QUALITY CHARACTERISTICS AND CONSUMER ACCEPTABILITY OF TRADITIONALLY FORMULATED AND REFORMULATED HIGH PHENOLIC PEANUT BUTTERS

By

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(Under the Direction of Ruthann Swanson)

ABSTRACT

Polyphenols are antioxidants that confer potential health benefits. Peanut butters enhanced with high phenolic peanut skins were compared to commercial products deemed acceptable based on sales data. Objectives were: (1) to determine quality characteristics of commercially available peanut butters, (2) to compare quality characteristics of commercial products to peanut butter prototypes containing high phenolic peanut skins, and (3) to assess consumer responsiveness to health claims. Objective tests assessed texture and appearance. Appearance of reformulated peanut butters was comparable to commercial products. Reformulated peanut butters exhibited increases in firmness, adhesiveness, and gumminess and decreased ease of spreadability when compared to commercial products ($p<0.05$). Focus groups revealed interest in high fiber peanut butters with traditional quality characteristics. Marketing and packaging as high fiber products should be investigated.

INDEX WORDS: peanuts, peanut butter, sensory tests, peanut skins, health claims

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CHAPTER 1: INTRODUCTION

In recent years, chronic diseases such as heart disease, cancer, and diabetes have increasingly become health issues both worldwide and in the United States. Worldwide more people die of chronic diseases than infectious diseases, maternal and perinatal conditions, and nutritional deficiencies combined (WHO 2005a, WHO 2005b). In the United States, the Centers for Disease Control and Prevention (CDC) reports 133 million Americans had at least one chronic disease and seven out of ten deaths in 2005 were attributed to chronic diseases. Like the World Health Organization (2005ab), the CDC (2009, 2010) suggests these figures could be greatly reduced with the proper diet and physical activity.

Worldwide, cardiovascular disease is the leading cause of death with 17.1 million people suffering fatalities in 2005. It is estimated that in the year 2030, 23.6 million people will die from cardiovascular disease. According to the WHO, 80% of all cardiovascular diseases could be avoided through a healthy diet, physical activity, and the avoidance of tobacco (WHO 2005ab). Healthy diets full of fruits, vegetables, whole grains, and beans and peas can also help reduce the risk of developing many cancers. According to the American Institute of Cancer Research (AICR), having excess body fat increases the risk of developing seven cancers: esophageal, pancreatic, colon and rectum, endometrium, kidney and breast cancers. The AICR recommends that at least two-thirds of your meals should be fruits and vegetables, whole grains, and beans and peas; these dietary choices coupled with regular exercise will help maintain a healthy weight and reduce the risk of developing cancer (AICR, 2012). Diabetes has also become an increasing issue in the United States in recent years. According to the American Diabetes Association (ADA), 25.8 million people in the United States currently have diabetes with an additional 79 million people being prediabetic. The ADA recommends a healthy diet with fruits, vegetables, and low-fat dairy along with regular physical exercise to maintain a healthy weight and prevent or control diabetes (ADA, 2012). Therefore, a healthy diet has the potential to help reduce a person's risk of developing chronic diseases such as cardiovascular disease, cancer, and diabetes. Specifically, diets that are high in antioxidants may help to reduce the prevalence of these diseases.

Dietary antioxidants and health

Dietary antioxidants are defined as "a substance in foods that significantly decreases the adverse effects of reactive oxygen species, reactive nitrogen species, or both on normal physiological function in humans" (USDA and USDHHS 2010). Further, antioxidants have also been found to be beneficial in the prevention of inflammation (Shahidi 2004). Both nutritive and nonnutritive antioxidants are present in food. Phenolics, a non-nutritive class of antioxidants, are among the most studied of all the antioxidants. In plants, phenolics, which are the products of secondary metabolism, have been shown to help in the defense against pathogens, parasites, and predators. In humans, phenolics have been linked to protection against many chronic diseases including cardiovascular disease, neurodegenerative disorders, and cancer (Ovaskainen and others 2007, Lui 2004, Hodzic 2009).

It is due to their strong antioxidant properties that phenolics have a potential role in the prevention or management of chronic health conditions. Phenolics can act on reactive oxygen species directly or indirectly to limit cancer development, osteoporosis, and other chronic conditions (Scalbert and others 2005; Shahidi 2009). Like some other dietary antioxidants, phenolics help to decrease oxidative stress by scavenging free radicals which would otherwise cause cell damage. In humans, aging and associated chronic diseases are often associated with increased accumulation of oxidative damage due to reactive oxygen species. Chronic inflammation also has been associated with obesity, diabetes and cancers (Wellen and Hotamisligil 2005). Jensen and others (2006) found that individuals with higher consumption of whole grains had decreased biomarkers for inflammation and ischemic heart disease. Antioxidants, including phenolics found in these foods, have been credited with this decrease in inflammation biomarkers.

Dietary intake of antioxidants

Although phenolics and other antioxidant compounds found in plant-based foods have been shown to be beneficial to human health, it is likely that many people in the United States do not typically consume the amounts that are needed to realize the associated benefits (Manach and others 2004; The Peanut Institute 2010; Ovaskainen and others 2007). Fruits and vegetables, which contain phenolic acids, as well as other antioxidants**,** are the most common and highest sources of antioxidants in the American diet (Ovaskainen and others 2007). It is estimated that Americans consume 100 times more phenolics than the nutritive antioxidants vitamin E and carotenoids, and 10 times more phenolics than vitamin C, another nutritive antioxidant (Scalbert and others 2005; Chen and Blumberg 2008). However, most Americans likely consume less than the optimal intake as indicated by consumption of less than the recommended number of servings of fruits and vegetables. Although the MyPlate recommendation is that most people consume five to nine servings of fruits and vegetables each day, the typical American is only consuming 2.6 servings each day (USDA and USDHHS 2010). Because Americans do not consume the recommended amount of fruits and vegetables, they are likely not getting the associated health benefits from the antioxidants in these foods. By increasing consumption of antioxidants, the incidence of chronic diseases and illnesses in the American public may decrease.

Grain consumption also increases the amount of antioxidants in the American diet and on average Americans consume more than the number of servings recommended per day. However, of the grains consumed daily, the MyPlate dietary guidance suggests that half be consumed as whole grains, which are higher in antioxidants and other nutrients than are found in the more commonly consumed refined grains. Of the 6.4 ounces of grains consumed each day on average, only 0.6 ounces are typically whole grains. Thus, selection of refined grains over their whole grain counterparts decreases the potential antioxidant contribution from this dietary source. However, the level of consumed antioxidants likely increases among Americans with the inclusion of coffee, tea, dark chocolate, and wine which are commonly consumed as part of the diet; but, these foods have lower levels of polyphenols and therefore do not completely compensate for the inadequate dietary consumption of fruits and vegetables and whole grains (USDA and USDHHS 2010). At present, there is no recommendation for the amount of antioxidants that should be incorporated into the diet despite increasing evidence for the linkage between antioxidant consumption and decreases in chronic disease (Jensen and others 2006).

Historically, there have been some concerns with the consumption of phenolics and other antioxidants. Once classified as antinutrients, phenolic compounds have been shown to interfere with the absorption of nutrients in the digestive tract, cause growth inhibition, and potentially cause infertility (Thompson 1993). Some of these compounds have also been found to complex with proteins, starches, and enzymes, which causes a decrease in nutritional value of these high phenolic foods because the phenolic-macronutrient complexes that are formed are not as bioavailable. Historically, this reduction in nutrient bioavailablity was a major concern. However, in the 1970s and 1980s, there began to be a shift in dietary concerns from nutrient deficiencies to chronic disease prevention. This altered focus lead to a push to decrease consumption of fat, calories, and sugar while increasing consumption of fruits, vegetables, and other high antioxidant foods (National Dairy Council 2011). More recently, consumption of these high antioxidant foods has been linked to the promotion of healthy blood glucose and insulin levels as well as healthy plasma and triglyceride levels (USDA and USDHHS 2010). Today, consumption of high antioxidant foods such as fruits, vegetables, and whole grains is encouraged through dietary guidance such as My Plate and the Dietary Guidelines provided by government agencies (USDA and USDHHS 2010), as well as by non-government dietary guidance as shown via the Mediterranean Diet Pyramid (Bosetti and others 2003; WHO 2011; FDA 2010) and Dr. Weil's (2011) Anti-Inflammatory Pyramid.

Limiting effects on consumer consumption of foods high in antioxidants

The sensory properties of foods high in phenolics may not appeal to consumers. When selecting among available foods, it has been shown that perceived "taste" is the most influential factor influencing consumption (IFIC 2011). Taste as defined by consumers includes aromatics, flavor, texture, and mouthfeel. Many of the plant foods that naturally contain phenols tend to be bitter, acrid, or astringent. These are attributes that consumers find to be undesirable and products with notable levels of these sensory characteristics tend to be avoided. Further, people also tend to avoid bitter-tasting foods because, evolutionarily, the bitter taste is associated with toxins. By avoiding foods that taste bitter, humans and other animals avoid the potential threat of toxins present in those products. Knowing this, the food processing industry has removed the phenols and other compounds that contribute to the undesirable "taste" in order to encourage consumer acceptability and therefore product purchases. Debittering techniques used include selective breeding that eliminates the offensive compounds and processing techniques that remove the bitter tasting compounds. However, the consumer who selects these lower phenolic products will not realize the potential health benefits associated with the phenolics that occur naturally in the unaltered products (Drewnowski and Gomez-Carneros 2000).

Current consumer trends

American consumers are increasingly aware of the potential of dietary choices to positively impact health. The IFIC Survey (2011) reveals that 87% of Americans believe that foods and beverages can provide health benefits beyond basic nutrition. More specifically, consumers are aware of the protection afforded by antioxidants against free radical damage (84%). Additionally, 80% of consumers indicated that they are or would be interested in consuming food or beverages for added health benefits, suggesting a market for functional foods.

