The Value of Gluten-Free Attributes in Snack Foods

by

Jed Philip Sampson

A Thesis Presented in Partial Fulfillment
of the Requirements for the Degree
Master of Science

Approved November 2010 by the
Graduate Supervisory Committee:

Timothy Richards, Chair
Mark Manfredo
Geoffrey Pofahl

ARIZONA STATE UNIVERSITY

December 2010

ABSTRACT

Celiac Disease (CD) is now widespread as one in 133 people are currently diagnosed, while there were only one in 150 in 2006. Much of the research concerning CD is still in the early stages, as formal epidemiological studies are relatively recent. CD is aggravated by the consumption of gluten, which is found mainly in wheat, rye, oats, and barley. Not surprisingly, the rising prevalence of CD has created a significant business opportunity for food manufacturers in developing products that are tailored to CD sufferers. While the entire Gluten-Free (GF) industry has been experiencing double digit growth rates, the expansion in available snack foods has outstripped all others. Observation of GF snack food prices suggests that food manufacturers are responding to high retail prices associated with GF foods. However, GF foods are often also advertised with other attributes that generally sell for a premium over conventional foods. Therefore, whether the high retail price for GF snack foods can be attributed specifically to the GF attribute is an empirical question.

The objective of this research is to determine whether there is a retail-price premium for GF snack foods and, if there is, to estimate its magnitude. A hedonic pricing model is used to answer this question. Specifically, a hedonic pricing model was applied to a unique dataset of snack food products in order to estimate the marginal value for the GF attribute, while controlling for a number of other important attributes.

Results show that the GF attribute is both economically and statistically significant, implying a premium of nearly $1.86 above gluten-containing

products. Production costs for smaller manufacturers can be two to three times higher for GF foods relative to non-GF foods, but this still implies an excess premium of over $0.50 (assuming 40% margins). However, high premiums may not last as large retailers are utilizing their influence over suppliers to keep retail margins low. Therefore, the primary implication of the research is that the rapid growth in recent years can easily be explained on economic grounds for large agribusinesses, as this implies a major profit opportunity.

TABLE OF CONTENTS

Page

Page

Page

LIST OF TABLES

Table Page

Introduction

Celiac Disease (CD) is an inherited autoimmune disease (Rubin, 2006) in which damage to the small intestine may cause various symptoms (Stark, 1999). People diagnosed with CD are forced to adhere to a strict Gluten-Free (GF) diet, as this is currently the only effective treatment option available (Ciclitira, Ellis, Knut, and Lundin, 2005; Shin, 2009). To avoid abdominal distention and other debilitating effects, CD sufferers change their diets to contain virtually no gluten at all (Shan, Molberg, Parrot, Hausch, Filiz, Gray, Sollid, and Khosla, 2002). However, CD is far more complex than a simple gluten allergy.[1] With one of every 133 people around the United States diagnosed with CD (Niewinski, 2008), it appears that there is a significant business opportunity for food manufacturers to develop GF products targeted to this large, and growing, market segment. Whether growth in sales implies a profit opportunity as well, however, depends on whether consumers are willing to pay a premium for foods marketed as GF over the higher production costs incurred in using ingredients without gluten.

In this study, the focus is centered on snack foods for the reason that they are discretionary purchases – food items that consumers do not have to purchase, but do so frequently. GF snack foods tend to have relatively high retail prices, but many GF snack foods are also natural, organic, kosher or contain some other attribute (Lee, Zivin, and Green, 2007; Stevens and Rashid, 2008). Therefore,

[1]Indeed, CD is also being studied as one of a broader class of autoimmune diseases, which also includes multiple sclerosis, diabetes mellitus, and rheumatoid arthritis (Fasano, 2001).

whether there is a price-premium specifically attributable to the GF attribute is an empirical question.

The objective of this study is to determine whether there is a price premium associated with GF snack foods at the retail level. If consumers' willingness to pay for the GF attribute is greater than the cost of producing GF snack foods, then there is an opportunity for a new value-added agricultural product.

The empirical model is based on the attribute-theory of demand (Lancaster, 1966). According to the attribute theory, the demand for any good reflects the demand for its component attributes. Hedonic models are the empirical application of attribute theory as they are used to estimate the marginal values embodied in a particular product. This approach is ideally suited to identifying premia associated with GF products. Hedonic modeling is essentially an empirical framework in which the demand for a retail item is assumed to represent the sum of the demand for each of its components. For example, the demand for an individual house is comprised of the demand for bedrooms, bathrooms, garage space, kitchen and living area features, and not necessarily for the house itself (Witte, Sumka, and Erekson, 1979; Harding, Knight, and Sirmans, 2003). In the current study, the demand for snack foods is driven by the demand for its measurable attributes, one of which may appeal to CD sufferers.

There is always some question as to which attributes to include in a hedonic pricing model. In this study, we rely on prior research in marketing, demand analysis and nutrition to suggest the set of attributes that are likely to be

important. In the final model, we include essential nutrients, origin of production and brand name. Estimating the hedonic model provides information on attribute-level price premia in order to determine which contribute to the overall retail-price for GF snack foods.

Understanding the value of GF snack food products is important to a number of stakeholders in the food industry. First, retailers can use premium estimates to price their GF inventory to the ultimate consumer. Second, price premium estimates will help GF food manufacturers better understand the strength of the underlying trend, the prospects for future growth, and whether this premium is above cost. Third, understanding the market value of GF foods will also inform the relationship between member firms and their rivals. A firm that can successfully compete on price will have an advantage over its rivals, while maintaining a sustainable competitive advantage if their inventory is appropriately priced in the marketplace. Moreover, the importance for estimating the marginal value of the GF attribute within snack foods also has implications for marketing professionals. Marketers can use these estimates in developing more effective campaigns for products that reach specific market segments, while pricing products in order to maximize profits.

Recent studies consider the GF premium issue, but from fundamentally different perspectives. This study provides complementary information to Lee, Zivin, and Green (2007), and Stevens and Rashid (2008). Both of these studies estimate GF premia for products in different food categories as they found that on average, GF products were more expensive than their gluten-containing

counterparts by 240-242%. Due to the fact that purchases made in the snack food category represent discretionary purchases, preferences can be more clearly identified than with staple foods, which have to be purchased in some form or other.

Background on Celiac Disease

There is a growing interest among CD sufferers, researchers, and the general population regarding possible dietary treatments for the disease. Also known as Celiac Sprue, in years past it was incorrectly thought of as a childhood disease (Stark, 1999). However, it was later found that in numerous individuals, general symptoms may not develop until later in life (Shan, Molberg, Parrot, Hausch, Filiz, Gray, Sollid, and Khosla, 2002). Nonetheless, CD does still frequently appear in the early stages of childhood, as severe symptoms include diarrhea, general abdominal distension, and a failure to thrive (Shan, Molberg, Parrot, Hausch, Filiz, Gray, Sollid, and Khosla, 2002). CD is one of the most common food-related illnesses among children throughout Europe and in the U.S. as well (Ohlund, Olsson, Hernell, and Ohlund, 2010). CD is not isolated to the U.S. as a growing body of literature documents the emergence of CD as a common disease in diverse populations across the globe (Leffler, Edwards-George, Dennis, Schuppan, Cook, Franko, Blom-Hoffman and Kelly, 2008). With the prevalence of CD, finding some sort of treatment, if not a cure, is a global health imperative.

