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SHORT REPORT

The effect of substituting alternative grains in the diet on the nutritional profile of the gluten-free diet

A. R. Lee, D. L. Ng, E. Dave, E. J. Ciaccio & P. H. R. Green

Celiac Disease Center, Department of Medicine, Columbia University, New York, USA

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Correspondence
Anne R Lee, Director of Nutritional Services, Schär USA, 7 B Dean's Court, Santa Fe, NM 87508, USA.
Tel.: +1 505 474 2992
Fax: +1 505 424 3531
E-mail: anne.lee@schar.com

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Abstract

Background: The only treatment for coeliac disease is lifelong adherence to a gluten-free diet. Several studies have reported nutritional deficiencies in individuals on a gluten-free diet. The present study aimed to determine whether the nutritional profile of gluten-free diet could be improved through the use of alternative grains.

Methods: A retrospective review of diet history records by a celiac specialist dietitian were used to establish a 'standard' gluten-free dietary pattern. An 'alternative' gluten-free dietary pattern was developed that substituted naturally gluten-free grains or gluten-free products made from 'alternative' flours (oats, high fibre gluten-free bread and quinoa) in the standard pattern. A paired *t*-test was performed to identify statistical significance between the 'alternative' and standard gluten-free dietary pattern.

Results: Analysis of standard pattern indicated that 38% of meals and snacks contained no grain or starch choice. Of those meals that contained a grain or starch component, rice was the grain chosen 44% of the time. The inclusion of alternative grains or grain products provided a higher nutrient profile compared to the standard gluten-free dietary pattern ($P = 0.002$). Several nutrients; protein (20.6 g versus 11 g), iron (18.4 mg versus 1.4 mg), calcium (182 mg versus 0 mg) and fibre (12.7 g versus 5 g) were significantly increased by changing the grain or starch component in the dietary pattern. The B vitamin content (riboflavin, niacin and folate) was improved, although this was not statistically significant ($P = 0.125$).

Discussion: The inclusion of alternative grain-based products increased the nutrient profile of the gluten-free dietary pattern significantly.

Introduction

Coeliac disease is an autoimmune disorder that occurs in genetically predisposed individuals subsequent to the inclusion of gluten in the diet. The resultant inflammatory response in the intestine generally results in villous atrophy, autoantibody production and systemic effects. Some individuals experience gastrointestinal symptoms, whereas other remain asymptomatic. Coeliac disease was once thought to be a rare childhood disorder, but it is now recognised to affect approximately 1% of the population worldwide (Green & Cellier, 2007).

Gluten is used as the generic term for the storage protein component of wheat, rye and barley. Different grains have different protein sequences, thus rendering them as either toxic or safe for individuals with coeliac disease. Oats do not share the same prolamine sequence as wheat, rye and barley, and therefore are not considered toxic. However, there is a percentage of the population with celiac disease who are sensitive to avenin, the specific protein found in oats. Other studies have demonstrated no intestinal reaction to the inclusion of oats in the gluten-free diet (Kilmartin *et al.*, 2003). In a systematic review of literature on oat inclusion in the gluten-free diet Haboubi *et al.* (2006) concluded that most patients are able to tolerate oats because there were no significant differences between the oat study group and the controls on biopsy, villous height to crypt ratio, or serology. The other concern with regard to oat

inclusion in the gluten-free diet is the potential for cross contamination because of frequent contact with wheat during the harvesting, milling and processing (Kasarda, 2001; Thompson 2004). In some studies, the inclusion of oats has been linked to an increased acceptance of the gluten-free diet with no negative effect on the intestinal biopsy (Janatuinen *et al.*, 1995; Peraaho *et al.*, 2004). In a study by Peraaho *et al.* (2004) it was noted that the inclusion of oats would increase the variety and nutrient content of the gluten-free diet.

Recent studies have shown some nutritional inadequacies associated with the gluten-free diet (Thompson, 2000; Hallert *et al.*, 2002; Dickey & Kearney, 2006). As the only treatment for coeliac disease remains the gluten-free diet, this raises a concern over the long-term health of individuals with coeliac disease. In one study (Thompson, 2000) it was demonstrated that many of the gluten-free products were not enriched, fortified or naturally rich sources of folate, iron, or fibre. In another study (Thompson *et al.*, 2005), it was demonstrated that 37% of males and 79% of females did not meet the recommended amount of grain servings per day. The USDA through the Food Guide Pyramid (USDA; accessed February 2009) recommends six to 11 servings from the grain/bread/starch group per day to meet the daily recommended intake for B complex vitamins and fibre. In the same study, most of the female participants did not meet recommended nutrient intakes. Of the female participants, only 44% met their recommended intake for iron, 46% for fibre, and only 31% met their recommended intake of calcium. In a further study, Hallert *et al.* (2002) demonstrated nutritional deficiencies of individuals on the gluten-free diet in 56% of the study participants, despite biopsy proven remission. It was shown that the quantity of bread consumed in the study population was similar to the control population; however, the gluten-free bread provided less folate per serving (Hallert *et al.*, 2002). In another study, Dickey & Kearney (2006) further describe nutritional concerns of the gluten-free diet. In that study, 81% of the population gained weight when on the gluten-free diet. The concern over the weight gain lies in the fact that 90% of the study population were at normal weight or with a body mass index (BMI) > 20 at diagnosis. Of the study population that was obese, 82% gained more weight. The present study aimed to determine whether the nutrient profile of the gluten-free diet could be improved by the substitution of alternative grains.