Although there is no legal US definition for "functional foods," they are commonly considered to be any food that offers "additional benefits that may reduce the risk of disease or promote optimal health" (ADA, 2009). The additional benefits may be inherent or added through enhancement or processing (ADA, 2009). Thus, functional foods may fall in the "better-for-you" class of products. "Better for-you" foods are those foods that a consumer would typically consume that have been reformulated to have more nutritious profiles such as being lower in fat or sodium, or higher in antioxidants. When products like those in the "better-for-you" category are reformulated to impart health benefits, targeting basic foods eaten across all sectors of the population enables the associated benefits to reach the most people (van Raaj and others, 2009).

Acceptance and continued use of "better-for-you" foods is important for consumers if they are going to realize the potential benefits afforded by these alternatives to conventional foods in the marketplace. According to the IFIC Survey (2011), consumers (65%) are increasingly making dietary choices based on beliefs that specific foods or food ingredients can help them improve their health. However, taste (88%) and price (72%) are the most important influences on purchasing decisions. This shows that, while healthfulness is an important criterion influencing consumer food selections today, healthfulness alone does not ensure consumer selections or continued use. Among consumers, functional foods are viewed as being members of the particular food category to which they belong, rather than as a separate homogenous product category. Therefore, functional foods and their consumer acceptability should be studied as members of their product category (Siro and others 2008), as products not classified as “better-for-you” in each product category are the direct competitors.

When considering what products in the marketplace to buy, consumers rely on information available on the packaging or at point-of-sale. This includes not only the nutrition facts label, but also health claims that are present on the packaging, as well as the ingredient list on processed products (Drichoutis and others 2006). According to the Nutrition and Labeling Education Act (NLEA) of 1990, antioxidant claims on food products are considered to be an authorized health claim**.** To qualify as an authorized health claim, a relationship between a food, food component, dietary ingredient, or dietary supplement and risk of a disease must be established. The FDA Moderization Act of 1997 authorized the use of health claims based on authoritative statements from an appropriate federal agency or the National Academy of Sciences (NAS) (FDA 1999). An example of an antioxidant health claim that may be found on food labels might be: *“this food is a good source of antioxidant beta-carotene”* (FDA 2009a).

Peanuts and peanut butters

It is estimated that, of all of the “nuts” consumed by Americans each year, 67% are in the form of peanuts or peanut butter (The Peanut Institute 2010). While peanuts are not botanically a nut, but rather a legume, they are used like nuts in the American diet due to their sensory qualities post-processing. Peanuts have many of the nutritional and health benefits associated with tree nuts (ADA, 2009).

When roasted peanuts are processed into peanut butter and labeled as such, this processed product must meet the Standard of Identity as detailed by the FDA (FDA 2009b). The

Standard of Identity states that peanut butters must consist of at least 90 percent peanuts and contain no more than 55 percent fat. The remaining 10 percent of peanut butter may consist of salt, specific sweeteners, and oil (FDA 2009b, FDA 2011). In general, a serving of peanut butter, about two tablespoons, contains about 190 calories, eight grams of protein, 16 grams of fat, no cholesterol, and only three grams of sugar. Peanut butter is also a good source of many vitamins and minerals. Niacin, magnesium, vitamin E, folate, copper, and phosphorous are all found in peanut butters and contribute 10 to 20% of the daily values of these vitamins and minerals per serving (National Peanut Board 2010). Therefore, despite its high fat content, peanut butter is a good source of many nutrients.

Peanuts and peanut butters are also good sources of phenolic compounds. Levels present are often reported as total phenolics content (TPC), a measure of all of the phenolics present in solution, after extraction from the food matrix. For convenience, it is typically assumed that all phenolic acids present exist as a specific phenolic acid, often gallic acid; data are reported as gallic acid equivalents (GAE). Studies have shown that there are 4.2 mg GAE in one gram of skinless peanuts (Chen and Blumberg 2008). Reported levels of total phenolics in peanut skins range from 90mg GAE/g to 150mg GAE/g (Nepote and others 2002; Yu and others 2005), with amounts varying with sample source and the sample preparation and extraction technique used. Levels of specific phenolic compounds are also reported. Ballard (2008) reported that commercially available peanut butters contain 0.27 to 0.75 µg/g resveratrol and 0.07 to 0.23 µg/g picied, a glucoside of trans-resveratrol, both phenolic compounds. Therefore, one serving (2 tablespoons or 36 grams) of peanut butter yields 9.72 to 27 µg resveratrol and 2.52 to 8.28 µg picied. In addition to resveratrol, several additional phenolic compounds including p-hydroxybenzoic acid, p-coumaric acid, ferulic acid, epicatechin, quercetin, and chlorogenic acid have been identified in peanuts and peanut products (Win and others 2011). Of these compounds, ferulic acid and epicatechin were only found in the peanut skins.

Although peanuts and peanut products are popular among Americans consumers, peanuts are one of the eight foods responsible for 90% of the allergic reactions to food in the United States and any food containing peanuts or peanut products except oil are covered by the required allergen declaration on the product label. An allergic reaction can range from less severe symptoms such as coughing and tingling in the mouth to extremely dangerous symptoms such as swelling in the tongue and throat and loss of consciousness and even death (CDC 2012). It has recently been found that some polyphenols, such as tannins, are able to bind the peanut proteins responsible for this allergic reaction thereby making these proteins unavailable to the body during digestion (Chung and Reed 2012). The proanthocyanidins in the peanut skins are phenolic compounds that can complex with the allergen, making it indigestible in the body. Theoretically, the addition of peanut skins to peanut butter may reduce or prevent allergic reactions to the peanuts (Takano and others 2007; Tomochika and others 2011).

Consumers have specific expectations for the aroma, appearance, flavor, and texture of peanut butter. Peanut butter should smell like fresh, roasted peanuts. It should have a rich, warm, golden, caramel coloring and should not be too light or dark for such products are seen as bland or burnt, respectively. Consumers are highly suspicious of particulates in the peanut butter, especially darker colored particulates. Because of this fact, peanut butters should be well blended to be a uniform color. Although peanut butter should have a gloss or satin sheen, it should not appear oily to the eye. Generally, peanut butters should have the flavor of fresh roasted peanuts, be somewhat sweet and should not have a bland taste. Texture is expected to be smooth and firm, although crunchy as well as creamy styles are available; regardless of style, it should not be oily, grainy, stiff, runny, gluey, or pasty. Although adhesiveness is desirable, the peanut butter should not be too sticky; rather, the product should melt in the mouth and slide easily down the throat. Spreadability, a related attribute, is also an important textural characteristic. Although the peanut butter should stick to the knife, it should also spread easily and thickly on a piece of bread without tearing the bread (McNeill and others 2000).

Consumers use peanut butter in a variety of ways. Peanut butter can be used as a snack, as part of a main meal, or as an ingredient in a product. Therefore, when purchasing peanut butter, how the product will be used, price, and preference are all considered when selecting among available products (McNeill and others 2000). Many customers, especially those over the age of 35, are extremely brand loyal. However, the market for peanut butter is continuing to expand and includes more healthful and natural varieties that are particularly popular among health conscious consumers and parents with young children (Mintel Reports 2010).

Because of peanut butter's unique nutritional profile, this product is a good source of nutrition for most people. It provides protein without adding cholesterol to the diet and provides many vitamins and minerals. The fat present is mostly monounsaturated. It also contains a number of phenolic compounds. During the processing of peanut butter, peanut skins are removed from the peanuts; these skins also contain high levels phenolic compounds and if consumed may further increase phenolic content, broaden the range of phenolics present and thereby contribute to a decreased risk of chronic diseases, without the added challenge of changing consumer dietary patterns. In preliminary work, high antioxidant value-added peanut butter prototypes were created with the addition of ground peanut skins, an industry by-product, while the standard of identity of the product as dictated by the US FDA was maintained. Total phenolics content of the peanut skin-enhanced peanut butters increased linearly by 93, 278, 490 and 741% at 1.25, 2.5, 3.75 and 5% addition levels, respectively, when compared to peanut butters devoid of peanut skins (Ma and others, 2011). Yet for a successful product launch, these peanut butters must have no adverse flavor/taste, texture or appearance defects. Preliminary sensory studies have shown this to be the case: consumers found the overall acceptability as well as the acceptability of the appearance, texture and flavor of the peanut butters fortified with up to 2.5% peanut skins (both blanched and light roasted) equal to those with no added peanut skins. When fortified with 5% blanched peanut skins only the appearance was slightly less acceptable than the non-fortifed product; however, no differences in overall acceptability or the acceptability of texture or flavor were found. Further, no differences in ease of spreadability were found (Sanders and others 2011). These high antioxidant peanut butter prototypes provide a potential opportunity to capitalize on consumer desire for convenient, commonly consumed better-for-you products at an affordable price.

Research questions

(1) What are the baseline quality characteristics of the traditionally formulated peanut butter products currently in the marketplace;

(2) how do these products compare to high phenolic reformulated peanut butter prototypes identified as high in antioxidants;

(3) and are consumers responsive to antioxidant claims on reformulated peanut butters?

Overall hypothesis

The range of quality characteristics of peanut butters available in the marketplace will encompass those exhibited by peanut butters reformulated to enhance phenolic content and consumers will be responsive to antioxidant claims on reformulated peanut butters.

