise a balanced gluten-free diet. Anyway, it is highly recommended to follow the nutritionists or medical specialist instructions as well as to do the periodic analysis of the nutritional status, especially for children, adolescents and risk persons, to maintain the best balance.

After the previous discussion, it is clear that the gluten-free diet is not a good option for persons without diagnosis of gluten hypersensitivity, especially when it relies in the abuse of industrialized products. If healthy people decide to follow a gluten-free diet because they consider it is healthier or fashionable, they should be very careful to accomplish the nutrition balance.

Advantages	Disadvantages	Risks
<ul style="list-style-type: none"> • Control of celiac disease, correcting the intestinal absorption problems • Prevents chronic celiac disease complications • Reduce gastrointestinal symptoms triggered by wheat in wheat allergy, non-celiac sensitivity and irritable bowel syndrome 	<ul style="list-style-type: none"> • Unbalance of some nutrients if not well supervised • High costs • Difficult to socialize, social stigma • Palatability • Poor variety and nutritious quality 	<ul style="list-style-type: none"> • Malnutrition • Chronic diseases related to lack of vitamins, minerals and fibre and excess of fat and sodium • Development of eating disorders • Difficult for celiac disease diagnosis and other diseases if self-administrated

Table 1. Characteristics of the gluten-free diet.

