Green Banana Pasta: An Alternative for Gluten-Free Diets

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ARTICLE INFORMATION

Article history:
Accepted 26 March 2012

Keywords:
Celiac disease
Gluten-free pasta
Green banana flour

2212-2672/$36.00
doi: 10.1016/j.jand.2012.04.002

ABSTRACT

The objective of this study was to develop and analyze a gluten-free pasta made with green banana flour. The study was divided into five steps: preparation/selection, chemical, sensory, technological, and statistical analysis. The modified sample presented greater acceptance (84.5% for celiac individuals and 61.2% for nonceliac) than standard samples (53.6% for nonceliac individuals). There was no significant difference between the modified and the standard samples in terms of appearance, aroma, flavor, and overall quality. The modified pastas presented approximately 98% less lipids. Green bananas are considered a subproduct of low commercial value with little industrial use. The possibility of developing gluten-free products with green banana flour can expand the product supply for people with celiac disease and contribute to a more diverse diet.
J Acad Nutr Diet. 2012;112:1068-1072.

CELIAC DISEASE (CD) IS AN IMMUNOMEDIATED ENteropathy that affects 0.3%[1] to 1.0% of the world population and it is characterized by permanent intolerance to gluten.[2] The only current form of treatment for CD is to remove gluten from the diet. Following a strict gluten-free diet is neither practical nor easy to accomplish because of problems adapting to modified products and difficulties finding gluten-free products on the market.[3]

According to the Celiac Foundation, pasta is one of the products that is most demanded by people with celiac disease (CD).[4] Pasta is traditionally made from wheat products because the consistency and elasticity of the dough depend on the strength of the gluten.[5] The process of removing gluten from nonconventional pasta includes seeking a structure similar to gluten by using technology that explores the functional properties of starch in raw materials, or by adding flours that are rich in protein or other ingredients that have characteristics similar to gluten in food.[6]

Based on the evidence, it is important to search for alternatives that promote characteristics similar to those found in wheat-based preparations, and perfect and develop other food options that would expand product supply and encourage greater acceptance of new food standards by people with CD.[7-9]

The possibility of using green banana flour to produce pasta products allows the possibility of aggregating bioactive compounds, such as resistant starch and phenolic acids,[10] with this product, which is generally missing these nutrients. In addition, using banana flour as a substitute for wheat flour reduces preparation costs,[11] and it can be purchased by the public in a variety of stores.

It is also important to mention that the high quantity of resistant starch in green banana flour (approximately 74% of its composition) might contribute to controlling glycemic indexes, cholesterol, gastric fullness, intestinal regularity, and fermentation by intestinal bacteria, producing short-chain fatty acids that can prevent cancer in intestinal cells.[12]

Considering that untreated CD promotes cancer in intestinal cells, a highly inflammatory mucosal status, and several nutrient deficiencies, and that oxidative stress is an important factor in its pathogenesis,[13] developing gluten-free pasta products with bioactive compounds such as the ones present in green banana flour is very important for CD patients. Therefore, the objective of this study was to develop gluten-free pasta made with green banana flour.

METHODS

This study takes an exploratory and quantitative approach that was divided into the following steps: preparation of pasta samples, chemical analysis, technological analysis, sensory analysis of the products, and statistical analysis of the data achieved. The pasta sample with green banana flour was developed, and another pasta sample made from wheat was used as the standard for comparison.

Materials

Whole-wheat flour (12% protein, Vitao), fresh whole eggs (Qualita), green banana flour (Inutri), egg whites (Qualita), guar gum (Gastronomylab), and xanthan gum (Gastronomylab) were all purchased locally.

Pasta Preparation

For the whole-wheat pasta preparation, the chosen recipe contained whole-wheat flour (60.6%) and whole egg (39.4%). Green banana flour (47.0%), egg whites (31.5%), water (16.4%), guar gum (2.5%), and xanthan gum (2.5%) were used to make the green banana pasta. Both doughs followed the same protocols for preparation of low-thickness pasta and fettuccine. Ingredients were mixed for 30 minutes for complete homogenization. Dough was strained in a cylindrical machine (Marcato) and cut into fettuccine strips and then dehydrated in a kiln (Fabbe-Primar) at 140°F for 2 hours. After drying, pastas were cooked in boiling water (207.8°F).