Specific aims
Specific Aim 1:
To characterize the appearance of commercially available peanut butter samples with objective techniques.
It is hypothesized that there is a range of appearances in commercially available peanut butters.
Specific Aim 2:
To characterize the texture of commercially available peanut butter samples with instrumental techniques.
It is hypothesized that there is a range of textures available in commercially available peanut butters.
Specific Aim 3:
To compare the appearance and texture of reformulated high phenolic peanut butters with those in the marketplace.
It is hypothesized that the reformulated high phenolic peanut butters will have appearance and texture characteristics that fall within the range found for commercially available peanut butters.
Specific Aim 4:
To assess the responsiveness of consumers to antioxidant labels on reformulated high phenolic peanut butters through focus groups
It is hypothesized that consumers will be accepting of the antioxidant labels on the peanut butters and explanatory themes will emerge from the focus groups.

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CHAPTER 2: LITERATURE REVIEW

Phytochemicals

Phytochemicals are compounds found in plants that can affect the health of humans. These compounds are not essential nutrients; however, they may provide some health benefits beyond that of basic nutrition. These compounds can be found in abundance in fruits, vegetables, grains, and other plant-based foods. Phytochemicals are known to be a part of a plant's natural defense mechanisms, providing protection against microbial threats. They also provide color, aroma, and flavor to foods when those plants are consumed. In humans, phytochemicals can confer protection against an array of diseases ranging from cancer to asthma.

There are 5 classes of phytochemicals: carotenoids, phenolics, alkaloids, nitrogen-containing compounds, and organosulfur compounds (Figure 2.1) (Liu 2004). Each class is characterized by the structure of the base skeleton and number and type of constituent atoms. Across the five classes, scientists have identified over 5000 distinct phytochemicals. Of all of the phytochemical classes, carotenoids and phenolics are the most studied due to their antioxidant and anti-carcinogenic properties in humans. Carotenoids are nutritive phytochemicals whereas phenolics are non-nutritive phytochemicals (Drewnowski and Gomez-Carneros 2000) that can be further divided into phenolic acids, flavonoids, stibenes, coumarins, and tannins (Figure 2.1) (Liu 2004).

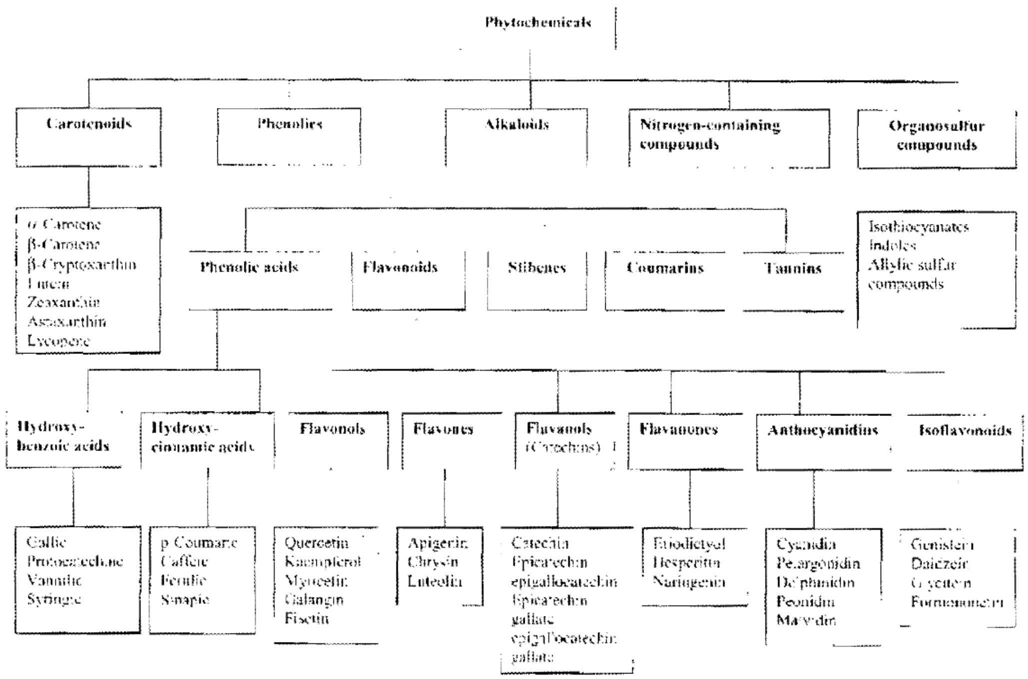

Figure 2.1: Classification of dietary phytochemicals (Lui 2004)

Phenolics

Phenolics are denoted by the presence of one or more aromatic rings and one or more hydroxyl groups (Hodzic 2009). The aromatic ring structure of a phenolic compound makes it a good antioxidant. Figure 2.2 shows some common polyphenols found in foods. Antioxidants, like phenolics, may influence the development of chronic disease through two related mechanisms: reduction of chronic inflammation and oxidative stress. Oxidative stress is a condition in which oxidants form in excess in the body and potentially led to damage to tissues and organs (Sies 1997). This occurs when metabolic processes form unstable atoms, or free radicals. These free radicals then strip electrons from surrounding atoms in order to achieve stability. The stripped atoms then become unstable and strip electrons from other surrounding atoms, thereby perpetuating the cycle. This process continues until all of the atoms are stabilized (Kuroki and others 2003; Sohal and Weindruch 1996; Sies 1997). When a free radical is captured by a phenolic compound, the resonance in the aromatic rings helps to stabilize the compound, making it a lower energy compound than are compounds with free radicals that do not have resonance. This allows the phenolic compounds to stabilize radicals and prevent further damage to cells associated with oxidative stress (Scalbert and others 2005). When present, free radicals damage the cell and necrosis may result (Simopoulos 2001); alternatively, mutant cells that can cause diseases may form within the body. A diet high in antioxidants, including phenolics, can reduce cell damage caused by free radicals and keep effects of oxidative stress to a minimum. Therefore, antioxidants help prevent and manage these diseases through effects on reactive oxygen species (Sies 1997; Simopoulos 2001).

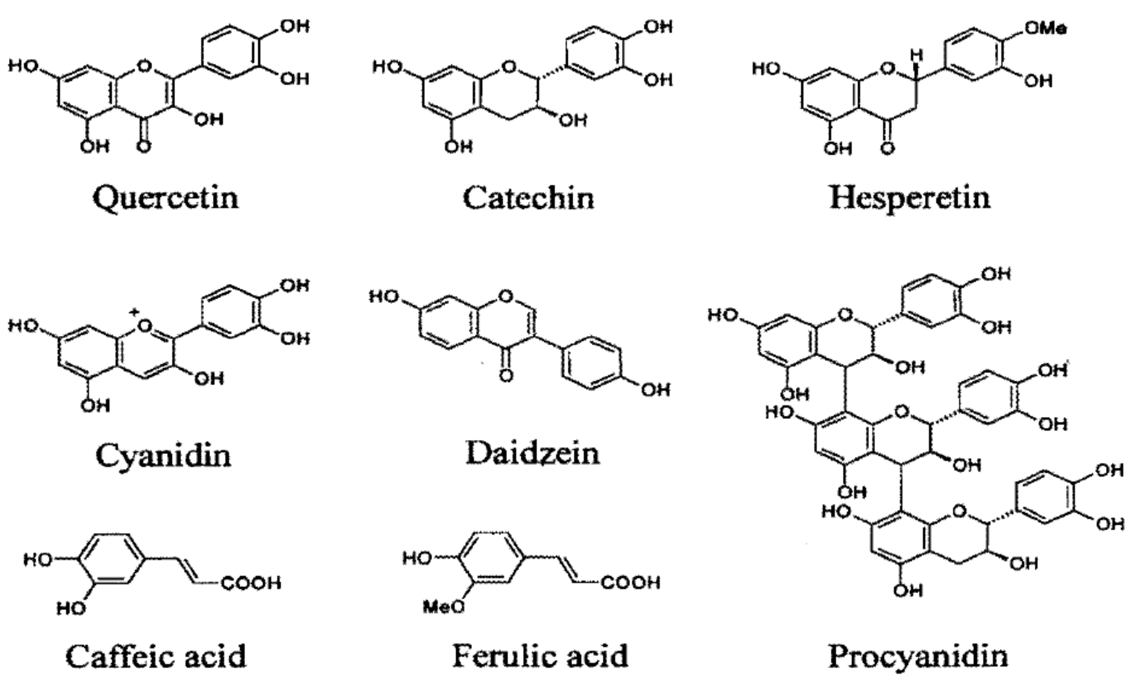

FIGURE 2.2: Structures of common polyphenols (Scalbert and others 2005)

In addition to effects on the development of neurodegenerative diseases, cardiovascular disease, and cancers, oxidative stress has been linked to chronic inflammation (Shahidi 2004; Ovaskainen and others 2007) and antioxidants may influence the development of chronic diseases specifically through an effect on chronic inflammation. Inflammation is a protective mechanism in which fluid surrounds the injured tissues and helps to protect and facilitate healing of the affected area. While this is often a signal of an acute injury, inflammation is emerging as a chronic condition in some individuals and has been associated with obesity, diabetes, and cancers (Wellen and Hotamisligil 2005). Jensen and others (2006) noted that lower inflammatory status in individuals may be associated with positive dietary choices such as healthful carbohydrates including dietary fiber and low glycemic index carbohydrates. Further, Jensen and others (2006) showed that increased intakes of whole grains, specifically, reduced the prevalence of plasma homocysteine, a marker for inflammation. These anti-inflammatory effects have been linked to the presence of antioxidants. Therefore, an increase in antioxidants in the diet through selection of high phenolic foods has the potential to decrease inflammation associated with chronic diseases (Jensen and others 2006; Wellen and Hotamisligil 2005).