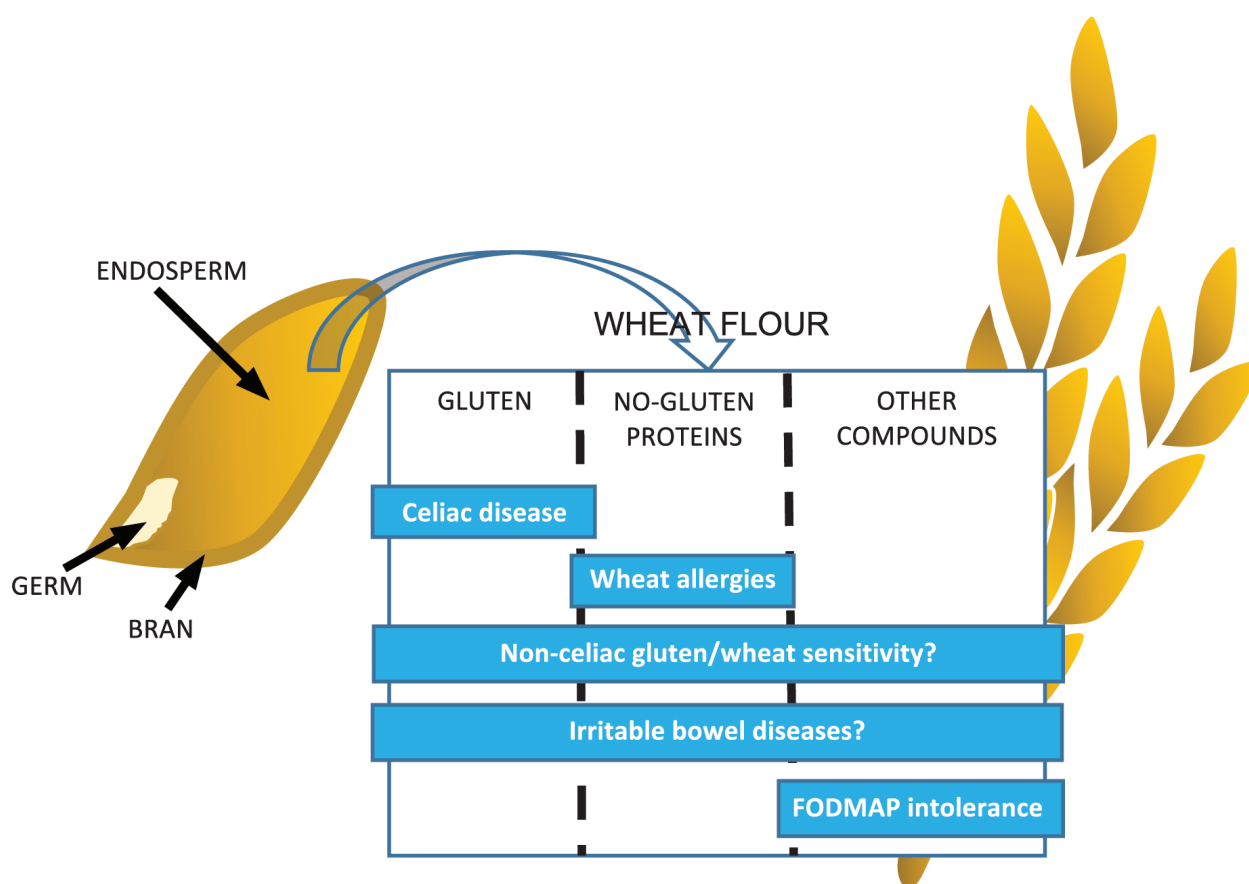


Figure 1. Hypothetic design to discriminate among the wheat components possibly related to each wheat-related disease, for dietary recommendation.

2.5. Gluten-free diet as a therapy and as a self-prescribed food regimen

The differential diagnosis of the actual disease among gluten-/wheat-related disorders has important prognostic and therapeutic implications for the patient. An undiagnosed celiac disease in children may result in growth restriction, emaciation, osteoporosis, dental problems and in acute cases electrolyte imbalance and hypocalcaemia that can be life-threatening [38]. In contrast, following a gluten-free diet in the absence of symptoms or diagnosis might mask underlying diseases.

In the last decade, due to easier access to information, self-diagnosis of gluten-/wheat-related disorders has increased, and because there is more wide availability of gluten-free foods, many people follow a gluten-free diet. This implies that one person recognizes his own symptoms and without medical advice associates them with any of the previously described diseases. Subsequently, one adopts the gluten-free diet looking for improvement. This can generate benefits in the short term in those cases where the symptoms decrease. Golley et al. [16] published a study of 1184 Australians surveyed from the general population, where 10.6% were already on a gluten-free diet, while just 1.2% of them had formal diagnosis of celiac disease. However, 80% of the followers do to relieve symptoms such as bloating, abdominal discomfort, asthenia and adynamia. Perhaps the placebo effect is part of these results while a strict following was not registered.

Self-prescription of gluten-free diet may cause unsuccessful medical diagnosis because gluten consumption is necessary to obtain an accurate and reliable blood test and biopsy. When the patient is already on a gluten-free diet, a challenge with gluten is done for a long time before performing the diagnostic test [39].

Having a medical diagnosis influences the type of diet to follow, for example, gluten-free, wheat-free or restricted in FODMAP (**Figure 1**). In addition, depending on the nature of the disease, the duration of treatment may differ between being temporary or required lifelong as for celiac disease. Favourably, a diagnosis can bring relief to a person, eliminates uncertainty, generates social acceptance, facilitates adherence to the diet and can help convince the family about the importance of the diet and the negative consequences of lack of attachment [39].

Some followers of the gluten-free diet do not have gastrointestinal symptoms and decide to enrol in a gluten-restricted regimen for other causes. In the Golley study [16], this subgroup represents up to 20% of the people in a gluten-free diet, referring reasons such as having a family member with celiac disease, personal taste or preference. In the USA, the main reason to follow a gluten-restricted diet is that people believed that gluten-free industrialized products were healthier than regular ones [40]. Although it is changing nowadays, the market cost of gluten-free foods is still extremely high, which means that there are so many undiagnosed people following a gluten-free diet.

The fact that such a large proportion of the population is in such gluten-free–restrictive regimen forces health personnel to be alert and well informed about the nutritional adequacy of the gluten-free diet in general, in order to guide and counsel this special group. Healthy people on a gluten-free diet may unnecessarily limit the variety and quality of their diet [41]. Believing that these products are healthier or considering them suitable for weight loss can cause an overconsumption of gluten-free energy-rich and nutrient-poor products and could result in the opposite way, promoting weight gain [42].

A new aspect in gluten-related disease and gluten-free diet is the intestinal microbiota. The gut microbiota and its products play an important role in the pathophysiology of celiac disease, and dietary composition can modulate the structure of microbiota. Bonder et al. [5] found that in healthy people, the gluten-free diet did not induce major inflammatory or metabolic changes in gut function after 1-month intervention, in contrast to people with celiac disease. However, they observed a decrease in the proportion of *Veillonellaceae*, considered a pro-inflammatory family frequently reported in patients with inflammatory bowel syndrome. Possibly, it could be another reason explaining why the gluten-free diet benefits this group of patients.