Chemical and Nutritional Analyses

Analyses were done in triplicate to determine moisture by the Adolfo Lutz Institute method,[14] fiber by the Adolfo Lutz Institute method,[14] ash by the Association of Analytical Chemists method,[15] protein by Kjeldahl method,[15] and lipids by the Association of Analytical Chemists method.[15] Carbohydrates were calculated by difference, subtracting the values for moisture, fiber, protein, lipids, and fixed mineral residue from 100. In order to calculate the energy values, the averages of fat, protein, and carbohydrates were multiplied by the Atwater factors. Cooking times were determined by cooking 10 g of samples in 140 mL boiling water. Samples were taken off the water every 30 seconds to evaluate the total gelatinization of starch by pasta compression (American Association of Cereal Chemists method). Cooking times, the coefficients of water absorption (determined by the relation of weight increase after cooking and the dough weight, American Association of Cereal Chemists), the increase in volume (verified by the kerosene volume displaced by 10 g of the product before and after cooking), the loss of soluble solids, stickiness, and firmness (evaluated by Texturometer TA-XT2i; Stable Microsystems) were evaluated to determine the cooking quality of pasta.[16]

Sensory Evaluation

To determine the levels of taster acceptance of the modified preparations, sensory tests were applied using an affective quantitative method with a hedonic scale of nine points (9=extreme like to 1=extreme dislike). These tests were done with 50 untrained tasters (aged between 20 and 32 years; equally divided among men and women) who were not averse to pasta and did not have CD (control group) and with 25 CD patients (aged between 19 and 41 years; 40% men and 60% women). The CD patients were recruited randomly among the CD group of the Brasília University Hospital and the control subjects were employees of a public institution in Brasilia. The tests were held from 9:30 AM to 11:00 AM. The attributes that were evaluated were appearance, aroma, flavor, texture, and overall quality of the product.

Subjects received 20 g of each cooked pasta sample on identical-coded white plastic 20-cm plates. Subjects were advised to drink water at room temperature (approximately 25°C) between the analyses of each sample.

Statistical Analyses

Subsequently, percentages and averages of acceptance were calculated, as well as means and standard deviation of all the data. The sensory tests and the technology were analyzed using the STATISTICA 6.0 program. Analysis of variance statistics were applied using a minimum significant difference test (α=5%).

The Institutional Review Board of the University of Brasilia Ethics Commission approved the research (CEP/FS 009/2005).

RESULTS AND DISCUSSION

In developing the modified pastas, replacing wheat flour with green banana flour and substituting the whole eggs for just the egg whites were prioritized, as developed in this study for the green banana flour pasta. These alterations were intended to reduce lipid content and increase the protein value of the modified pasta, because gluten removal causes the loss of an important protein fraction that is responsible for the desirable sensory and technological characteristics of pasta products.

Animal protein products normally used in nonconventional pastas are generally derivatives of milk, fish, or micro-organism–derived proteins. The technological requirements for these ingredients are the perfect initial solubility and the rapid coagulation during thermal treatment (drying or cooking). It is important to note that egg protein, especially egg whites, has a strong influence on the quality of gluten-free pasta products due to its high protein content, which can be coagulated at low heat.[17] The use of egg whites in the green banana flour pasta was important because they present good coagulation, easy access, and low cost. Besides the egg whites, the gums were also included to promote similar gluten characteristics because egg whites do not substitute gluten completely.

The pasta samples were dehydrated in the oven at 140°F for egg white coagulation temperature. It is possible to obtain nonconventional pasta with good quality when protein substances are added to the formula, helping the protein net formation when heat is applied. Therefore, drying pasta at high temperature creates a protein network that envelops the starch during later cooking and prevents its release in the cooking water. In this manner, the pasta is less sticky, which is typical of gluten-free nonconventional pasta. In addition, guar and xanthan gums were used to promote firmness, elasticity, moisture, and uniformity in the pasta, which are characteristics attributed to gluten.