Phenolic Determination in Foods

There are a variety of tests used to determine the phenolic content of a food. The oxygen radical adsorption capacity assay (ORAC), measures total antioxidant capacity of a food by determining the decrease in fluorescence after being mixed with free radical generators. An ORAC database for foods and ingredients has recently been generated by the UDSA (Huang and others 2005, Scalbert and others 2005). The ferric-reducing ability of plasma (FRAP) assay is also used to determine antioxidant capacity. In this assay, the antioxidant capacity is measured by single electron transfers. The ability of the substance to trap free radicals and reduce other chemicals is determined using ferric ions as oxidants (Huang and others 2005). Total Phenolic Content (TPC) is a third way to measure phenolics in compounds. This is also a single electron transfer-based assay. The Folin-Ciocalteu reagent is used to react with the phenolic compounds through an oxidation-reduction reaction. In this assay, a phosphomolybdic/phosphotungstic acid reagent is reduced by the antioxidant. This creates a molybdenum oxide which is blue in color. The intensity of the color is directly proportional to the total quantity of phenolic compounds in the sample (Park and others 2009). Linear correlations have been found between the phenolic profiles generated by TPC and antioxidant activity as measured by FRAP. While FRAP and ORAC have been found to be reliable measures of antioxidant capacity in foods, TPC is more sensitive specifically to phenolic compounds. Because TPC is highly standardized and used in research world-wide, a large body of data has been obtained with this method (Huang and others 2005). However, a number of variables impact the final numbers obtained. The extraction conditions employed such as choice of solvent system, material:solvent ratio, particle size distribution, extraction times, number of extractions, and temperature (Nepote and others 2005; Dai and Mumper 2010) impact the efficiency of extraction and thereby result in different recoveries of phenolics. In addition, various researchers (Francisco and Resurreccion 2009) have used different standard curves, which also impact the absolute phenolics values obtained.

Phenolics in the American Diet

The most common phenolics compounds in the typical American diet are the flavonoids and derivatives of phenolic acids, with fruits, vegetables, nuts, spices, herbs, legumes, and beverages as the main dietary sources. Fruits such as cherries, pears, grapes, and berries contain 200-300 mg of polyphenols per 100 g of the fruit, and an eight ounce cup of coffee or eight ounces of red wine contains about 100 mg of polyphenols. (Manach and others 2004, Scalbert and others 2005). Younger plants tend to have higher amounts of polyphenols than do mature plants (Drewnowski and Gomes-Carneros 2000), and whole or minimally processed foods tend to have higher levels than are found in their more highly processed counterparts (Shahidi 2009). According to Scalbert and others (2005), it is estimated that intake in the United States of phenolics, specifically, is about 1 g/day. This is higher than the intake for all of the other dietary antioxidants.

Polyphenolics in Peanuts and Peanut Butters

Peanuts and peanut products are commonly consumed foods in the United States that also contribute to the dietary intake of antioxidants, as well as other nutrients. Improved diet quality has been associated with the consumption of peanuts and peanut products (e.g. peanut butter) as indicated by the lower intakes of saturated fat and cholesterol and by the higher intakes of the micronutrients vitamin A, vitamin E, folate, calcium, magnesium, zinc and iron, and dietary fiber. Further, despite a higher energy intake over a two-day period, peanut and peanut product consumption was not associated with a higher BMI (Griel and others 2004). Recent data suggest that regular nut consumption, including peanuts, may help regulate body weight through effects on satiety and fat absorption (Coates and Howe 2007). According to the American Dietetic Associations (2009) position paper on functional foods, consumption of peanuts, like tree nuts, may also reduce the risk of sudden cardiac death by reducing total cholesterol and LDL cholesterol. Reduction in total cholesterol by 4-12% and LDL cholesterol by 6-15% with consumption of "healthy nuts" has been reported (Hasler 2002). In addition, peanuts are a good source of protein, containing more protein than any other legume or nut. Further, peanuts are a less expensive form of protein in the diet than are red meats and poultry, making them a good choice for individuals with limited income. In February 2012, the United States Department of Labor's Bureau of Labor Statistics reported the average prices of retail food showing that peanut butter, ground beef, and chicken breasts cost $2.75 per pound, $3.92 per pound, and $3.11 per pound, respectively (BLS 2012).

Peanuts and peanut products contain several different phenolic compounds; p-hydroxybenzoic acid, p-coumaric acid, ferulic acid, epicatechin, quercetin, chlorogenic acid, and resveratrol have been identified (Win and others 2011). Both the types and levels of phenolics present are influenced by genetic types, environmental conditions, germination, ripening, processing, and storage. Phenolics, which are secondary metabolites in plants, generally concentrate in the outer layers such as the peel, shell, and hull (Bravo 1998) and the specific ones present often differ depending on the specific site analyzed within the plant, irrespective of other influential factors. For example, in peanuts, ferulic acid and epicatechin are only found in the skins. A range of 3.26 milligrams to 5.52 mg of gallic acid equivalents per 1 gram of peanut butter, with an average of 4.2 mg gallic acid equivalents, has been found. Peanut skins have been found to have a significantly higher amount of gallic acid equivalents with 90 to 150 milligrams of gallic acid equivalents per gram (Kornsteiner and others 2006). The phenolics compounds found in peanuts , individually or in different combinations, have been shown to be potentially anti-carcinogenic, anti-tumor, anti-viral, and anti-inflammatory (Ferrero and others 1998, Hu and others 2001, Alper and Mattes 2003, de Jong and others 2003, Win and others 2011). However, in general, it appears to be the combination of bioactives and their synergistic effects that are responsible for their effects on disease prevention (Shahidi 2009). TPC of peanut butters reformulated with peanut skins subjected to different heat treatments at different incorporation levels is found in Table 2.1.

Table 2.1: Total Phenolic Content (mg/g GAE) of Peanut Butters (Sanders and others 2011)

Total Phenolic Content (mg/g GAE) [a] of Peanut Butters as affected by peanut skin incorporation and heat treatment within level of peanut skin incorporation (n=3)

	Heat	LS-Means ± SEM			
Skin[b]		0	2.5	5	StdErr
		3.4c	5.6b	10.0a	0.30
Heat (Skin) [b]	Blanched	3.3f	5.7d	10.0b	0.52
	Light	3.9ef	5.9d	12.2a	0.52
	Medium	3.0f	5.3de	7.7c	0.52

[a] Total phenolic content was determined with Folin Ciocalteu reagent and reported in mg/g Gallic acid equivalents (GAE)

[b] LS-means followed by different letters are significantly different ($p<0.05$) according to mixed model analysis of variance (PROC MIXED) and LS-means separation with PDIFF.

Peanut Butter Standard of Identify and USDA Grading Standards

Standards of identity are federally-set requirements that state what a food product must contain in order to be marketed under a specific name in interstate commerce. These standards are set to protect the customer so that he or she knows exactly what he or she is purchasing and will not be deceived by labeling. The standard of identity for peanut butter was set by the FDA in 1968 and states that in order to be labeled as peanut butter, the product must contain at least 90 percent peanuts and be no more than 55 percent fat. Additional ingredients such as salt, sugar, dextrose, honey, or hydrogenated or partially hydrogenated peanut oil are allowed and must be listed and accounted for on the nutrient facts label and in the ingredient list. Other ingredients permitted to be added to peanut butters include emulsifiers such as lecithin. Furthermore, the standard of identity prohibits the addition of artificial colors or flavors or vitamins A,B,C, and D. While the establishment of a standard of identity helps with monitoring and assuring quality control of peanut butter, companies trying to reformulate peanut butters to enhance their nutritional profile have encountered legal issues because the new products that were reformulated to meet consumer demands for lower-fat peanut butters did not meet the standard of identity set for peanut butter. These new, healthier products cannot be labeled peanut butter, but rather are classified as peanut spreads (FDA 2009b). Because peanut skins are an inherent part of the peanut, their incorporation does not violate the standard of identity. In addition, the incorporation of peanut skins allows the bioactives present in the peanut skins as well as the kernel to be incorporated, capitalizing on their synergistic action (Shahidi 2009).

In 1972, The USDA established standards for grades of peanut butter based on color, consistency, absence of defects, and flavor and aroma. Defects are outlined for each grading category. Any off-color, such as too light brown, too dark brown or slightly grey would be considered a defect. Textural defects for peanut butter as outlined include excessively thick or thin such that spreadability of the product is affected, the presence of dark particulates, and any other characteristics that affect the wholesomeness of the product or detract from the appearance or credibility of the product. Each characteristic is given a score and then these individual scores are summed to obtain an overall score for the peanut butter. This overall score can then be translated into a grade. U.S. Grade A or U.S. Fancy peanut butters have scores of 90 or above, demonstrating that they have good color and consistency, are practically free from defects, have good flavor and aroma, and have uniform dispersion of any added ingredients. U.S. Grade B or U.S. Choice peanut butters have earned a rating of 80 to 90 points. These peanut butters are classified as having reasonably good color and consistency, are reasonably free of defects, have reasonably good flavor and aroma, and have reasonably uniform dispersion of added ingredients. Peanut butters that receive a score of less than 80 points are classified as substandard and do not make it to the consumer marketplace (USDA 1983).

Peanut butters are available in several forms based on texture, stabilization, and packing-style. Textures include smooth, which does not contain any pieces of peanuts and chunky or crunchy, which do contain peanut pieces. Peanut butters are also classified as stabilized or nonstabilized. Stabilized peanut butters are those that have been prepared by any special process or with any special ingredient so that separation of the oil does not occur, whereas nonstabilized peanut butters have not had any process or ingredient added in order to prevent separation. Packing style is designated regular or specialty-pack style. Regular pack is defined as “a stabilized type peanut butter prepared from peanuts from which the skins have been removed and to which salt and suitable nutritive sweetener(s) have been added.” Specialty packed peanut butters would be any peanut butter that does not fit this definition, therefore peanut butters made from unblanched peanuts or those in which the above mentioned ingredients required for stability have not been added would be classified as specialty pack (USDA 1983).