Materials and methods

The nutritional intakes of fifty randomly selected patients were retrospectively reviewed by the coeliac specialist dietitian. The 3-day usual intakes were written down by the patient and brought to a follow-up session with the dietitian. The grain/starch choices were recorded in an Excel spreadsheet (Microsoft Corp., Redmond, WA, USA) by grain category, number of servings of grains and meal at which the grain was consumed. Foods consumed between meals were tabulated as snacks. The number and variety of grains were recorded by meal and snack. The criteria of the Food and Nutrition Service of the USDA was used to define what constituted a meal and a snack (USDA; accessed September 2007). A meal pattern includes serving from each of the groups: protein, dairy, fruit or vegetable, and grain. A snack consists of at least two choices from: protein, dairy, fruit or vegetable, or grain. The consumption patterns from the fifty diet records were used to create one average intake pattern. The 'alternative' gluten-free dietary pattern was developed by substituting only the grain or starch portion of the standard menu pattern with alternative gluten-free grains or grain products. The alternative diet used cereal at breakfast (oats), bread at lunch (high fibre brown rice bread) and a starch side dish for the evening meal (quinoa). These items were chosen based on local availability and nutritional profile of the alternative product and were substituted in a serving per serving ratio. The nutrient composition was tabulated using the USDA food composition data bank (US Department of Agriculture, 2006; accessed September 2007), product web sites and product packaging where necessary. Specifically the content of protein, fat, carbohydrate, fibre, thiamine, riboflavin, niacin, folate, iron and calcium formed the basis of our nutrient comparison between the two menu patterns (Table 1). The study was approved by the Columbia University Institutional Review Board.

Table 1 Comparison of select nutrients of the standard and alternative gluten-free dietary pattern to the daily recommended intake (DRI)

Nutrient	Standard diet pattern	Alternative diet pattern	DRI
Protein (g)	11	20.6	56 males 46 females
Fat (g)	7	13.1	20–35
Fibre (g)	5	12.7	38 males 25 females
Thiamine (mg)	0.65	0.69	1.2 males 1.1 females
Riboflavin (mg)	0.21	0.81	1.3 males 1.1 females
Niacin (mg)	4.5	7.57	16 males 14 females
Folate (μm)	23	150.5	400
Iron (mg)	1.4	18.4	8 males 18 females
Calcium (mg)	0	182	1000

DRI (1998), National Academy of Sciences, Institute of Medicine, Food and Nutrition Board.

Statistical analysis

Statistical analysis was carried out using the SIGMASTAT, version 3.11 (Systat Software, Inc. San Jose, CA, USA) at the Coeliac Disease Centre at Columbia University. Analysis of variance and paired *t*-tests were used to identify statistical significance between 'alternate' and the standard gluten-free dietary patterns.

Results

Only the grain choices were analysed for the nutrient content comparing both the standard and the alternative pattern (Table 1). In analysing only the grain portion of the diet, the impact of changing the source of the grains on the overall nutrient profile could be isolated.

The usual intake of our study participants was similar to findings of Thompson *et al.*, (2005). The standard gluten-free diet pattern did not meet the USDA recommended number of six to 11 grain servings per day. The study population omitted a grain at a meal 39% of the time. The grain variety consumed was also very limited. Rice was used as the grain in 44% of the meals, followed by potato 8%, oats 5% and corn 4%. Buckwheat and quinoa were each used for only one meal. Millet was not selected by any participant for any meal. The usual menu pattern from the fifty subjects consisted of rice cereal at breakfast, white rice or tapioca bread, rice crackers or rice itself at lunch, and rice as a side dish at dinner. Indeed, the diet records revealed that 38% of the grain commonly consumed was white rice, followed by brown rice at 6%, giving a total of 44% of meals comprising rice based grains (Table 2). Interestingly, on 16% of occasions, the meals were omitted completely, and, on 17% of occasions, a snack food was used as the meal. In addition, 55% of the total snacks comprised commercially prepared snack foods, such as chips, pretzels and gluten-free cookies, donuts and cakes.