Analyses of the chemical composition of the preparations (Table 1) revealed that modified pasta had decreased levels of lipid content of >98%. Although pasta is not a relevant source of lipids in the diet, this reduction is important to patients with CD who are undergoing treatment, especially because gluten-free preparations typically have high levels of lipid content to technologically compensate for the removal of gluten.[7,18] The developed pasta will not be one of the products that contribute to high fat intake. The combination of increased calorie intake and better nutrient absorption generally leads to excessive weight gain in patients undergoing treatment, which can make continued treatment difficult.[1]

The ash content found in the pasta samples made with green banana flour was 52.7% higher than the quantity of ashes in the other pasta, which can be beneficial in treating nutritional deficiencies caused by CD.[19]

When comparing the green banana flour pasta to the gluten-free pastas made from rice flour and quinoa commercialized in Brazil, it is observed that the green banana flour pasta presents, in a 100-g portion, 83 kcal (Table 2), and the other gluten-free pastas present 135 kcal (label information). In addition, the commercial pastas present the same amount of fiber as the green banana flour pasta, but 52% more carbohydrates and 60% more protein. Green banana flour pasta does not present fat in a portion and the commercial gluten-free pastas present 1 g. With this comparison, it is possible to show the product's relevance to nutritional quality.

Table 1. Chemical composition and cooking characteristics of the pasta samples in a study to develop and analyze a gluten-free pasta made with green banana flour

Parameter	Standard pasta	Green banana pasta
Chemical composition (%)	←——— *mean±standard deviation* ———→	
Moisture	10.81±0.26	11.77±0.67
Lipids	5.74±0.46	0.00±0.00
Protein	19.32±0.14	9.30±0.10
Fibers	3.33±0.22	2.08±0.21
Ash	1.80±0.02	2.75±0.03
Carbohydrates	59.00±0.63	74.10±0.98
Cooking characteristics		
	←——— *minutes* ———→	
Cooking time	6^{y}	8^{z}
	←——— *mean±standard deviation* ———→	
Water absorption (%)	263.23 ± 11.88^{y}	401.73 ± 18.86^{z}
Volume increase (%)	404.76 ± 12.08^{y}	452.38 ± 19.02^{y}
Solids loss (%/mL)	4.48 ± 1.22^{y}	12.75 ± 1.98^{z}
Firmness (gf)	850.00 ± 50.00^{y}	530.00 ± 20.00^{z}
Stickiness (gf)	100.00 ± 30.00^{y}	250.00 ± 60.00^{z}

^{yz}Different letters represent statistical differences between the samples ($P<0.05$). For each analysis, triplicates were used, as well as triplicates for pasta dough production and cooking process.

Table 2. Nutritional evaluation of the pasta samples per 100-g portion in a study to develop and analyze a gluten-free pasta made with green banana flour

Parameter	Standard pasta	Green banana pasta
Energy (kcal)	138.74	83.00
% Energy from fat	14.14	0.00
Fat (g)	2.18	0.00
Protein (g)	7.35	2.32
Carbohydrates (g)	22.43	18.43
Fibers (g)	1.27	0.52

The quantity of fibers in the standard pasta was higher than that found in the modified pastas; it is important to note that green banana flour has almost 50% resistant starch in its composition, which acts similarly to fiber in the body.[20] Due to the lack of an adequate method to determine resistant starch, its content was added to the carbohydrate percentage. Although resistant starch was not quantified, and fiber and resistant starch are different compounds, studies show that fiber and resistant starch (together) would increase 37% in green banana flour. There is considerable interest in the nutritional significance of the forms of resistant starches in foods. Several investigations suggest that resistant starch–rich foods are associated with reduced glycemic responses, with reduced serum lipids in the blood, and intestinal modulation.[21]

The starch and protein content presented in the mixture influenced the firmness and stickiness of the produced pastas (Table 1). The standard pasta became firmer and less sticky when compared with the modified one. Although there were statistically different results among the standard and modified pastas for firmness and stickiness, the differences when the pastas were cooked did not negatively influence the sensorial quality of the analyzed products (Table 3).