Peanut Butter Processing

Peanut butter is made by roasting the peanuts (either in oil or by dry roasting). The peanuts are then allowed to cool prior to blanching. Blanching is the process that removes the peanut skin from the kernels. Both dry and wet blanching are used. In dry blanching, the kernels are exposed to warm air, which loosens the peanut skins. The kernels are then passed through a blanching machine where large rollers rub the surface of the kernels until the skins fall off. Temperatures for dry blanching range from 94°C to 175°C with application times of 5 to 25 minutes (Francisco and Resurreccion 2009). Both whole and split nuts can be dry blanched. Water blanching may also be done. In this process the peanuts are placed on a conveyor belt. Blades then slit the peanut skins. The peanuts are then exposed to hot water sprayers which help to loosen the slit skins. Large rollers then assist in removing the skins. If water blanching is done, the peanuts must be dried prior to further processing into peanut butter. For quality control, in both blanching methods, kernels are checked with electronic color sorters to ensure that the blanching process is complete and the skins are removed (American Peanut Council 2011).

High phenolic peanut skins become a byproduct of the roasting and blanching processes. These skins are typically discarded and either incinerated or sold as animal feed (Ballard 2008). However, by incorporating the skins into the peanut butter, a high phenolic product with a broader range of phenolics, may be produced. If blended-in well so the consumer does not notice a significant color difference and the particulates incorporated are inconspicuous, this may create an acceptable consumer product with a higher level of phenolics than found in the conventionally processed product. Preliminary consumer data (Table 2.2) suggests reformulation to increase phenolic content with the addition of peanut skins in peanut butter produces a product that equals the acceptability of the traditionally formulated product (Sanders and others 2011).

Table 2.2: Consumer Acceptability of Peanut Butters (Sanders and others 2011)

Table 4.9: Consumer Acceptability of peanut butters prepared with added peanut skins differing in heat treatment (n=140)

	Skin Level LS-Means ± Standard Error[a]						
	0%	2.5%			5.0%		
Attribute	Control	Blanched	Light Roast	Medium Roast	Blanched	Light Roast	Medium Roast
Appearance[b]	6.4 ± 0.2a	6.5 ± 0.2a	6.2 ± 0.2a	5.8 ± 0.2a	5.5 ± 0.2c	5.0 ± 0.2d	4.6 ± 0.2d
Ease of Spreadability[b]	6.7 ± 0.1a	6.8 ± 0.2a	6.3 ± 0.2a	6.3 ± 0.2a	6.5 ± 0.2a	5.8 ± 0.2b	5.8 ± 0.2b
Consistency[c]	6.0 ± 0.1c	6.2 ± 0.2bc	6.4 ± 0.2b	6.4 ± 0.2b	6.0 ± 0.2c	7.0 ± 0.2a	6.9 ± 0.2a
Texture[b]	6.5 ± 0.1a	6.5 ± 0.2a	6.3 ± 0.2ab	6.3 ± 0.2ab	6.4 ± 0.2a	5.8 ± 0.2bc	5.6 ± 0.2c
Flavor[b]	6.6 ± 0.2ab	6.9 ± 0.2a	6.2 ± 0.2bcd	6.4 ± 0.2abc	6.2 ± 0.2bcd	6.0 ± 0.2cd	5.7 ± 0.2d
Overall[b] Acceptability	6.5 ± 0.1ab	6.7 ± 0.2a	6.2 ± 0.2bcd	6.4 ± 0.2abc	6.1 ± 0.2cd	5.9 ± 0.2d	5.4 ± 0.2e

[a] LS-means ± standard error within a row followed by a different letters differ significantly ($p<0.05$)
[b] Evaluated on a 9-point hedonic scale where 1 = dislike extremely and 9 = like extremely
[c] Evaluated on a 9-point scale where 1 = runny; 9 = stiff

Sensory Attributes of Peanut Butter

Aroma, appearance, flavor, and texture influence consumer acceptability of peanut butter. McNeill and others (2000) conducted two focus groups to determine peanut butter attributes important in consumer selection and use. In each focus group, participants provided descriptive characteristics of peanut butter without an aid, provided descriptive characteristics aided by tasting, and provided descriptive characteristics based on the descriptors previously established for appearance, aroma, flavor, and texture. Both desirable and undesirable characteristics were identified. It was found that customers expect peanut butter to smell like fresh, roasted peanuts without any detection of rancidity, sourness, or burnt odors. For a majority of customers, peanut butter appearance is extremely important aspect when selecting among available products for purchase. Color was the most important aspect of appearance and a rich, warm, golden, caramel coloring was desired. Peanut butters that were too light or dark were perceived as bland or burnt, respectively, suggesting color is used to assess flavor. Peanut butter should also have a gloss or satin sheen, however it should not appear oily to the eye. When selecting peanut butter, consumers were highly suspicious of darker colored particulates in the peanut butter. Because of this fact, peanut butters should be well blended to be a uniform color. However, presence of particulates is characteristic of natural peanut butters which are a growing market segment (Mintel Reports, 2010)., suggesting some consumers are accepting of this “defect.”

For consumers, peanut butter flavor was difficult to define. However, most indicated that a somewhat sweet, rich, but not bland, flavor reminiscent of fresh roasted peanuts was desirable. Texture was also an important aspect of peanut butter acceptability. Peanut butters are available in creamy, medium, and chunky or crunchy textures (USDA 1983) and quality characteristics depend somewhat on these textures. However, overall, peanut butter should be smooth and firm. It should not be oily, grainy, stiff, runny, gluey, or pasty. Mouthfeel of peanut butter should not be too sticky, rather, the product should melt in the mouth and slide easily down the throat. Spreadability is also an important textural attribute. The peanut butter should stick to the knife and spread easily and thickly on a piece of bread without tearing the bread (McNeill and others 2000).

Commercially Available Peanut Butters in the United States

Peanut butters are a popular commodity in the United States. Because peanut butter is such a common commodity in the United States, it is important to know what peanut butters are currently available and future trends in the peanut butter market. There are many different brands of peanut butter available and many of these brands offer a variety of choices. Peanut butters can be purchased in creamy or crunchy textures with natural or organic claims and as a low-fat spread along with other options.

Peanut butter consumers tend to be extremely brand loyal. Once a consumer finds a brand that he or she likes, he or she will buy the same brand and style every time with very little consideration as to possible alternatives available in the market (Mintel Reports 2010). In 2010, J.M Smucker Co. had the largest market share of peanut butter with their Jif brand at 38.8% (425 million dollars) followed by Skippy and Peter Pan peanut butters at 19.8% and 7.9% of the market share, respectively (Table 2.1). Private label peanut butters accounted for 20.2% of all peanut butters sold in the United States in 2010. Jif has been able to maintain the largest percentage market share of all companies because of their marketing campaign that targets mothers as well as continuing to come up with new, innovative products that consumers want such as Jif To Go, Jif Omega-3, and Jif Peanut Butter and Honey (Mintel Reports 2010).

Market Drivers

Today, an increasing number of people are opting for “better for you” foods instead of dieting because this approach allows consumers to continue eating the foods that they enjoy while still eating healthier (Sloan 2008). While consumers want healthier options to traditional marketplace items, they also desire quality products. When comparing traditional items to reformulated "better-for-you" items, consumers demand equivalent sensory attributes in the products. They expect the new product to have an improved nutrient profile and the same or similar taste, smell, and texture as found in the original product. Also, when deciding whether or not to choose the reformulated product rather than the less healthy original, consumers will consider the price of the product in comparison with its counterpart. If consumers perceive the reformulated product to be beneficial to them, they may be willing to pay a higher cost for the new product; however, if they do not see the product as beneficial, they will be unlikely to switch to the reformulated product (Drichoutis and others 2006; van Raaji and others 2009; Sloan 2008; Sloan 2009).

Recent industry reformulation efforts have resulted in the emergence of more natural varieties of peanut butter and these new products are helping to reposition peanut butter as a healthier choice. Consumers are increasingly demanding natural peanut butters because they believe these products are "better-for-you." For the consumer, the "natural" claim is often synonymous with minimal processing, less added ingredients, and positive health benefits. Therefore, many brands including Smucker's, Jif, Peter Pan, and Skippy have begun to produce natural peanut butters (Mintel Reports 2010). Other brands, such as MaraNatha, are also producing natural peanut butters. In 2009-2010, the peanut butter market saw a 22.1% increase in the "other brands" category. This was the largest growth category seen in the time period. This category also includes the smaller companies that make natural peanut butters. This may indicate a shift from past consumer brand loyalty (McNeill and others 2000; Mintel Reports 2010) to consumers' willingness to try new brands.

The emergence of healthier foods also has led to a consumer demand for “functional fresh” products. “Functional fresh” products contain ingredients consumers not only associate with positive health outcomes but also with the product itself; this concept does not exclude processed products but rather relates more closely to the fortification ingredients chosen to impart the desired health benefits (Sloan, 2009). Peanut skins are a natural product, already associated by the consumer with peanuts.

Therefore, peanut butters fortified with peanut skins have the potential to help meet the increasing consumer demand for “better-for-you” foods and “functional fresh” foods. With the addition of peanut skins to the peanut butters, consumers are potentially able to increase thehealth benefits without having to change their diets. As long as the peanut butters fortified with peanut skins have similar color, texture, taste, and price as the traditional products, consumers looking for “better-for-you” and “functional fresh” foods could increase their consumption of phenolics while still enjoying a favorite food.