Gluten forms as a result of a protein matrix, as individual cells of wheat flour that contain networks of gluten proteins are brought together during dough mixing (Shewry, Halford, Belton, and Tatham, 2002). Gluten is not only a

characteristic of wheat flour, as it can also be found in oats, rye, and barley (Stark, 1999). CD is an inherited, autoimmune disease characterized by intolerance to gluten (Rubin, 2006). Patients diagnosed with CD suffer because their small intestinal lining becomes damaged by a protein fraction of gluten called gliadin (Stark, 1999). Damage to the small intestine can have far-reaching effects as it digests and absorbs nutrients, water, and bile salts (Stark, 1999). Other than general abdominal distension, symptoms may consist of weight loss, growth failure, delayed puberty, vomiting, and possible fatigue (Rubin, 2006). Rubin (2006) also notes that if left untreated, CD can lead to cancer, bone disease, and malnutrition.

The importance of CD research is not only helpful for the patients who suffer from the above mentioned symptoms, as it is but one disease within a general class of autoimmune disorders. CD research is also being done to help understand its pathogenesis on a worldwide basis (Fasano, 2001). CD embodies various autoimmune diseases, where the environmental factors are similar (Fasano, 2001). Moreover, researchers have found that by analyzing CD, they are able to gain medical insight into multiple sclerosis, diabetes mellitus, and rheumatoid arthritis (Fasano, 2001). Environmental triggers have also been recognized, as continuous CD research has provided additional insight into certain areas where information has been lacking (Fasano, 2001).

GF diets are also being studied to possibly help identify behavior improvement for children with Autism. In a study conducted by Whiteley, Rodgers, Savery, and Shattock (1999), 31 children (23 males and 8 females) were

involved in a GF diet trial. Restricting autistic children to a GF diet, researchers monitored each subject over a 5 month period using various testing applications which included both parental and teacher questionnaire sessions, observation reports, psychometric tests and urinary profiling (Whiteley, Rodgers, Savery, and Shattock, 1999). The results of this study suggested that participants on a GF diet showed an improvement on a number of behavioral measures (Whiteley, Rodgers, Savery, and Shattock, 1999). Furthermore, data from parental interviews as well as teacher observations demonstrated that a proportion of participants on the GF diet were reported as showing some improvement in autistic behaviors, predominantly after 3 months on the diet (Whiteley, Rodgers, Savery, and Shattock, 1999). In addition, results also showed that nearly 67 percent of parents with children on dietary intervention rated the introduction of a GF diet as leading to clear and significant improvement in their child's autistic behaviors. Moreover, 60 percent of the parents with celiac affected children suggested that the reintroduction of gluten back into typical consumption habits were connected with a slight worsening of general autistic behaviors as well (Whiteley, Rodgers, Savery, and Shattock, 1999). The value of a GF diet is revealed not only through an understanding of the pathogenesis of CD but also through the treatment of children diagnosed with Autism.

Furthermore, interest in CD has risen simply due to an increase in the number of people around the United States and the rest of the world diagnosed with the disorder. As of 2006, the ratio of diagnosed CD patients was one in every 150 (White, 2006), while currently one in every 133 people suffer from CD

throughout the United States (Niewinski, 2008). Additionally, CD is a life-long disease, and if untreated it can lead to morbidity along with increased mortality (Shan, Molberg, Parrot, Hausch, Filiz, Gray, Sollid, and Khosla, 2002). However, these data might be biased because of the development of newer, more accurate methods of diagnosis. In fact, there is now a clear procedure for the diagnosis of CD which involves a simple blood test that can be carried out by the patient's general practitioner (Mendoza and McGough, 2005). There are two types of blood tests designed to screen for CD, both of which test for antibodies. Here, suitable test selection is important to produce the most accurate diagnostic information (Mendoza and McGough, 2005). Nevertheless, these authors stress the fact that the range of symptoms that is now recognized is far wider than previously thought, but symptoms are still often missed, or misdiagnosed as Irritable Bowel Syndrome. Such problems with the diagnosis of CD imply that a biopsy of the small intestine remains the gold standard (Green and Jabri, 2006). It is clear that the proper screening for CD plays a vital role for each patient from the early stages.

Despite its increasing prevalence in most population groups, along with the harmful effects CD can have on the body, the only effective treatment option is a strict dietary abstinence from virtually all grain-based foods (Shan, Molberg, Parrot, Hausch, Filiz, Gray, Sollid, and Khosla, 2002). With the increasing awareness of gluten sensitivity, so too has come an increased expectation of new and novel treatment options (Ciclitira, Ellis, Knut, and Lundin, 2005). However, adhering to a strict GF diet seems to be the only prescription for affected people

(Shin, 2009), and therefore remains as the only currently available treatment option (Niewinski, 2008). Nonetheless, the effectiveness of a GF diet also varies from patient-to-patient. In a clinical study conducted by Wahab, Meijer, and Mulder (2002), 158 CD patients that were using strict GF diets underwent follow-up appointments where small intestine biopsies were conducted to test whether villous atrophy was still present. Here, emphasis is typically put on the villous atrophy in the duodenal and jejunal regions, as these tissues are most frequently linked with CD (Malterre, 2009). Wahab, Meijer, and Mulder (2002), found that the recovery profiles of the patients with CD revealed that only 65% of the patients reached remission within 2 years. Moreover, within 5 years, nearly 86% were in complete remission, and in long-term follow-up, virtually 90% of patients showed normalization of villous structure. Undoubtedly, recovery from CD after starting a GF diet can take time, as symptom improvement may vary in a subgroup of patients. However, recovery can also be incomplete or even absent in certain celiac patients (Wahab, Meijer, and Mulder, 2002).

Much of the variation in the effectiveness of a GF diet may be caused by complications from eating processed foodstuffs. It is estimated that almost 80% of the food we eat is processed in some form (Edelman and Fewell, 1985). Furthermore, Edelman and Fewell (1985) add that the term 'processed' must not be misunderstood as it is basically a manufacturing technique to preserve products that, if left to the atmosphere, would become inedible for aesthetic reasons. Although wheat is one of the three most important crops in the world, together with maize and rice (Shewry, Halford, Belton, and Tatham, 2002), maintaining a

GF diet has become increasingly easier due to the expanding number of food products in all categories (Shin, 2009). Additionally, a GF diet can consist of products such as butter, cheese, and milk, fruits and vegetables, along with any meats, poultry, fish and eggs. Additionally, the GF diet can also consist of beans, corn, nuts, and rice (Niewinski, 2008), eliminating foods and by-products containing wheat, rye, barley and oats (Niewinski, 2008).[2] Recent data suggests that it is possible for at least a small subset of adult patients with CD to be intolerant of the proteins in oats as well (Ciclitira, Ellis, Knut, and Lundin, 2005). Thompson (1997) argues that oats may be permitted in a GF diet; however it is likely to differ among countries, hospitals, and general practitioners. Thompson (1997) also notes that the inclusion of oats in a GF diet depends on whether future research will engender widespread support through extensive clinical testing (Thompson, 1997). Moreover, this controversy highlights a major issue surrounding the certification process for the industry's food manufacturers.

Foods may be the proximate cause of CD, but bouts can be triggered by either emotional stress (Stark, 1999) or stress-like infections, pregnancy, surgery, or viral infections (Rubin, 2006). Due to a lack of motivation, information, or a combination of the two, certain patients struggle to comply with the strict dietary regulations and usually continue their normal gluten-containing diet (Ciclitira, Ellis, Knut, and Lundin, 2005). An interesting aspect of CD is that the majority of affected patients simply do not know they have the disease. In fact, about 95% of celiac affected people are undiagnosed (www.celiaccentral.org). Patients who

[2]Although oats contain no gluten, they have traditionally been excluded from the GF diet (Ciclitira, Ellis, Knut, and Lundin, 2005).

have a subclinical form of CD may be unaware, because outwardly, they have no physical symptoms, yet certain patients still may present positive test results for CD and villous atrophy on the intestinal biopsy (Niewinski, 2008). However, clinical sensitivity differs considerably between patients (Ciclitira, Ellis, Knut, and Lundin, 2005). According to these authors, some patients may not be able to tolerate trace amounts of gluten, whereas others appear to tolerate large transgressions. Thus, screening for CD has been essential for the health and well-being of affected patients, with considerable progress being made during the last decade.