A current very common practice in athletes is to follow the gluten-free diet, perhaps influenced by news about a famous tennis player with celiac disease diagnosed five years ago. According to Lis et al. [43], more than 40% of endurance athletes follow it at least half the time. They consider the idea that these foods, in addition to being healthier and useful for controlling their weight, relieve systemic inflammation and improve athletic performance. However, the double-blind, placebo-controlled, crossover study by Lis et al. [43], in 13 competitive cyclists,

found neither positive nor negative effects on performance, gastrointestinal symptoms or systemic inflammation measured as cytokine responses: IL1A, IL-6, IL-8, IL-10, IL-15 and tumour necrosis factor alpha. For all these reasons, it is recommended that athletes seek nutritional advice to ensure that their diet meets the special requirements that their sport implies, before deciding to start a gluten-free plan.

3. Conclusion

Due to the global epidemic of malnutrition, where extreme problems such as obesity and emaciation prevail together, public health policies should implement a promotion to increase the consumption of real healthy foods, such as whole grains, fresh fruits and vegetables, and reduce the consumption of discretionary foods [41].

Thus, the awareness of gluten effects on healthy and diagnosed individuals is summarized in that a gluten-free diet should be understood as a therapy and therefore only to be prescribed and supervised by specialists. Finally, to eat occasionally a gluten-free foodstuff does not need any prescription but money to buy it.

Author details

Ana María Calderón de la Barca* and Maria Esther Mejía-León

*Address all correspondence to: amc@ciad.mx

Centro de Investigación en Alimentación y Desarrollo, A. C., Hermosillo, Sonora, Mexico

References

- [1] Elli L, Branchi F, Tomba C, Villalta D, Norsa L, Ferretti F, et al. Diagnosis of gluten related disorders: celiac disease, wheat allergy and non-celiac gluten sensitivity. *World J Gastroenterol.* 2015;**21**:7110–7119. DOI: 10.3748/wjg.v21.i23.7110
- [2] Sapone A, Bai JC, Ciacci C, Dolinsek J, Green PH, Hadjivassiliou M, et al. Spectrum of gluten-related disorders: consensus on new nomenclature and classification. *BMC Med.* 2012;**10**:13. DOI: 10.1186/1741-7015-10-13
- [3] Catassi C, Bai JC, Bonaz B, Bouma G, Calabrò A, Carroccio A, et al. Non-celiac gluten sensitivity: the new frontier of gluten related disorders. *Nutrients.* 2013;**5**:3839–3853. DOI: 10.3390/nu5103839
- [4] Gaesser GA and Angadi SS. Navigating the gluten-free boom. *JAAPA.* 2016;**28**:1–7. DOI: 10.1097/01.JAA.0000469434.67572.a4