Table 2.3: Consumer consumption of peanut butter in total dollars spent and market share percentage

Company	Brand	2009*	% market share	2010*	% market share	Sales growth 2009-10	
		$million		$million		% change	% change
J. M. Smucker Co.	Total	410	39.4	425	38.8	3.8	-0.6
	Jif	313	30.1	327	29.8	4.3	-0.3
	Smucker's	30	2.9	30	2.8	-0.4	-0.1
	Goober	17	1.6	18	1.6	5.2	0
	Simply Jif	17	1.6	17	1.5	2.3	-0.1
	Laura Scudder	11	1.1	12	1.1	4.4	0
	Adams	11	1.1	11	1	-1.5	-0.1
	Jif To Go	8	0.7	8	0.7	5.8	0
	Other	3	0.3	3	0.3	4.9	0
Unilever	Total	208	20	217	19.8	4	-0.2
	Skippy	166	16	173	15.8	4	-0.2
	Skippy Super Chunk	23	2.2	23	2.1	-0.9	-0.1
	Skippy Natural	19	1.8	21	1.9	9.9	0.1
ConAgra Foods Inc.	Total	94	9	87	7.9	-7.3	-1.1
	Peter Pan	83	7.9	77	7	-7	-0.9
	Peter Pan Smart Choice	7	0.7	7	0.6	-8.1	-0.1
	Other	4	0.4	3	0.3	-10.7	-0.1
Private label		210	20.2	221	20.2	5.3	0
Other		120	11.5	146	13.3	22.1	1.8
Total		1,042	100	1,096	100	5.3	-

Source: Mintel Reports (2010)/Based on SymphonyIRI group InfoScan® Reviews™

Labeling/ Point of Sale Information

As more and more nutrition labeling has emerged in the United States, it has been found that consumers are relying more on this information when making decisions about purchases. Consumers want to avoid potential negative ingredients in foods and desire to find foods that will promote health and wellness. Health claims on the front of packages alter the consumers view of the item and they tend to see the item as being healthier than similar products that are available but do not contain a nutritional health claim. This perceived benefit alters the consumers' perspective and will cause the consumer to purchase the product that is seen as healthier. However, this selection is contingent on the perceived "taste" of the product. While consumers desire healthier options for foods that they would normally eat, they will not switch to the healthier product if it does not have the sensory attributes that they desire. These sensory attributes are typically those associated with the conventionally formulated product. Consumers would rather have a less healthy food with the taste they like than a healthier option that does not meet their taste requirements (Drichoutis and others 2006; van Trijp and van der Lans 2007; Williams 2005). Therefore, if a peanut butter product was made available with a health claim, and had the same or similar sensory qualities as the traditionally formulated products, consumers may be more willing to switch to the new product with the health claim because they would see this product as healthier than the traditional products.

Health claims are researched extensively by the FDA and the relationship between the nutrient and a specific disease must be well established before being approved for a health claim. Currently products that contain an authorized health claim about antioxidants must include a disclaimer in the same size and typeface as the claim that states that evidence is limited or not conclusive. Furthermore, because there is little scientific evidence to conclusively support the link between antioxidants and specific diseases, only certain antioxidants such as vitamin E and vitamin C, are eligible for these health claims (See Table 2.4)(FDA 2009a, b, c). However, with increasing research coming out about antioxidants, consumers are becoming more aware of the health benefits that antioxidants can convey. With the positive perception of antioxidants today, having a peanut butter with an antioxidant claim could cause consumers to consider switching from the traditional peanut butter that they purchase to a new, high antioxidant peanut butter.

Table 2.4: Current FDA health claims examples (FDA 2009c)

Health Claim	Model Claim Statments
Fruits, Vegetables, and grain products that contain fiber, particularly soluble fiber and the risk of Coronary Heart Disease	Diets low in saturated fat and cholesterol and rich in fruits, vegetables, and grain products that contain some types of dietary fiber, particularly soluble fiber, may reduce the risk of heart disease, a disease associated with many factors.
Fruits and Vegetables and Cancer	Low fat diets rich in fruits and vegetables (foods that are low in fat and may contain dietary fiber, Vitamin A, or Vitamin C) may reduce the risk of some types of cancer, a disease associated with many factors. Broccoli is high in vitamin A and C, and it is a good source of ditary fiber.
Soluble fiber and risk of coronary heart disease	Soluble fiber from foods such as [name of soluble fiber source, and, if desired, name of food product], as part of a diet low in saturated fat and cholesterol, may reduce the risk of heart disease. A serving of [name of food product] supplies __ grams of the [necessary daily dietary intake for the benefit] soluble fiber from [name of soluble fiber source] necessary per day to have this effect.
Antioxidant vitamins and Cancer	(1) Some scientific evidence suggests that consumption of antioxidant vitamins may reduce the risk of certain forms of cancer. However, FDA has determined that this evidence is limited and not conclusive. or, (2) Some scientific evidence suggests that consumption of antioxidant vitamins may reduce the risk of certain forms of cancer. However, FDA does not endorse this claim because this evidence is limited and not conclusive. or, (3) FDA has determined that although some scientific evidence suggests that consumption of antioxidant vitamins may reduce the risk of certain forms of cancer, this evidence is limited and not conclusive.
Nuts and Heart Disease	Scientific evidence suggests but does not prove that eating 1.5 ounces per day of most nuts [such as name of specific nut] as part of a diet low in saturated fat and cholesterol may reduce the risk of heart disease. [See nutrition information for fat content.] Note: The bracketed phrase naming a specific nut is optional. The bracketed fat content disclosure statement is applicable to a claim made for whole or chopped nuts, but not a claim made for nut-containing products.

Consumer use of health claims on packaging depends on many different factors including individual characteristics; situational, behavioral, and attitudinal factors; nutrition knowledge; motivation; and product involvement factors. Individual factors include age, gender, and education. Studies have found that as age and education increase, people are more likely to read nutrition information on packaging, including nutrition claims, the nutrition facts label, and the ingredient list. This may be due to several factors. For example, as people get older, they become more concerned with their health and are looking for ways to help manage or prevent diseases. This health-related concern causes them to be more likely to read the nutritional information provided on packaging, especially concerning fat content and cholesterol. Education also plays a role in label reading. More educated people have been found to use the nutritional claims and the nutrition facts label to help make decisions about which products to purchase. This population is better able than individuals with less education to make comparisons and use information about sugar, fat, and cholesterol content when purchasing foods. Gender is another factor that comes into play when selecting among alternatives. Females have been shown to be more likely to use the information provided on packaging than males. In general, males tend to be more skeptical concerning nutrition labeling and may not believe that the information is helpful. Further, they may also not see diet and health as being a problem with which they need to be concerned (Drichoutis and others 2005).

Situational, behavioral, and attitudinal factors also play a role when using nutritional information. Income, employment status, special diet considerations, household size, being the main meal planner or grocery shopper, and the surrounding environment can all play a role in deciphering and having confidence in the information on food packaging. Low income or unemployment status causes people to be more cautious when making purchases; therefore they are more likely to buy low-cost foods, even if these foods are not the most healthful foods available. Being the main meal planner or grocery shopper and having larger households with children increase the likelihood of using package nutritional information (Drichoutis and others 2005).

Nutrition knowledge and motivation are other factors that affect reading of nutrition labels. As nutrition knowledge or perceived nutrition knowledge increases, reading and understanding of package labels increases. People who perceive themselves as having nutrition knowledge feel they better understand what the labels mean and are better equipped to interpret the information. In addition, the presence of nutrition labels on packaging may increase nutrition knowledge resulting in consumers who are better equipped to make purchasing decisions. As their purchasing decisions result in healthier choices, consumers are motivated to continue reading labels, thereby further increasing their nutritional knowledge. Even people who do not have a perceived sense of nutritional knowledge may read the labels and gain some knowledge (Drichoutis and others 2005).

Product involvement factors come into effect with repeat purchases. Product involvement factors that influence consumer nutrition label reading include price, nutrition, and taste. Each of these factors influences the extent to which consumers use nutrition labels in the marketplace. If price of a product is a concern to the consumer, he or she will be less likely to read the labels and will simply purchase the least expensive product. As expected, if nutrition is a concern to the consumer, he or she will be more likely to read the labeling on the packages and factor it as well as price into the decision-making process. Finally, taste may or may not alter consumer reading of nutritional information on the package. If products are equivalent in sensory attributes, nutritional labeling may come into play. When comparing products with similar sensory profiles, consumers may then look for additional nutritional benefits when making their decision (Drichoutis and others 2005).

While all of these factors may affect consumer choices, many consumers do not know how to accurately interpret nutritional claims on products. Some people are skeptical of these claims and do not believe that they will actually benefit from consuming the particular food or nutrient being highlighted. Other people see nutritional claims on food products and place too much emphasis on that label information. These people do not truly understand what the label means, and believe that the product is better than it really is. Furthermore, people may assume that because there is a claim for one nutrient, this claim applies to all other nutrients in the product. Often this is not the case and consumers who use label claims in this manner are purchasing items based on misinterpreted information. Another important issue with nutritional labeling is that most people do not know the difference between the types of claims. Knowing the difference between the different claims is important because it allows the consumer to know how much scientific evidence supports the claim, who is ensuring the validity of the claim, and what nutrient and disease or condition are being linked. Without this knowledge, many people can be misled by claims (Drichoutis and others 2006; van Trijp and van der Lans 2007).