In addition to the importance of screening, contamination may also be an issue. Heterogeneity in gluten intolerance plays a major role in the physical well-being of certain individuals. Thus, patients need to be diligent in reading labels of processed foods, and must be aware of gluten in additives, emulsifiers and stabilizers (Luchtefeld, Burton, and Donavon, 2003). Trace amounts of gluten may be present even though the 'free from claim' is stated on the package. Most countries define this diet in accordance with the Codex Alimentarius Commission or the Food and Agricultural Organization (FAO) of the United Nations and the World Health Organization (WHO) (Faulkner-Hogg, Selby, and Loblay, 1999). Here, Codex Alimentarius allows the inclusion of up to 0.3% protein from gluten-containing grains in foods labeled GF. Although this may be only a trace amount, Faulkner-Hogg, Selby, and Loblay (1999), conducted a study where 39 patients who suffer from CD were placed on two types of GF diets. Dietary analysis indicated that 22 (56%) were consuming a GF diet as defined by the WHO/FAO

Codex Alimentarius. The remaining 17 followed a no-detectable-gluten-diet as defined by Food Standards Australia (Faulkner-Hogg, Selby, and Loblay, 1999). The results suggested that of the patients who switched to a true GF diet, symptom improvement was experienced in 24 (77%) patients (Faulkner-Hogg, Selby, and Loblay, 1999). Thus, consumption of trace amounts of gluten, traditionally allowed in a Codex-GF diet, may be responsible for the continuing symptoms seen in some patients with CD (Faulkner-Hogg, Selby, and Loblay, 1999). Moreover, a standard for GF claims is needed throughout the world.

Classifications which vary throughout multiple countries and organizations continually add to the ongoing confusion while increasing the risk for food manufacturers. From this, the complexity of the gluten mechanism has frustrated attempts to produce a gold standard throughout the industry (Ciclitira, Ellis, Knut, and Lundin, 2005). In response, the GF Intolerance Group was created to help eliminate the confusion surrounding these ingredients' and to assist those with gluten intolerance conditions (White, 2006). Due to the response variations in patients, major food manufacturers have been more cautious about embracing the 'free-from' claim, although products under their name are currently being sold for people with food allergies. Shin (2009) claims that, unlike organic products, there are no government standards for what the 'free from' claim actually means. However, organizations such as the GF Intolerance Group hope to stem the current lack of universal understanding among both manufacturers and consumers about what GF means (Runestad, 2007). According to Runestad

(2007), in the absence of federal regulations, food companies are using a variety of standards in manufacturing GF products.

Interest in GF foods is also rising due to their connection to organic and kosher products through their common concern regarding food safety. The GF Intolerance Group has thus partnered with the Orthodox Union and its subsidiary, Food Services Inc., to conduct independent and unannounced inspections, along with random product pulls off retail shelves, and ingredient testing (White, 2006). GF products are also popular with consumers who are diet conscious and those that want to eat natural, less processed foods. White (2006) finds that some consumers report lowering their intake of gluten in order to help eliminate gastric and allergy problems. Furthermore, for retailers who stock GF products, celiac sufferers are only the tip of the iceberg (Wilcox, 2005). GF products have also gained favor with people on low-carbohydrate diets, as well as those trying to avoid secondary chemical compounds found in wheat and dairy (Wilcox, 2005).

With this increased interest, sales of GF products have been on the rise for several years (Enis, 2010). Although virtually all product categories have been growing rapidly, the market for GF snacks is exploding (White-Sax, 2009). Snack food categories realized an annual growth rate of 28% from 2004 through 2008, as the total market size is estimated to be $1.5 to $1.7 billion, as reported by the International Dairy-Deli-Bakery Association (Enis, 2010). GF foods are increasingly becoming more main-stream. Currently, Wal-Mart is requiring its suppliers to identify whether foods carrying its private label, Great Value, contain gluten (White, 2006). Retailing experts believe Wal-Mart is hoping to lure the

approximately two million Americans who suffer from CD away from the natural and organic stores that have traditionally dominated the GF market (Wilcox, 2005). White-Sax (2009) notes that cereal giant General Mills is rolling out a line of GF cookies, brownies, and cake mixes under its Betty Croker brand. According to White-Sax (2009), General Mills research showed that nearly 12% of all U.S. households want to eliminate or at least reduce their overall gluten intake.

Since they are oriented to sell products to "the average consumer," profitably marketing GF foods represents a significant problem for retailers. However, the awareness of gluten-related illnesses, along with the realization that food can help solve the problem, has spawned the market growth for GF items cited above (Friedrick, 2007). Indeed, GF product launches were up 86 percent alone in 2006 from year to year (Runestad, 2007). Moreover, in 2004, Packaged Facts predicted that the market for GF specific products will grow 25 percent annually (White, 2006).

Although predictions of market growth and profitability have been encouraging to GF food manufacturers, there is little research on the actual cost of producing GF foods. Lee, Zivin, and Green (2007) construct a 'market basket' of regular products (gluten-containing) along with their GF counterparts, and find that every GF product costs more than the gluten-containing. Specifically, they found an average GF premium of approximately 240%. In addition, when comparing different regions of the United States, they report considerable variability in availability, but perhaps surprisingly, not in the price. Lee, Zivin,

and Green (2007) also find that GF products are more difficult to obtain than conventional product, which explains in part why they are more expensive, placing a greater burden on the patient population that is trying to seek relief from their CD. These authors also find that a traditional GF diet, which includes many commercially prepared GF foods, is nutritionally deficient compared with a regular diet.

In a study similar to Lee, Zivin, and Green (2007), Stevens and Rashid (2008) compared 56 GF products to gluten-containing foods in the two largest grocery stores in Nova Scotia. They found that GF products were 242% more expensive than their gluten-containing counterparts. Based on these two studies, it is clear that although there is demand for GF products, prices are abnormally high for typical consumer goods.

However, there are economies of scale in food production, so the small scale of GF producers can explain some of the GF premiums as production costs tend to be higher. Expensive ingredients, such as specialty flours, cost three to four times the price of traditional wheat-based flours (McEvoy, 2010). Along with raw ingredients, McEvoy (2010) notes that the additional sanitation requirements (allergen removal) to keep celiac consumers safe takes time and money. Training specialized workers also increases the production costs for GF food manufacturers. Quality assurance is also important for small manufacturers, but is costly. Furthermore, small manufacturers are finding that, in order to turn a profit, distribution must be shifted onto the internet, where sales are focused on boxed flour blends instead of the traditional over-the-counter ready-made

products (McEvoy, 2010). In addition, smaller bakeries have found that eliminating all gluten-containing products is more cost effective as constant upkeep and sanitation necessities are no longer needed (McEvoy, 2010).

High growth rates for the GF snack foods category have also created problems for smaller manufacturers (Friedrick, 2007; Runestad, 2007; White, 2006; McEvoy, 2010). Increased awareness of this niche market has attracted attention of large retailers, which use their market power to keep wholesale prices down. Economies of scale represent an essential competitive advantage to large retailers such as Wal-Mart (White, 2006; Wilcox, 2005). In addition, larger retailers also have the financial leverage over smaller suppliers as production can be outsourced overseas. Thus, as production moves away from smaller bakeries and into mainstream it is likely that only large manufacturers will benefit as their production costs are far lower.