- [5] Bonder MJ, Tigchelaar EF, Cai X, Trynka G, Cenit MC, Hrdlickova B, et al. The influence of a short-term gluten-free diet on the human gut microbiome. *Genome Med.* 2016;**8**:45. DOI: 10.1186/s13073-016-0295-y
- [6] Ludvigsson JF, Leffler DA, Bai JC, Biagi F, Fasano A, Green PHR, et al. The Oslo definitions for celiac disease and related terms. *Gut.* 2013;**62**:43–52. DOI: 10.1136/gutjnl-2011-301346
- [7] Rubio-Tapia A, Hill ID, Kelly CP, Calderwood AH, Murray JA. ACG clinical guidelines: diagnosis and management of celiac disease. *Am J Gastroenterol.* 2013;**108**:656–676. DOI: 10.1038/ajg.2013.79
- [8] Araya M, Mondragon A, Perez-Bravo F, Roessler JL, Alarcon T, Rios G, et al. Celiac disease in a Chilean population carrying Amerindian traits. *J Pediatr Gastroenterol Nutr.* 2000;**31**:381–386.
- [9] Mejía-León ME and Calderón de la Barca AM. HLA-DQ genetic risk gradient for type 1 diabetes and celiac disease in Northwest Mexico. *Rev Gastroenterol Méx.* 2015;**80**:135–143. DOI: 10.1016/j.rgm.2015.03.003
- [10] Wang H, Zhou G, Luo L, Crusius JBA, Yuan A, Kou J, et al. Serological screening for celiac disease in adult Chinese patients with diarrhea predominant irritable bowel syndrome. *Medicine (Baltimore).* 2015;**94**:e1779. DOI: 10.1097/MD.0000000000001779.
- [11] Czaja-Bulsa G and Bulsa M. What do we know now about IgE-mediated wheat allergy in children?. *Nutrients.* 2017;**9**:35. DOI: 10.20944/preprints201612.0132.v1
- [12] Carroccio A, Mansueto P, Iacono G, Soresi M, D'Alcamo A, Cavataio F, et al. Non-celiac wheat sensitivity diagnosed by double-blind placebo-controlled challenge: exploring a new clinical entity. *Am J Gastroenterol.* 2012;**107**:1898–1906. DOI: 10.1038/ajg.2012.236.
- [13] Catassi C, Elli L, Bonaz B, Bouma G, Carroccio A, Castillejo G. Diagnosis of non-celiac gluten sensitivity (NCGS): the Salerno experts' criteria. *Nutrients.* 2015;**7**:4966–4977. DOI: 10.3390/nu7064966
- [14] De Giorgio R, Volta U, Gibson PR. Sensitivity to wheat, gluten and FODMAPs in IBS: facts or fiction?. *Gut.* 2016;**65**:169–178. DOI: 10.1136/gutjnl-2015-309757
- [15] Huebener S, Tanaka CK, Uhde M, Zone JJ, Vensel WH, Kasarda DD, et al. Specific non-gluten proteins of wheat are novel target antigens in celiac disease humoral response. *J Proteome Res.* 2015;**14**:503–511. DOI: 10.1021/pr500809b
- [16] Golley S, Corsini N, Topping D, Morell M, Mohr P. Motivations for avoiding wheat consumption in Australia: results from a population survey. *Public Health Nutr.* 2014;**18**:490–499. DOI: 10.1017/S1368980014000652
- [17] WHO/FAO. Codex Alimentarius: Food Labelling. 5th Edition. Rome, 2007. ISBN 978-92-5-105840-4. Available from: ftp://ftp.fao.org/codex/Publications/Booklets/Labelling/Labelling_2007_EN.pdf (Accessed 02/15/2017).
- [18] Pellegrini N and Agostoni C. Nutritional aspects of gluten-free products. *J Sci Food Agric.* 2015;**95**:2380–2385. DOI: 10.1002/jsfa.7101

- [19] Nunes K. Beyond the peak: What's next for gluten-free foods?. Available from: FoodBusinessNews.net, Oct. 6, 2016. (Accessed 02/15/2017)
- [20] Gelski J. Getting a grip on gluten-free growth. Available from: FoodBusinessNews.net, Jul. 24, 2015. (Accessed 02/15/2017)
- [21] Sharma GM, Pereira M, Williams KM. Gluten detection in foods available in the United States – a market survey. *Food Chem.* 2015;**169**:120–126. DOI: 10.1016/j.foodchem.2014.07.134
- [22] US Food and Drug Administration. Federal Register. Final Rule; Document 78 FR 47154: Food labelling; gluten-free labelling of foods. Vol. 78, No. 150, Aug. 5, 2013. Available from: <https://www.federalregister.gov/articles/2013/08/05/2013-18813/food-labeling-glutenfree-labeling-of-foods>. (Accessed 02/15/2017).
- [23] Mir SA, Shah MA, Naik HR, Zargar IA. Influence of hydrocolloids on dough handling and technological properties of gluten-free breads. *Trends Food Sci Technol.* 2016;**51**:49–57. DOI: 10.1016/j.tifs.2016.03.005
- [24] Conte P, Fadda C, Piga A and Collar C. Techno-functional and nutritional performance of commercial breads available in Europe. *Food Sci Technol Int.* 2016;**22**:621–633. DOI: 10.1177/1082013216637724
- [25] Davis-Richardson A, Triplett E. A model for the role of gut bacteria in the development of autoimmunity for type 1 diabetes. *Diabetologia.* 2015;**58**:1386–1393. DOI: 10.1007/s00125-015-3614-8
- [26] Lerner A and Matthias T. Changes in intestinal tight junction permeability associated with industrial food additives explain the rising incidence of autoimmune disease. *Autoimmun Rev.* 2015;**14**:479–489.
- [27] Caio G, Riegler G, Patturelli M, Facchiano A, De Magistris L, Sapone A. Pathophysiology of non-celiac gluten sensitivity: where are we now in 2016?. *Minerva Gastroenterol Dietol.* 2016;**63**:16–21. DOI: 10.23736/S1121-421X.16.02346-1.
- [28] Reilly NR. The gluten-free diet: recognizing fact, fiction, and fad. *The J Pediatr.* 2016;**175**:206–210. DOI: 10.1016/j.jpeds.2016.04.014
- [29] Capriles VD, Arêas JA. Effects of prebiotic inulin-type fructans on structure, quality, sensory acceptance and glycemic response of gluten-free breads. *Food Funct.* 2013;**4**:104–110. DOI: 10.1039/c2fo10283h
- [30] Krupa-Kozak U, Świętecka D, Bączek N, Brzóska MM. Inulin and fructo-oligosaccharide affect in vitro calcium uptake and absorption from calcium-enriched gluten-free bread. *Food Funct.* 2016;**7**:1950–1958. DOI: 10.1039/c6fo00140h
- [31] Lerner A and Matthias T. Possible association between celiac disease and bacterial transglutaminase in food processing: a hypothesis. *Nutr Rev.* 2015;**73**:544–552. DOI: 10.1093/nutrit/nuv011