Consumer dietary guidance

In an attempt to improve diets overall, including increasing antioxidant consumption, the United States government publishes the Dietary Guidelines for Americans, with the most recent version published as the Dietary Guidelines for Americans 2010. The American government also provides dietary guidance to consumers via MyPlate (USDA 2012). These consumer oriented publications differ because The Dietary Guidelines provide an overview of the types of foods that people should be eating, in what amounts, and the scientific basis for these claims, whereas MyPlate helps people to individualize their diets and choose foods that are appropriate for their age and weight (USDA and USDHHS 2010). Neither the Dietary Guidelines nor MyPlate specifically emphasize the increase consumption of antioxidants; however, adequate consumption of fruits, vegetables, and whole grains which are major sources of antioxidants is stressed. Adequate consumption of these foods, will be associated with the increased consumption of antioxidants as well. In addition to the Dietary Guidelines and MyPlate, the United States government releases Healthy People, ten-year national objectives for improving the health of Americans. In 2000, Healthy People 2010 was released and consumption of fruits and vegetables and other sources of fiber including whole grains were emphasized. The fruit and vegetable objectives outlined in Healthy People 2010 were to have seventy-five percent of the population two years old and older consume two or more servings of fruit per day and fifty percent of the population two years old and older consume three or more servings of vegetables per day. Data collected in 2009 however, show that these goals were not met as only 32.5 percent and 26.3 percent of adults consumed two fruits and three vegetables per day, respectively. The new Healthy People 2020 objectives for fruits and vegetables, which were released in 2010, are to further increase fruit consumption from the current consumption of 0.5 cups to 0.9 cups per 1000 calories consumed and to increase vegetable consumption from the current consumption of 0.8 cups to 1.1 cups per 1000 calories consumed. Healthy People 2010 also had an objective to “increase the proportion of persons aged 2 years and older who consume at least six daily servings of grain products, with at least three being whole grains.” This objective also was not met. The usual intake of grains for the adults in the United States was 6.4 ounces in 2010; however, only 0.6 ounces were from whole grains. The new objective for Healthy People 2020 has been set at 0.6 ounce equivalents of whole grains per 1,000 calories consumed (CDC 2010; UDHHS 2012). Since most people currently only consume 0.3 ounce equivalents of whole grains per 1,000 calories, this objective is aimed at increasing current consumption of whole grains.

The Dietary Guidelines have also begun to emphasize intake of fiber. Dietary fiber comes from sources such as fruits, vegetables, and whole grains. The typical American diet does not contain the necessary amount of fiber. It is recommended that women intake 25 grams per day and men consume 38 grams per day of fiber; however, most Americans consume only 15 grams per day on average. Most of this fiber comes from refined flour found in rolls, breads, and pizza crust. These foods make-up a substantial portion of the American diet, but the refined flours present are not the best sources of grain-based fiber. Whole grain breads and cereals are better options than those are those made with refined flour. However, while whole grains can make a substantial contribution to dietary fiber intake, inclusion of other high fiber foods in the diet facilitates reaching the recommended intake levels. Indeed, the Dietary Guidelines recommend increased intakes of beans and peas, fruits, and vegetables, as well as whole grains. Fiber is important in the diet because it helps to reduce the risk of cardiovascular disease, cancers, obesity, and type II diabetes mellitus. Fiber has also been shown to promote healthy lipid profiles and normal gastrointestinal function (USDA and USDHHS 2010).

While government resources and guidance are helpful to many people when making dietary choices, there are several other, nongovernmental food guides that proactive consumers often consult. The Mediterranean Food Guide Pyramid is based on the traditional diets of people who live near the Mediterranean Sea. During the 1950s, American doctor Ancel Keys conducted the Seven Countries Study and found that people whose diets were high in fruits and vegetables, contained plant-based oils, little red meat and moderate amounts of red wine, had significantly lower incidences of cardiovascular disease. This diet was found to be typical of the diets in Greece, Crete and southern Italy (Hu 2001). In addition to the consumption of plant foods and the selection of low- and non-fat options, and reliance on olive oil instead of butter or margarine as the main fat, the Mediterranean diet emphasizes minimal processing of these foods. With this diet, fish and egg consumption is encouraged weekly while it is recommended that red meat consumption be kept to a minimum, with consumption no more frequent than a few times per month. Further, fruits are eaten regularly and often replace sugar-sweetened desserts. Wine consumption is encouraged in moderation because it contains flavonoids, which have high antioxidant properties. Similarly, the fruits, vegetables, and healthy oils, consumption of which is encouraged, all contain antioxidants. Finally, regular exercise that promotes a healthy weight is a major component of the Mediterranean lifestyle, which serves as the basis of the Mediterranean Dietary Guide (Bosetti and others 2003; WHO 2011; FDA 2010).

Another dietary aid that people often use as a guide to their dietary choices is Dr. Weil's Anti-Inflammatory Food Pyramid. This food guide was designed to help promote healthy living through the incorporation of anti-inflammatory foods in the diet. This pyramid emphasizes fruits and vegetables as the base of the diet followed by grains and carbohydrates, and healthy fats and protein (Weil 2011).

Peanut Butter Quality Assessment Methods

Appearance Evaluation

The USDA Grading Manual (1983) describes how to assess peanut butters for several quality characteristics including the presence of dark particulates, using two photographic guides (USDA Inspection Aid No. 95), which illustrate the maximum limit for presence of dark particles for Grades A and B. When the extent of particulates presence exceeds those established for Grade B, the product is simply classified as substandard. These two photographic guides are inadequate in today's marketplace, however, because they do not represent the whole spectrum of possibilities for particulates present in peanut butters, particularly those in the natural category. During the preliminary studies in which the peanut skin enhanced prototypes were developed, a 6-point particulate scale was developed, with each point on the scale represented by a peanut butter currently in the marketplace. On this scale, one represents the least particulate presence, and six is the most particulate presence (Sanders and others 2011). This particulate perception tool (Appendix A) is based on USDA grading methodology modified to employ a commercially available peanut butter as an anchor for each point on the scale. This approach is similar to that employed by descriptive sensory panelists employing Texture Profile Analysis (Szczesniak and others 1963). Use involves oriented assessors who after comparing the actual samples to the reference products, identify the point on the reference scale that is the closest match.

According to the USDA Grading Manual (1983), good color is considered to be “a rich color typical of peanut butter prepared from properly roasted peanuts. This color is a medium brown that is not too light, too dark, and without grey hues.” However, peanut butter producers often use instrumental assessment of color as part of their quality assurance program (Pattee and others 1991). These instrumental methods provide quantitative data that allow products to be compared. Furthermore, instrumental measurements eliminate the subjective nature of using humans to determine color. Not everyone sees colors the same way, so using calibrated instruments, allows every sample to be evaluated with a reproducible technique. Also, instrumental tests for color take less time and are simple to perform (Good 2002, Mabon 1993).

Using the instrumental method, CIELAB values are generated. This method gives L*, a*, and b* color values. These values have been shown to correlate with the way humans see color and allow any possible color perceived by humans to be quantified. The L* value is the white-black axis, the a* value is the red-green axis, and the b* value is the yellow-blue axis. In the experiment, Pattee and others (1991) who compared instrumental color assessment of peanut butters with those obtained from a trained descriptive flavor panel that also characterized color, established the suitability of instrumental assessment of peanut butter color.

Textural Analysis

Texture of peanut butters is extremely important to consumers (McNeill and others 2000). Traditionally, peanut butter texture has been measured through lubricated squeezing flow viscometry, capillary extrusion rheometry, and using a cone pentrometer and an Instron Universal testing machine equipped with a plunger attachment (Muego and others 1990). These tests measure rheological properties and textural quality. Muego and others (1990) used three different measures to determine texture instrumentally: a Precision universal penetrometer equipped with a cone-shaped probe and an Instron universal testing machine (50kg load cell) equipped with two different test cells: (1) a flat ended cylindrical plunger, and (2) a flat plate. The cone penetrometer instrumental method was the easiest to implement and the most rapid method, however more information was obtained when either of the Instron compression tests was employed. By comparing their instrumental findings with descriptive sensory evaluations, it was found that none of the instrumental methods correlated well with adhesiveness as perceived by sensory panelists. However, spreadability as determined by all three techniques correlated well with sensory descriptions. Similarly, hardness determined using the flat plate compression correlated with sensory assessments for firmness. The researchers concluded that each method could provide valuable data on peanut butter quality characteristics, but overall, the compression methods were better correlated with sensory evaluations than was the cone penetration method.

Focus Groups

Proactive wellness-focused consumers are increasingly purchasing functional foods and nutraceutical beverages in an effort to maintain health and control health care costs (Sloan 2009). These consumers are aware of the link between functional foods and functional food components and health benefits such as the protection afforded by antioxidants against free radical damage (IFIC 2011). Polyphenols specifically, are associated with positive health effects against chronic diseases like cancers, cardiovascular disease, diabetes, neurodegerative disease and osteoporosis, due to their effects on oxidative stress and inflammation (Hodzic 2009, Jensen and others 2006, Liu 2004, Scalbert and others 2005, Ullah and Khan 2008). With the awareness of the capacity of antioxidants to help prevent chronic diseases, it is reasonable to suggest consumers may use this knowledge when making purchasing decisions.

The Theory of Planned Behavior (TPB) is a theoretical framework that has been used to predict and understand behavior change, including dietary behavior and specifically, the acceptance of functional foods (Verbeke, 2005). The key tenet of TPB is that intention has the greatest influence over behavior. Intention is predicted by attitudes (how an individual evaluates the outcomes of performing the behavior); subjective norms (perceived social pressure to perform the behavior); and perceived behavior control (an individual's beliefs about available resources and opportunities to carry-out the behavior) (Ajzen, 1991). Recently, Hall and Fong (2007) have suggested that the TBP does not adequately predict dietary behavior because it does not weigh when the expected rewards occur: short-term or long-term. For the selection of functional foods over conventional foods, both are present. The immediate reward tends to be a hedonic one, suggesting that product acceptability will be key to selection.

Because acceptability is key to selection, consideration of immediate hedonic as well as distal benefit behaviors, such as health effects, within the TPB framework is helpful when attempting to understand consumer selection among available products. Dietary behaviors also tend to be habitual, suggesting that consumers must be given a reason to alter their behaviors. Extending the TPB to include these concepts increased its consumer behavior predictive ability (Collins and Mullan, 2011).