In the current environment, however, where small-scale production is still the norm, manufacturers compensate for higher production costs by pricing GF products higher compared to gluten-containing alternatives. However, it is still unclear how much of a premium is due to higher production costs, retail market power, and/or simply just clever marketing. The average snack in the data used for this study sells for $2.922 per unit. Assuming 40% retail margins, this implies a wholesale cost of $1.75 and, assuming ingredient costs constitute 30% of wholesale value, $0.52 of inputs that can be made GF. If GF ingredients cost three to four times non-GF inputs (McEvoy, 2010), then the retail price must be at

least $1.00 higher for GF foods to compensate. Anything above this amount is profit.[3]

Assuming that a combination of higher production costs, retail marketing power, and effective marketing campaigns will be reflected in the overall retail price for GF snack food products, the size of the GF premium becomes an important empirical question. While others have studied the price premium earned on GF snack foods (Lee, Zivin and Green, 2007; Stevens and Rashid), none have had access to the highly detailed data used here.

Econometric Model/Theory/Hypotheses

Building upon the hedonic theory of Lancaster (1966) and Rosen (1974), our empirical model uses prices for snack food items to estimate the willingness to pay for each component attribute, most importantly the GF attribute. Variation in prices and attributes among the snack foods in the sample will identify the premium associated with each. With these premia, the estimates are compared

[3]Sutton, Balch, and Lefebvre (1995), find that many food manufacturers use advertising messages that present 'the facts' about a specific health behavior, on the assumption that exposure to these facts will lead to the desired behavior. They also note that this approach can yield unanticipated outcomes. These authors describe an example of women with breast cancer who have a family history of the disease. A marketing campaign was designed with the intent of increasing women's knowledge about various risk factors, and in turn, to cause them to seek suitable screening methods (Sutton, Balch, and Lefebvre, 1995). Through further research, however, they found that this particular health message proved to be ineffective since women who did not have any family history of the disease did not seek medical information. Informative advertising targeted toward celiac affected consumers may prove to be effective; however, as approximately 97% of individuals with CD have genetic markers (Niewinski, 2008).

with the cost comparison studies of Lee, Zivin, and Green (2007), and Stevens and Rashid (2008).

The structure of the hedonic model is straightforward. Prices of a large sample of snack foods, both GF and gluten-containing, are considered endogenous variables, while the attributes are assumed to be exogenous explanatory variables. However, a hedonic model is more than a simple regression model. Rosen (1974), for example, shows that a hedonic model is an equilibrium model of attribute-level marginal values and marginal costs in perfect competition. More specifically, Rosen (1974) builds upon the attribute-theory of demand developed by Lancaster (1966). The "attribute theory of demand" maintains that the value of a consumer good is nothing more than the sum of the values of its parts. For example, the value of a house is the sum of the value of its bathrooms, bedrooms, living spaces, and other attributes that a house buyer values (Witte, Sumka, and Erekson, 1979; Harding, Knight, and Sirmans, 2003). This theory lends itself to empirical application through linear regression models as marginal attribute values are thought to be additive, at least as an initial, testable assumption. Conveniently, the marginal attribute values in this model are interpreted as estimates of the willingness to pay or the shadow value of each non-traded attribute. Thus, market values can be imputed to attributes that are not directly traded on their own.

As reported by GNPD, the prices for each snack food product represent the overall retail price per package. In order to control for package-size variation, prices were divided by the corresponding unit package size. Thus, as the

dependent variable, prices are still considered to be endogenous, as stated above. In this application, additional attributes consisted of nutritional contents, along with origin of production and brand recognition for GF and gluten-containing products. Of course, the presence or absence of gluten is the key variable of interest to this study.

Hedonic modeling is not without controversy, however. Arguea and Hsiao (1993), for example, take issue with applying the hedonic model in cross-sectional data. Specifically, they argue that in order to clearly identify market supply or demand for the implicit characteristics being used, one must rely on factors which change over a given period of time. Conversely, Ekeland, Heckman, and Nesheim (2004) maintain that the frequently used linearization strategies made to simplify identification problems can be misleading as the hedonic model is generically nonlinear. These authors first consider whether equilibrium in hedonic markets impose any limitations on estimating equations and if there is any potential to identify technology and preferences from data throughout a single market. In this study, the hedonic model was estimated under the assumption that GF product attributes are exogenously determined, therefore meeting the condition for identification described by Ekeland, Heckman, and Nesheim (2004).

Consumers are attracted to GF foods due to the lack of processing, and the more "natural" characteristics that this implies (White, 2006). While an intractably large number of attributes can potentially be regarded as relevant to the econometric model (Sirmans, Macpherson, and Zietz, 2005), the attributes

here were chosen carefully to avoid potential estimation issues. At the same time, variables were chosen in an attempt to fully explain the observed variation in prices throughout the dataset. Qualitative variables were included as binary or categorical variables, and their parameters were interpreted as marginal values in the discrete sense of the term. Country of origin is also included to account for any origin-specific variation in cost, or perhaps unobserved ingredients that may cause snacks from one country to sell for more than another. Table 1 shows how major producing countries were determined based on the amount of variants in the overall dataset. More specifically, a country was deemed to be a 'major producing country' based on the number of variants in the dataset produced by firms based in that country. For this application, any country which had greater than or equal to 20 observations was considered to be a major producing country, as anything less was not included. Therefore, the variable was constructed purely based on popularity, and not by standard economic measures. For example, as seen in Table 1, the United States had 187 variants so qualifies as a major producing country.

The third variable indicates whether the product is sold under a recognizable brand name (1 = Yes, 0 = if otherwise). In order to eliminate any bias, or assumptions for what actually constitutes a brand name, the same process was used as the origin of production variable. Here, products that were considered for this category were purely based off of the number of variants in the dataset. Due to the overall size and variability of snack food products throughout, brands were considered to be recognizable if they were observed at least 10 times

or greater, under each country of origin that was being considered. Although this model included observations for a large dataset of snack food products, the majority only appeared in modest increments, which led to the lower classification of 10 or more variants in order to be considered a recognizable brand name.

We also include a number of continuous attribute variables. Total fat (g) is a critical source of differentiation among snack foods as many products advertised as low-fat are intended to appeal to a specific market segment. Second, fiber (g) is also included as it is expected to be highly valued by consumers, particularly in otherwise low-fiber GF diets (Stojceska, Ainsworth, Plunkett, and İbanoğlu, 2010). Finally, protein (g) is expected to be valued for similar reasons as fiber. Namely, it is a staple in the consumer diet and is contained in virtually every snack food item in the sample.

[Table 1 in here]

For the GF variable, the first hypothesis is that the estimated coefficient is strictly positive, indicating that GF snack foods sell for higher retail prices even after controlling for other valuable attributes. This hypothesis is partially based off of the findings found by Lee, Zivin, and Green (2007), and Stevens and Rashid (2008), as GF products were 240-242% more expensive than their gluten-containing counterparts. In addition, this reasoning corresponds to the higher production costs involved in GF snack food production. GF snack foods are also expected to sell for premiums at retail partly due to the niche market opportunity they represent. In the dataset, the inclusion of specialty items such as high protein

snack bars may lead to this outcome. Nevertheless, due to the size of the overall dataset, there is confidence that this problem will not likely bias the final results.

Second, it is expected that the origin of production will have a positive effect as well. Since this variable assumes a value of 1 if the snack food is produced in a major manufacturing country, there is a higher likelihood that premium brands are sold in the country, thus increasing the price. However, this effect may also be negative due to economies of scale. The net effect, therefore, is an empirical question.