It was verified that the cooking time for modified pasta was substantially longer than the cooking time for the standard sample. It is most likely that this longer cooking time also caused greater release of soluble solids in the cooking water. The standard preparation released fewer soluble solids in the water due to its gluten content.

In addition, the green banana pasta showed greater water absorption, which leads to higher yield after cooking, which can, in turn, reduce the cost of the final preparation. Among the evaluated pastas, the standard one presented the lowest percentage of water absorption. The greater water absorption by the green banana flour pasta when compared with the whole wheat probably occurred because of the higher cooking time needed for complete gelatinization of resistant starch.[22]

Percentage calculations and acceptance averages were used to characterize the acceptance of the product. Table 3 shows that, on average, there is no significant difference between the pastas in terms of their appearance, aroma, flavor, and overall quality. However, there was less acceptance of the whole-wheat noodle texture. This result can be explained by the fact that Brazilian consumers tend to overcook pasta.[23] The wheat pasta, the only one to have the viscoelastic network provided by gluten, was possibly considered harder than what is common to the tasters.

Table 3. Acceptance[a] means and percentages of the pasta samples for individuals with or without celiac disease in a study to develop and analyze a gluten-free pasta made with green banana flour

	Standard Pasta	Green Banana Pasta	
	NCD[b] (n=50)	NCD (n=50)	CD[c] (n=25)
	←——— *mean±standard deviation (%)* ———→		
Appearance	5.38±2.08[x] (52)	4.90±1.92[x] (50)	5.96±1.37[x] (68)
Aroma	5.68±2.74[x] (50)	5.92±2.55[x] (56)	6.98±1.13[y] (84)
Flavor	5.72±3.00[x] (56)	5.92±2.22[x](64)	7.56±1.09[y] (92)
Texture	5.46±3.1[x] (50)	6.00±2.68[z] (68)	7.20±1.01[y] (92)
Overall quality	5.93±1.91[x] (60)	6.13±1.68[x] (68)	7.06±1.31[y] (88)

[a]Acceptance range from 9 (most acceptable) to 1 (least acceptable).
[b]NCD=individuals without celiac disease.
[c]CD=individuals with celiac disease.
[xyz]Different letters represent statistical differences between the samples ($P<0.05$).

An analysis of the acceptance percentages demonstrates that the modified pasta received most points in the attributes evaluated than standard pasta for individuals without CD. During sensorial analysis with CD patients, it was verified that the acceptance of the modified pasta samples was higher than the acceptance by nonceliac patients. This can be explained by the CD individuals' habit of consuming modified products, although this particular aspect was not evaluated in the present work.[7] Among the analyzed pastas for non-CD subjects, there was a statistical difference only for the texture.

It can also be observed that the modified pasta was better accepted than the standard pasta in aroma, flavor, texture, and overall quality, which indicates that this product can possibly be commercialized both to CD patients and non-CD individuals. The modified sample had greater sensory quality (84.5% for celiac individuals and 61.2% for nonceliac) than standard samples (53.6% for nonceliac individuals), according to all the analyses performed.

CONCLUSIONS

This study demonstrates the importance of gluten's technological properties in pasta products and suggests alternative approaches for modifying preparations aggregating healthier ingredients, and decreasing lipid content. CD-modified products are generally lipid rich because fat ameliorates the sensorial losses of gluten removal.

Producing pasta products with green banana flour is important to increase CD patients' food choices. Patients can benefit from ingesting a preparation with a better nutrient profile that is made from a food product produced and consumed worldwide. In addition, green bananas are considered a subproduct of little commercial value and insignificant industrial advantage. Considering that CD has a high impact on financial costs both personal and governmental, using less expensive and healthier ingredients represents a cost reduction. Also, for banana growers and pasta product makers, this represents the possibility of diversifying and expanding their market.

This product is an option accepted by CD patients and could encourage the industry to search for new products using green banana flour.

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STATEMENT OF POTENTIAL CONFLICT OF INTEREST

No potential conflict of interest was reported by the authors.

FUNDING/SUPPORT

There is no funding to disclose.