- [32] Dekking EHA, Van Veblen PA, de Ru A, et al. Microbial transglutaminases generate T cell stimulatory epitopes involved in celiac disease. *J Cereal Sci.* 2008;**47**:339–346. DOI: 10.1016/j.jcs.2007.05.004
- [33] Cabrera-Chávez F, Rouzaud-Sández O, Sotelo-Cruz N, Calderón de la Barca AM. Transglutaminase treatment of wheat and maize prolamins of bread increases the serum IgA reactivity of celiac disease patients. *J Agric Food Chem.* 2008;**56**:1387–1391. DOI: 10.1021/jf0724163.
- [34] Mazzeo T, Cauzzi S, Brighenti F and Pellegrini N. The development of a composition database of gluten-free products. *Public Health Nutr.* 2014;**18**:1353–1357. DOI: 10.1017/S1368980014001682
- [35] Estevez V, Ayala J, Vespa C, Araya M. The gluten-free basic food basket: a problem of availability, cost and nutritional composition. *Eur J Clin Nutr.* 2016;**70**:1215–1217. DOI: 10.1038/ejcn.2016.139
- [36] Vici G, Belli L, Biondi M, Polzonetti V. Gluten free diet and nutrient deficiencies: a review. *Clin Nutr.* 2016;**35**:1236–1241. DOI: 10.1016/j.clnu.2016.05.002
- [37] Miranda J, Lasa A, Bustamante MA, Churruca I, Simon E. Nutritional differences between a gluten-free diet and a diet containing equivalent products with gluten. *Plant Foods Hum Nutr.* 2014;**69**:182–187. DOI: 10.1007/s11130-014-0410-4
- [38] Sotelo N, Calderón de la Barca AM, Hurtado JG. Celiac disease in children from the northwest of Mexico: clinical characteristics of 24 cases. *Rev Gastroenterol Mex.* 2013;**78**:211–218. DOI: 10.1016/j.rgmex.2013.07.005
- [39] Copelton DA, Valle G. “You don’t need a prescription to go gluten-free”: the scientific self-diagnosis of celiac disease. *Soc Sci Med.* 2009;**69**:623–631. DOI: 10.1016/j.socscimed.2009.05.012
- [40] The NPD Group. Percentage of U.S. adults trying to cut down or avoid gluten in their diets reaches new high in 2013, reports NPD, Chicago, March 6, 2013. Available from: <https://www.npd.com/wps/portal/npd/us/news/press-releases/percentage-of-us-adults-trying-to-cut-down-or-avoid-gluten-in-their-diets-reaches-new-high-in-2013-reports-npd/> (Accessed 02/15/2017).
- [41] 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.* 2015;**114**:448–454. DOI: 10.1017/S0007114515002056
- [42] Staudacher HM, Gibson PR. How healthy is a gluten-free diet?. *Br J Nutr.* 2015;**114**:1539–1541. DOI: 10.1017/S000711451500330X
- [43] Lis D, Stellingwerff T, Kitic CM, Ahuja KDK, Fell J. No effects of a short-term gluten-free diet on performance in nonceliac athletes. *Med Sci Sports Exerc.* 2015;**47**:2563–2570. DOI: 10.1249/MSS.000000000000069