Third, brand recognition is expected to have a positive effect on retail prices. Mainly due to brand loyalty, consumers forced to adhere to a GF diet may opt for the well recognizable brand. However, this may also be due to safety concerns from any contamination issues. The GF market lacks a well-defined set of industry standards, and as a result, consumers have less confidence in suppliers which drives them to more well established brands. Additionally, due to the use of alternative GF flours, consumer preferences concerning taste can increase brand awareness through basic word-of-mouth advertising.

The total fat (g) coefficient is expected to have a positive marginal value, principally due to the issue of consumer preferences for overall taste. Although interpretations vary, increased fat has shown to improve the overall taste of the GF product, when substituting grain-based flour for traditional wheat. This may seem counterintuitive, as many health-conscious consumers avoid products that are high in fat, lowering the marginal value of fat content. Additionally, as White (2006), and Wilcox (2005) point out, GF suppliers have been attracting

consumers who are diet conscious, as well as those who favor more natural and less processed foods. However, consumers are often misguided when supplementing a GF diet in order to lose weight (Lee, Zivin, and Green, 2007). The GF diet is nutritionally deficient of essential content, and should not be viewed as the next fad diet. Therefore, the effect of fat content on the market price of snack foods is expected to be positive.

Following a similar line of reasoning, fiber is expected to have a positive effect as well, due to the general nutritional deficiency in a GF diet. Dietary fiber is also highly sought after given the other well-known health benefits. Specifically, due to the variety in GF snack foods, consumers should respond favorably to higher amounts of fiber.

Last, protein content is expected to have a similar effect as fiber. Usually, protein is also highly sought after throughout the snack foods category as consumers attempt to maximize their nutritional intake when pressed for time. Thus, it is assumed that consumers eat snack food products mostly on the go, therefore putting more of a premium on essential nutritional content such as protein. Also, as many snack food products are marketed towards children, consumers tend to select more health conscious items.

Combining each of these elements, the econometric model is written as:

$$\textbf{Price} = \beta_0 + \delta_1\textbf{GF} + \delta_2\textbf{Major Producing Country} + \delta_3\textbf{Brand Name} + \delta_4\textbf{Total Fat} + \delta_5\textbf{Fiber} + \delta_6\textbf{Protein} + \varepsilon \quad (1)$$

Ultimately, the model that provided the best fit to the data was a log-log form. Therefore, every variable excluding the binary indicators for the GF estimate,

major producing countries, and brand name parameters, were transformed into logs. Each parameter in equation (1), therefore, is interpreted as the elasticity of price with respect to attributes. Consequently, it is necessary to convert the estimated parameter back to a marginal value. To do so, we use the relationship given by:

$$\partial \mathbf{logP}/\partial \mathbf{logGF} = (\partial \mathbf{P}/\partial \mathbf{GF}) \cdot (\mathbf{GF}/\mathbf{P}) \qquad (2)$$

Where GF is the mean of the GF attribute in the data set, P is the average price, and $(\partial \mathbf{P}/\partial \mathbf{GF})$ is the parameter estimate.

Total fat content is one of the more essential ingredients that directly affect the overall quality of any food item. However, research suggests that consumers simply do not understand the basic information about dietary fat, including both the good and bad forms (Diekman and Malcolm, 1999). In addition, these authors suggest that despite this misunderstanding, consumers are cutting out more visible fat in all foods. GF products are notorious for their poor taste, yet this does not in any way suggest lower quality. Seed-based flours are substituted for traditional wheat forms, as this inevitably alters the overall taste and formula makeup. Likewise, consumers emphasize fat content across all food categories, and tend to base consumption decisions on total fat, at least in an implicit way. Furthermore, to combat negative opinions on the overall taste of certain GF products, particularly in the snack foods category, suppliers have been adding fat (g) to their brands.

For a well-balanced diet, fiber intake is essential. However, it has been shown that a fiber deficiency is among those associated with a GF diet, as

multiple products are frequently made from refined flour and/or starch (Stojceska, Ainsworth, Plunkett, and İbanoğlu, 2010). Furthermore, Sabanis, Lebesi, and Tzia (2009), conducted an experiment in which they added additional dietary fiber to breads from maize and oat in GF formulations. Adding fiber produced breads with significantly higher loaf volume and crumb softness compared to the control non-fiber GF bread. These studies show the potential for developing fiber-rich GF breads to increase acceptability and dietary fiber intake (Sabanis, Lebesi, and Tzia, 2009). Moreover, Sabanis, Lebesi, and Tzia (2009), as well as Stojceska Ainsworth, Plunkett and İbanoğlu (2010), find that the enrichment of GF baked products with dietary fiber seems to be necessary because celiac patients have a generally low intake of fiber due to their GF diet. Thus, dietary fiber should be included in the hedonic model as fiber has proven to be a beneficial attribute that consumers are likely to be willing to pay a premium for.

Protein is also an important attribute of GF foods. Protein is highly sought after as an essential dietary nutrient. Particularly due to the prevalence of CD in children, parents who seek high protein GF snack food products are likely to place a positive marginal value on higher protein content. Additionally, similar to the discussion of brand image, suppliers can use the addition of protein as a point of differentiation. Although this has not been proven, GF snack food consumers must continually balance the good with the bad. Consumers may be forced to purchase a product that would not originally have been made if more choices were made available to them. Therefore, protein content should have a positive influence on the prices of GF snack food items.

Data

All of the data was collected from the Mintel (www.gnpd.com) Global New Products Database (GNPD). A total of 2,300 snack food observations were used in the analysis. Of the total sample, GF snack food products comprised half (1,150), while the other 1,150 snack foods were comparable gluten-containing items. The data represent foods that were introduced in January 2000 through July 2010. GNPD, however, contains many incomplete records as the data-gathering service relies on field representations that often do not have access to information on all attributes at the necessary level of accuracy. Therefore, only complete observations were used, as every attribute must have been present for its inclusion in the analysis**.**

Snack food items for both GF and gluten-containing categories consisted of a wide range of products. The data represent products from a number of countries, but items representing snack foods varied only slightly on a country-to-country basis. As the data in Table 1 shows, snack food products for the United States and Canada include a variety of popcorn products, fruit and nut mixes, rice crackers, assorted granola bars, and yogurt, along with a multitude of potato chip flavors. As for Argentina, Brazil, and the United Kingdom, snack food products were similar to that of the United States and Canada, but also included corn-based chips, assorted nuts, and variety packs of dried fruits. Therefore, snack foods are surprisingly similar throughout the data given the variation in origin, as most observations consisted of nut mixes, assorted granola bars, and potato chips. In addition to the types of snack foods products, as seen in Table 1, a list of

recognizable brand names were provided for each major producing country. Again, this list of brand names was based purely on the total numbers of variants associated with each brand.

Recall that the prices which we used for this estimation as the dependent variable represented the retail level, and in order to control for package size throughout the model, the obtained unit package size in grams were divided into the snack products' corresponding retail price. Thus, package size varied by product category, as the mean for the overall dataset was 145.281 grams (5.124 ounces). GF snack food product sizes averaged 158.354 grams (5.585 ounces), while the observed gluten-containing products averaged 132.208 grams (4.663 ounces) per package size. While GF snack food observations have higher package sizes, it should not bias the estimation results because the size differences are small and not correlated with per-gram prices.

Summary data for all relevant variables is provided in Table 2. The average retail price per package size for GF products is $2.922, when compared to the $0.809 estimate for gluten-containing snack foods. Lower prices for gluten-containing products are consistent with the summary results as reported by Stevens and Rashid (2008).

[Table 2 in here]

Results

In this section, results are presented from a number of specification tests for the hedonic regression model, and then to the tests of the core hypotheses of the paper. Namely, the size and determinants of the observed GF price premium.