Table 2 Grain and grain product consumption patterns on the standard gluten-free dietary pattern

Grain	Percentage of meals/snacks
Rice	44
White rice	38
Brown rice	6
Potato	8
Oats	5
Corn	3
Buckwheat	1
Quinoa	1
Millet	0
No grain consumed	38

The standard gluten-free diet did not meet the recommended intake for fibre, thiamine, riboflavin, niacin folate, iron, or calcium (Table 1). The change in dietary grains significantly increased selected nutrient levels in the diet; protein (20.6 g versus 11 g), iron (18.4 mg versus 1.4 mg), calcium (182 mg versus 0 mg) and fibre (12.7 g versus 5 g). The 'alternative diet' provided an improved nutrient profile compared to the standard gluten-free diet ($P = 0.0002$). The comparisons of the nutrient content of the two diets are detailed in Table 1. Although the B complex vitamin portion of the diet (thiamine, riboflavin, niacin and folate) was not statistically different ($P = 0.125$), there were improved values for each vitamin.

Discussion

Historically, research on a gluten-free diet has often focused on which grains (Janatuinen *et al.*, 1995; Peraaho *et al.*, 2004) should be excluded or included. Recent research has focused on the potential nutritional deficits of the gluten-free diet (Hallert *et al.*, 2002; Thompson *et al.*, 2005; Dickey & Kearney, 2006). The focus of the present study was to evaluate the effect of the alternative grains on the nutrient profile of the gluten-free dietary pattern.

By substituting three alternative grains in the place of the standard gluten-free diet menu choices, the nutritional profile of the diet improved. The items for the alternative diet were chosen for three reasons: nutrient profile, availability and cost. One reason noted for the exclusion of this portion of the diet was due to the increased cost of the gluten-free products in the USA. The increased cost of gluten-free foods was confirmed in our recent study that looked at cost and availability across different regions of the USA (Lee *et al.*, 2007). The alternative grains selected provide the specific nutrients that are lower in the standard gluten-free diet menu pattern (Thompson, 2000). This small change positively impacts the nutrient profile of the grain portion of the gluten-free diet. In this analysis, the grain and grain product portion of the diet was the primary focus because the specific nutrient deficiencies noted in earlier studies (Dickey & Kearney, 2006) and the lack of grain consumption (Thompson *et al.*, 2005) can be amended by the inclusion of gluten-free alternative grains and grain products. By adding three servings of gluten-free alternative grains, the nutrients (fibre, thiamine, riboflavin, niacin, folate and iron) are improved (Table 1). By adding the alternative grains, the amount of protein, fat and calories from these foods would also be added to the diet. As noted in the study by Dickey & Kearney (2006), there is a growing concern regarding weight gain in individuals of normal and above BMI when on the gluten-free diet. Attention

should be given to the nutrient benefits of the alternative grains and grain products over the usual choices made on the standard gluten-free dietary pattern of high calorie, low nutrient snack foods and prepared gluten-free bakery products, and be incorporated into the standard gluten-free education session. Even in countries where gluten-free products are available by prescription, adding naturally gluten-free grains can increase the overall nutrient profile of the gluten-free diet.

Changing the grains in the gluten-free diet has the potential to improve the nutritional profile of the diet for individuals with coeliac disease. The grains used in the present study are widely available and often were less expensive. Therefore, altering the grain in the diet could potentially increase dietary compliance by reducing the economic burden of the diet. Because the present study focused only on the nutritional analyses of the two diets, the impact of the alternative pattern on dietary compliance, patient acceptability and long-term nutritional status warrant further study. Patients and their dietary counsellors require education with respect to the value of diversifying the 'standard' gluten-free diet to include the alternative grains. The grains and flours used are widely available in local grocery, health food and upscale markets. The intake pattern of this sample was similar to that reported in the study by Thompson *et al.* (2005) and indicates a wider population trend.

However, the limitations of the present study include a population bias because the diet history records were from individuals attending a large coeliac disease centre. Other limitations include the small sample size, the limited nutritional analysis, and the potential inaccuracies of reported food intakes.

Conflict of Interest, source of funding and authorship

The authors declare that they have no conflict of interests.
This study was conducted without any outside financial support, grants, or donations.
ARL was study guarantor, primary planner, conductor, and drafting of the manuscript. PHRG was involved in planning, drafting and editing of the manuscript. DLN conducted data analysis and input. ED compiled data and was involved in data input. EJC performed the statistical analysis. All authors critically reviewed the manuscript and approved the final version submitted for publication.

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