Results for the hedonic pricing model are shown in Table 3, which provides results from the Log-Log regression. To assess the goodness of fit, we considered the F-statistic and coefficient of determination (R^2). The coefficient of determination shown in Table 3 implies that the model provides an acceptable fit to the data, given that the data are cross-sectional in nature. Table 3 shows that 41.326% of the total variation in the price of snack foods is explained by variation in the values of attributes included in the model. Further, the F-statistic was reported to be 269.177, compared to a critical F-value of 2.10, thus indicating statistical significance for the overall model. Therefore, we reject the null hypothesis that all regression parameters are jointly equal to zero. In addition, as further indication of the goodness of fit of the log-log regression, each individual parameter estimate is statistically significant at a 5% level using two-tailed t-tests for each estimate.

The primary parameters of interest concern the marginal value of the GF attribute and the marginal nutrient shadow values. However, we first convert the estimated parameter to a marginal value using the transformation described above. With respect to the GF attribute, the calculated parameter is 2.538 and the t-ratio is 36.682. Therefore, we fail to reject the null hypothesis that the original estimated value for GF snack foods is zero. Converting the elasticity estimate to a marginal value using equation (2) implies that a snack food which is GF is expected to sell for $1.856 more than a gluten-containing alternative, *ceteris paribus*. Thus, snack products which are GF will be on average $1.86 above those which are gluten-containing at the retail level. Among the other parameters

of interest, snack foods from major producing countries sell for $0.101 (10 cents) more than non-major producing countries. This result is likely due to the fact that there are more premium brands sold in these countries, confirming the second hypothesis. Further, branded products sell for an average $0.096 more than unbranded products, also as expected.

On a per gram basis, total fat contributed $0.280/gram to the overall price. In addition, fat contributes only a slightly smaller amount to the price of snack foods as fiber, because the marginal value of fiber is estimated to be $0.175/gram of snack food. These results are consistent with prior research by Sabanis, Lebesi, and Tzia (2009), and Stojceska Ainsworth, Plunkett and İbanoğlu (2010), in that they find added fiber increases the overall price. Protein was hypothesized to have a positive effect on price, as it is highly sought after in a well balanced diet, especially in snack foods. The results in Table 3 show that the marginal value of protein is $0.134/gram – consistent with the hypothesis, but a lower marginal value than either fat or fiber. Ultimately, however, the primary concern is with the sign and significance of the GF marginal variable.

These results are broadly consistent with prior findings, as we find that GF products have higher prices compared to their gluten-containing counterparts. As reported in the cost analysis studies conducted by Lee, Zivin, and Green (2007), and Stevens and Rashid (2008), GF products were on average 240-242% more costly than gluten-containing foods. Because the hedonic model describes the marginal value of each attribute, our estimated premium is higher than the cost premiums reported by Lee, Zivin, and Green (2007), and Stevens and Rashid

(2008). Therefore, the retail price premium for GF foods is, indeed a measure of value-added and appears to be a profit opportunity for food manufacturers.

[Table 3 in here]

Discussion

In order to put the estimates of the marginal value of GF snack foods in context, recall that GF foods are primarily consumed by people with CD. Although the sample describes only snack foods, they still play a vital role in the GF diet. Even with the obvious dietary restrictions that celiac patients must abide by, snack food items are only purchased if the consumer decides he or she wants to indulge and consume them. Consequently, demand is likely to be highly elastic, as snack food purchases by CD consumers can be classified as impulse purchases. As the supply of any manufactured food product is highly elastic in the short run, these premiums are likely to disappear as food producers recognize the size of the price premiums associated with GF foods. If future research finds that the GF premium is declining over time, then this will provide evidence that manufacturers are responding to the incentive provided by high premiums, and are increasing supply as we expect.

Among the broader implications of these results, the findings call into question the efficiency of the snack food market. If market prices fully reflect all information that is available (Fama, 1970), then any profit opportunity should be arbitraged away by the entry of new firms. While Fama (1970) examined this theory originally in financial markets, its application is also well suited for this analysis concerning the attribute level premiums seen in the GF snack foods

category. With the implied assumptions regarding profitability, any manufacturer has an incentive to enter the GF snack food market if the per unit cost of production is less than or equal to $1.00. Recall that the estimated marginal value for the GF attribute is $1.86. In addition, as noted by White (2006) and Niewinski (2008), the increasing rates of CD diagnosis have helped to fuel market growth for the overall industry, including snack food products (White-Sax 2009; Enis, 2010). Moreover, GF snack foods have realized substantial growth rates both in the short-term, and are predicted to grow at similar rates in the long-term as well (Enis, 2010; White, 2006). Thus, not only has a profit opportunity been identified, it is one that is currently not being arbitraged away. Therefore, the market for GF snack foods is not operating at complete efficiency, and is said to inefficient. This finding raises the important question, therefore, of why agribusiness firms are not entering the market at a rate sufficient to bid down these premiums to the marginal cost of producing GF foods?

The GF snack foods market may be inefficient for any one of a number of reasons. First, due to the dominance of small scale manufacturers, economies of scale cannot be utilized. If realized average production costs are higher than assumed herein, then potential margins may be overstated for the small-size of the GF market. Larger manufacturers that are able to generate higher margins can regard this as an acquisition opportunity, however, and take advantage of existing premiums. Another explanation concerns the contamination issue throughout the production process for GF foods (Luchtefeld, Burton, and Donavon, 2003). Here, manufacturers that previously supplied gluten-containing products are having

difficulty in adopting GF counterparts (McEvoy, 2010). Thus, while economies of scope may not necessarily be absent, it is far more difficult to combine existing gluten-containing product lines with new GF counterparts. In addition, replicating purchases for machinery and general technology is forcing multiple manufacturers to eliminate their gluten-containing assortments (McEvoy, 2010).

Additionally, as both mainstream retailers, private label manufacturers such as Wal-Mart and national brand producers such as General Mills continue to adopt GF snack food products (White, 2006; Wilcox, 2005, White-Sax, 2009), shelf space for new introductions is limited. Lee, Zivin and Green (2007) found that GF products are more difficult to obtain than their gluten-containing counterparts. Even as the rates of diagnosis are increasing (White, 2006; Niewinski, 2008) celiac patients still currently only represent one in 133 people. Thus, retailers of any size, including Wal-Mart, must consider all opportunity costs when replacing gluten-containing products with their GF counterparts. This is due to the fact that while only one in 133 people may purchase a GF product, nearly everyone can potentially be considered a consumer of typical gluten-containing counterparts.

Conclusion

Although research has been proven to advance the awareness of CD and its association with the pathogenesis of other autoimmune diseases, there is still a need to understand the GF market, and the potential premiums which may exist. Here, the focus was on the GF snack foods category, as the rapid growth may be due in part to high retail premiums for products which are promoted as GF. To

approach this matter empirically, a hedonic pricing model was employed to estimate the willingness to pay for the GF attribute.

Using the hedonic regression model, marginal attribute values were estimated for the GF characteristic, origin of production, brand recognition, total fat (g), fiber (g), and protein contents (g). All attributes were statistically significant, as GF snack foods were estimated to sell for a premium of nearly $1.86 above other gluten-containing snack food products.

Although the marginal value of GF foods has been the focus of this analysis, estimated marginal values on a number of other attributes may be of interest to agribusiness firms attracted to entering the GF market. Specifically, snack foods of domestic origin sell for a significant premium, favoring U.S. based and local manufacturers seeking to capitalize on consumer unease with imported food products. Second, brand recognition also plays a vital role as a strong reputation will increase consumer confidence, and build brand loyalty. However, due to particular consumer preferences, product reformulation may be necessary to make GF foods more palatable given the inherent unsuitability of seed-based flours relative to more common, gluten-based inputs.

In addition, the premiums found for both fiber (g) and protein (g) also underline essential nutritional needs of CD sufferers. Dietary fiber is a major deficiency in the GF diet so manufacturers would be well advised to supplement the fiber content of their GF foods. Agribusiness firms can benefit by exploiting this premium, and gain market share among more health conscious individuals. Similarly, added protein content (g) was also found to raise the premiums in GF

snack food items. The relevance of this attribute sheds light on the demand for more nutritional snacks, as the lack of gluten should not affect other nutritional aspects or the overall quality seen throughout these products.

The premiums reported here can have implications for a variety of producers, consumers, and marketing professionals. With information on the marginal value for GF snack foods, agribusiness firms can use our results to guide future pricing strategies, especially when developing new products. Through increasing competition, manufacturers must be able to compete on price, as well as have the capability to endlessly differentiate its innovative product lines. Marketing professionals can also develop more effective campaigns as the attributes included in our model highlight potential factors which directly impact the willingness to pay for consumers. Additionally, retail level outlets can also apply this information to optimally price its GF snack food products, while it provides insight into the demand elasticity's seen throughout this category.

Implications, Limitations, and Future Research

Sirmans, Macpherson, and Zietz (2005) describe the conceptual problems with hedonic models, due primarily to identification concerns. Essentially, the Lancaster (1966) and Rosen (1974) models are not identified as the estimated equations could be specified as supply or demand. In addition, Sirmans, Macpherson, and Zietz (2005) argue that there is nearly an infinite amount of independent variables which can be included in a hedonic pricing model. For this reason, the authors note that there is a potential for multicollinearity among some of these variables. However, out of concern for the issues of multicollinearity,

simultaneity, and endogeneity, this analysis has carefully chosen the explanatory variables to minimize the impact of potential econometric problems. Moreover, the decision to exclude categories such as total calories and sugar reflected the sensitivity to the multicollinearity issue. Furthermore, Kennedy (2008) explains that multicollinearity will not depend on any theoretical or actual linear relationship among the regressors, but more on the existence of an approximate linear relationship (Kennedy, 2008). Thus, similar to calorie and sugar amounts, sodium was also left out of the model due to the fact that it was highly correlated with protein, total fat, and fiber variables.

The GF snack category is likely to be a source of much future research. In terms of demand analysis, there is a considerable amount of research regarding new product launches (Runestad, 2007) and overall sales (Enis, 2010). In addition, analyzing production cost data may provide a clearer outlook into the long term profitability of the industry. Furthermore, GF products are still relatively new. Therefore, more information on each product's attributes must be made available as consumers purchase these items. Future research can also take the same approach, however different GF market categories can be applied through hedonic modeling. Premiums associated with these models can then be compared, while also incorporating any trend analysis to provide a broader outlook on industry direction. Additionally, the range of attributes which can be included in future modeling is infinite. Thus, inclusion of alternative attributes can continually underline the factors which greatly affect this market, and provide further insight for agribusiness firms, and marketing professionals alike.

Moreover, additional opportunities can present itself as the possibility in which GF foods may be used to not only avoid irritating CD sufferers, but can also contribute to proactive treatment options as well. The future of food production on a global scale will only be extended in terms of its functionality, as innovative technologies and advances in medical research will call for increased production in various research areas. Here, the balancing of food for consumption and its applicability for novel uses in society will be of great debate. Moreover, the GF diet is a pure example of how its inclusion can help alleviate distension and even possible fatalities throughout an increasing patient group, yet continually provide the much needed treatment options in the fight against CD.

Table 1

Major Producing Countries, Snacks, Brands, and Number of Variants

Country	Snacks	Brands	Total Number of Variants
Argentina:	Nut Mix, Corn-Based Chips Dried Fruits	Annies Betty Crocker Bare Fruit	88
Australia:	Nut Mix Corn-Based Chips Granola Bars	Annies Fantastic Delites Freedom Foods	133
Brazil:	Nut Mix Dried Fruits Corn-Based Chips	Carrefour Don Pepe Elma Chips	671
Canada:	Popcorn Granola Bars Potato Chips	Oogie's Gourmet Mareblu Naturals Mrs. Mary's Natural	342
Netherlands:	Nut Mix Popcorn Cereal Mix	Annies Pop'n'Good Fantastic Delites	74
New Zealand:	Nut Mix Dried Fruits Potato Chips	Mother Earth Sun Health Foods Go Natural	23
U.K	Popcorn Granola Bars Corn-Based Chips	Betty Crocker Quaker Kettle Chips	73
U.S.	Popcorn Granola Bars Potato Chips	Trader Joe's Glutino Betty Crocker	187

Table 2

Summary Data for Hedonic Pricing Model

	Mean	Std. Dev.	Min.	Max.	#Obs.
Gluten-Free					
Price	2.922	2.731	0.040	27.990	1,150
Major Producing Countries	0.736	0.441	-	1.000	695
Brand Name	0.655	0.476	-	1.000	753
Total Fat (g)	19.789	16.646	-	126.984	1,150
Fiber (g)	5.145	5.176	-	50.000	1,150
Protein (g)	8.994	12.296	-	240.000	1,150
Gluten-Containing					
Price	0.809	0.262	0.340	1.800	1,150
Major Producing Countries	0.608	0.488	-	1.000	896
Brand Name	0.486	0.095	-	1.000	849
Total Fat (g)	23.605	15.348	-	100.000	1,150
Fiber (g)	5.602	4.992	-	44.000	1,150
Protein (g)	11.453	9.979	-	125.000	1,150

Table 3

Hedonic Pricing Model

Variables	Estimate	Marginal Value	Std. Error	T-Stat
Intercept	-6.931	-	0.118	-58.599
Gluten-Free[4]	2.538	1.856	0.069	36.682
Major Producing Countries[5]	0.280	0.101	0.048	5.737
Brand Name[6]	0.549	0.096	0.070	7.818
Ln Total Fat (g)[7]	0.202	0.280	0.043	4.636
Ln Fiber (g)[8]	0.242	0.175	0.063	3.836
Ln Protein (g)[9]	0.128	.0134	0.055	2.321
F-Stat	269.177			
R^2	0.413			

[4]The GF attribute variable was included in order to estimate whether there is a retail price premium when compared to gluten-containing snack foods. The GF attribute variable is categorical, since it was included as a binary indicator (1=GF, 0=gluten-containing).

[5]A country was considered to be 'major producing' if it was observed 20 or more times. The dataset included snack food products from all around the world, therefore only countries that were observed on multiple instances were considered to be 'major producing'.

[6]In order to categorize a brand name that is recognizable, the same methodology was utilized as 'major producing countries'. Here, a brand name was considered to be recognizable if it was associated with at least 10 snack food products under each country. The overall dataset contained multiple observations which observed numerous different brands, therefore leading to a lower brand classification quantity.

[7]Total Fat (g) content along with the preceding nutritional values was observed through the GNPD data collection, and represents the per gram estimate of each snack food at the retail level. This estimate is reported as the raw elasticity estimate, along with the converted marginal value.

[8]Fiber (g) content represents the amount which was provided for each snack food observation, also at the retail level. Similar to total fat (g) content, the measured quantity was transformed into log form, as it is reported as both an elasticity estimate and as a marginal value.

[9]Protein (g) content is simply the quantity associated with each snack food product throughout the dataset. The protein estimate was transformed into a log, as both the estimated elasticity, along with the converted marginal value at the retail level are reported.

Works Cited

Arguea, N. M., & Hsiao, C. (1993). Econometric Issues of Estimating Hedonic Price Functions: With an Application to the US Market for Automobiles. *Journal of Econometrics, 56*(1-2), 243-267.

Celiac Disease - Celiac Sprue. (2009). *Celiac Disease Symptoms and Gluten-Free Diet Information.* Retrieved from: http://www.celiaccentral.org/

Ciclitira, P. J., Ellis, J. H., Knut E., & Lundin, A. (2005). Gluten-free diet—what is toxic? *Best Practice & Research Clinical Gastroenterology*, 19(3), 359–371.

Diekman, C., & Malcolm, K. (2009). Consumer Perception and Insights on Fats and Fatty Acids: Knowledge on the Quality of Diet Fat. *Annals of Nutrition & Metabolism, 54*, 87-96.

Edelman, J., Fewell, A. (1985). Commodities into Food. *Philosophical Transactions of the Royal Society of London. Biological Sciences,* (310)1144, 317-325.

Ekeland, I., Heckman, J., & Nesheim, L. (2004). Identification and Estimation of Hedonic Models. *Journal of Political Economy, 112*(1), 304-310.

Enis, M. (2010). Gluten-Free: Still a Niche. *Supermarket News*, 58(7).

Fama, E.F. (1970). Efficient Capital Markets: A review of Theory and Empirical Work. *Journal of Finance,* 25(2), 383-417.

Fasano, A. (2001). Celiac disease: The past, the Present, the Future. *Pediatrics,* 107(4), 768-771.

Faulkner-Hogg, K.B., Selby, W.S., & Loblay, R.H. (1999). Dietary Analysis in Symptomatic Patients with Coeliac Disease on a Gluten-Free Diet: The Role of Trace Amounts of Gluten and Non-Gluten Food Intolerances. *Scandinavian Journal of Gastroenterology, 34*(8), 784-789.

Friedrick, J. (2007). Wheat Allergies, Awareness Drive Gluten-Free Sales. *Gourmet News,* 72(9), 22-23.

Green, P.H., & Jabri, B. (2006). Celiac Disease. *Annual Review of Medicine, 57,* 207.

Harding, J.P., Knight, J.R., & Sirmans, C.F. (2003). Estimating Bargaining Effects in Hedonic Models: Evidence from the Housing Market. *Real Estate Economics,* 31(4), 601-622.

Kennedy, P. (2008). A *Guide to Econometrics*. Fourth Edition. (pp.93-106). Malden, Massachusetts: Blackwell Publishing.

Lancaster, J.K. (1966). A New Approach to Consumer Theory. *The Journal of Political Economy,* 74(2), 132-157.

Lee, A., Zivin J., & Green, P. (2007). Economic Burden of a Gluten-Free Diet. *Journal of Human Nutrition & Dietetics,* 20(5), 423-430.

Leffler, D.A., Edwards-George, J., Dennis, M., Schuppan, D., Cook, F, Franko, D. L., Blom-Hoffman, J., & Kelly, C.P. (2008). Factors that Influence Adherence to a Gluten-Free Diet in Adults with Celiac Disease. *Digestive Diseases and Sciences, 53*(6), 1573-1581.

Luchtefeld, W., Burton, M.S., & Donavon, P. (2003). The Importance of Gluten-Free Diet. *Nurse Practitioner, 28*(7), 47-49.

Malterre, T. (2009). Digestive and Nutritional Considerations in Celiac Disease: Could Supplementation Help? *Alternative Medicine Review, 14*(3), 247-259.

McEvoy, C. (2010). The Challenge of Gluten-Free Food Production. *NFCA Online.* Retrieved from: http://www.celiaccentral.org/

Mendoza, N, & McGough, N. (2005). Coeliac Disease: An overview. *Nutrition & Food Science, 35*(3), 156-162.

Mintel-Global New Products Database. (2010). *Gluten-Free Data Set*. Retrieved from http://www.gnpd.com/

Niewinski, M.M. (2008). Advances in Celiac Disease and Gluten-Free Diet. *Journal of the American Dietetic Association*, 108(4), 661-672.

Ohlund, K., Olsson, C., Hernell, O., and Ohlund, I. (2010). Dietary shortcomings in children on a gluten-free diet. *Journal of Human Nutrition and Dietetics, 23*(3), 294-300. .

Rosen, S. (1974). Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition, *Journal of Political Economy*, Vol. 82(1), 34-55.

Rubin, K.W. (2006). Gluten-Free Menus. *Food Service Director*, Vol. 19(3), 19-20.

Runestad, T. (2007). Gluten-free label proposal should boost sector. *Functional Foods & Nutraceuticals*, Vol. 63(10), 10-11.

Sabanis, D., Lebesi, D., & Tzia, C. (2009). Effect of Dietary Fibre Enrichment on Selected Properties of Gluten-Free Bread. *Food Science and Technology, 42*(8), 1380-1389.

Shan, L, Molberg, O, Parrot, I, Hausch, F, Filiz, F, Gray, G.M, Sollid, L.M, & Khosla, C. (2002). Structural Basis for Gluten Intolerance in Celiac Sprue. *Science*, 297(5590), 2275-2279.

Shewry, P.R., Halford, N.G., Belton, P.S., & Tatham, A.S. (2002). The Structure and Properties of Gluten: An Elastic Protein from Wheat Grain. *Philosophical Transactions: Biological Sciences*, (357)1418, 133-142.

Shin, A. (2009). Companies cater to food allergies; Market Grows for Gluten-Free and Nut-Free Products. *The Huston Chronicle* p3.

Sirmans, G., Macpherson, D., & Zietz, E. (2005). The Composition of Hedonic Pricing Models. *Journal of Real Estate Literature*, *13*(1), 3-43.

Stark, S. (1999). Living with Celiac Disease. *The American Journal of Nursing*, 99(3), 24B-24D.

Stevens, L., & Rashid, M. (2008). Gluten-free and regular foods: a cost comparison. *Canadian Journal of Dietetic Practice & Research*, *69*(3), 147-150.

Stojceska, V., Ainsworth, P., Plunkett, A., & S., İbanoğlu. (2010). The Advantage of using Extrusion Processing for Increasing Dietary Fibre Level in Gluten-Free Products. *Food Chemistry, 121*(1), 156-164.

Sutton, S.M., Balch, G.I., & Lefebvre, C.R. (1995). Strategic Questions for Consumer-Based Health Communications. *Public Health Reports* 110(6), 725-733.

Thompson, T. (1997). Do oats belong in a gluten-free diet? *Journal of the American Dietetic Association, 97*(12), 376-379.

Wahab, P.J., Meijer, W.R., & Mulder, J.J.C. (2002). Histologic Follow-up of People with Celiac Disease on a Gluten-Free Diet; Slow and Incomplete Recovery. *American Journal of Clinical Pathology, 118,* 459-463.

Whiteley, P., Rodgers, J., Savery, D., & Shattock, P. (1999). A Gluten-Free Diet as an Intervention for Autism and Associated Spectrum Disorders: Preliminary Findings. *Autism, 3*(1), 45-65.

White, L. (2006). Gluten-Free Seal Introduced. *Gourmet News*, 71(1) 3-5.

White-Sax, B. (2009). Gluten-free takes the cake in snack food products. *Drug Store News, 31*(10), 125-126.

Witte, A.D., Sumka, H.J., & Erekson, H. (1979). An Estimate of a Structural Hedonic Price Model of the Housing Market: An Application of Rosen's Theory of Implicit Markets. *Econometrica,* 47(5), 1151-1173.

Wilcox, T. (2005). Wal-Mart goes gluten-free. *Natural Foods Merchandiser.* 26(9), 22-23.