Focus groups are increasingly being used in the qualitative investigation of consumer attitudes and opinions as they relate to nutrition and food product innovation. Focus groups can not only help to explain consumer behavior, but also assist in the design of products that meet consumer expectations and needs. Consumer focus groups have described the optimal characteristics of peanut butter (McNeill and others 2000) and attitudes towards functional foods in general (Barrios and others 2008). Conducting product specific focus groups in which the perceived qualities of traditional and reformulated peanut butters high in antioxidants are explored can give insight into what consumer's desire in their peanut butters and the influences on their purchasing decisions. The impact of specific product characteristics and information, including classification as a functional food, on purchasing decisions can be assessed.

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CHAPTER 3: METHODS AND MATERIALS

Study design

Appearance and texture of commercially produced peanut butters were determined through chemical or instrumental techniques using a factorial experimental design (Table 3.1). Eleven commercially available peanut butters and four laboratory produced peanut butters enhanced with peanut skins at 0, 2.5 and 5.0% were evaluated (Table 3.2). Two repetitions of each peanut butter were done for each test. Two different production lots were evaluated for commercially available peanut butters. For the laboratory produced peanut butters, two different production dates with peanuts and peanut skins sourced from different years were evaluated. However, for the laboratory produced peanut butters, peanut paste and peanut skin processors remained constant as did suppliers for the additional ingredients incorporated. The commercially available peanut butters were chosen based on the most recently available sales data. Because of the trend towards "better-for-you" and healthier foods (Sloan 2008; Mintel Reports 2010; Consumer Search 2011), natural peanut butters were included in the data analysis. Laboratory peanut butters were chosen based on consumer acceptability and phenolic content of the peanut butters (Sanders et al 2011). Potential impacts of identifying peanut butter as a functional food on consumer selection in the marketplace were explored through three focus groups; each focus group had 7-9 members.

Laboratory produced peanut butters

In accordance with the US Standard of Identity for peanut butter (FDA 2011), the control prototype peanut butter, which was made without peanut skins, consisted of 90% peanuts, 6.5% sugar, 1.5% salt, and 2% stabilizer. Roasted peanut paste, flour salt, and stabilizer were supplied by Seabrook Ingredients (Edenton, NC). The stabilizer was a hydrogenated blend of rapeseed and cottonseed oils. Granulated sugar was from Domino Sugar Corporation (New York, NY). In the reformulated prototypes, peanut skins, either blanched or roasted, replaced the stated percentage of peanut paste. Because the peanut skins were lower in fat than was the peanut paste replaced, RBD peanut oil sufficient to maintain the fat content also was incorporated. The roasted peanut skins were obtained from Golden Peanut Company (Alpharetta, GA). Roasting conditions were at 255°F for 11 minutes, followed by 310°F for 14 minutes. Dry blanched peanut skins were provided by Sylvester Blanching, a division of Universal Blanchers, LLC (Sylvester, GA). The peanut oil was from Planter’s Nut and Chocolate Company (Glenview, IL).

Table 3.1 Factorial Design for Instrumental Tests

Assessment	Factors
Texture: Spreadability	15 x 10 x 2[a]
Texture: TPA	15 x 10 x 2[b]
Appearance: Particulate Presence	15 x 3 x 3-4x2[c]
Appearance: Color	15 x 6 x 2[d]

[a] Number of peanut butters x number of samples analyzed x replications; measured using the texture analyzer (TAX-T2 Plus, Texture Technologies Corp., Scarsdale, NY) equipped with a 5 kg load cell and. Each sample was penetrated with TTC spreadability rig once to a distance of 2 mm to the bottom of the cone (Ahmed and Ali 1986) at a contact speed of 5 mm/sec. Data extracted with Texture Exponent 32 (Stable Micro Systems Ltd, Godalming, Surrey, England)

[b] Number of peanut butters analyzed x number of samples analyzed x replications; samples were compressed twice with a 7.62 cm diameter compression disc to 40% of its original height using the texture analyzer (TAX-T2 Plus, Texture Technologies Corp., Scarsdale, NY) equipped with a 5 kg load cell. There was a 5 second wait time between compressions. Samples were deposited with a #100 scoop onto a base-plate; contact and retreat speed was 5 mm/sec (Muego and others 1990).

[c] Number of peanut butters x number of samples analyzed x number of oriented assessors x replications; evaluators determined particulate presence based on comparison to a 6-point particulate reference scale adapted from USDA grading methodology (1983) and ordered 1-6 by increasing prevalence of visible particulates.

[d] Number of peanut butters x number of samples analyzed x replications; measured using a Minolta spectrophotometer (model CM-700d, Minolta Corp., Ramsey, NJ) set to 10-degree observer function, with specular component excluded, and cool fluorescent F6 illuminant.

Table 3.2 Peanut Butters Used for Instrumental and Sensory Analysis

Peanut Butter[a]	Brand/Production Information	City, State	Label Information
0% Control Prototype	University of Georgia Department of Food Science Food Processing Lab	Athens, GA	Peanut Butter
2.5% Dry Blanched Peanut Skins Prototype	University of Georgia Department of Food Science Food Processing Lab	Athens, GA	Peanut Butter
2.5% Light Roast Peanut Skins Prototype	University of Georgia Department of Food Science Food Processing Lab	Athens, GA	Peanut Butter
5.0% Dry Blanched Peanut Skins Prototype	University of Georgia Department of Food Science Food Processing Lab	Athens, GA	Peanut Butter
Jif Creamy	J.M. Smucker Co.	Lexington, KY	Peanut Butter
Jif Natural Creamy	J.M. Smucker Co.	Lexington, KY	Peanut Butter
MaraNatha Creamy	The Hain Celestial Group, Inc.	Melville, NY	Peanut Butter
Naturally More Creamy	Naturally More	Birmingham, AL	Peanut Spread
Peter Pan Creamy	ConAgra Foods, Inc.	Omaha, NE	Peanut Butter
Peter Pan Natural Creamy	ConAgra Foods, Inc.	Omaha, NE	Peanut Butter
Planter's Creamy	Kraft Foods, Inc.	Northfield, IL	Peanut Butter
Reese's Creamy	The Hershey Company	Hershey, PA	Peanut Butter
Skippy Creamy	Unilever Co.	Little Rock, AK	Peanut Butter
Skippy Natural Creamy	Unilever Co.	Little Rock, AK	Peanut Butter
Smucker's Creamy	J.M. Smucker Co.	Lexington, KY	Peanut Butter

[a] Commercially available peanut butters or spreads used for analysis were chosen based on the most recently available sales data (Mintel Reports 2010; Consumer Search 2011); reformulated high phenolic peanut butters were chosen based on prototype formulations deemed acceptable by a consumer sensory panel (Sanders and others 2011).

Quality Characterization

Appearance Determination

Peanut butter samples were spread onto USDA Inspection Aid No. 95 particulate presence sheets using a #60 scoop portion for each sample; each sample completely covered a 4 ½ in x 2 7/8 in area. Three samples per peanut butter were assessed by 3-4 assessors per replication and each sample was identified by a unique three-digit random number code. Anchors (Table 3.2) were also prepared on the USDA particulate presence sheets and were labeled as Anchor 1 through Anchor 6, with Anchor 1 indicating the least presence of particulates and Anchor 6 indicating the highest presence of particulates (USDA 1983, Sanders and others 2011). Three or four evaluators assigned each sample a value of 1-6, based on the closest visual match to the anchors.

Table 3.3: Commercially Available Peanut Butters Serving as Anchor Points on the 6-point Particulate Presence Reference Scale, where 1 is low and 6 is high

Commercial Peanut Butter	Product Information	City, State	Position on Particulate Scale[a]
Reese's Creamy	Hershey Co.	Hershey, PA	1
Welch's Bama Creamy	Algood Food Co.	Louisville, KY	2
Skippy Creamy	Unilever Co.	Little Rock, AK	3
Jif Creamy	J.M. Smucker Co.	Lexington, KY	4
Smucker's Natural Creamy	J.M. Smucker Co.	Lexington, KY	5
Earthfare Organic Creamy	EarthFare	Fletcher, NC	6

[a] Scale developed based on USDA (1983) Grading Standards methodology; pictorial representations of each anchor is found in Appendix A

A Minolta Reflectance Spectrophotometer (model CM-700d; Konica Minolta Sensing, Inc., Ramsey, NJ) was used to determine color of the peanut butter samples. The spectrophotometer was calibrated using a white calibration cap (CM A177). Three color assessments were recorded for each sample: L*, a*, and b*. The L* is lightness, a* is the red-green axis, and b* is the yellow-blue axis. The spectrophotometer took 5 readings for each value and then averaged these assessments to generate the single value per assessment that was used in data analysis. The samples prepared for particulate presence assessment also were used for color determination. Each sample was analyzed for color at two different locations (Pattee and others 1991).

Texture Assessment

Texture of the peanut butter samples was determined using a Texture Analyzer (TA-XT2 Plus, Texture Technologies Corp., Scarsdale, New York), with data extracted from the time-force curve with Texture Exponent 32 software (Texture Technologies Corp., Scarsdale, New York). Both texture profile analysis (TPA) and spreadability tests were performed on each sample using a 5 kg load cell and a crossarm pre-test, test and return speed of 5.00 mm/sec. Ten room temperature samples (21-23°C) from each formulation were analyzed for each instrumental assessment of texture, per replication or production run.

For TPA, the sample (~11.7g) was deposited with a #100 scoop directly on the baseplate and compressed twice to 40% of its original height with a 7.62 cm compression disc; there was a 5 second wait period between compressions. Contact paper covered both the base plate and the compression disc in order to reduce friction with the samples. Data (Figure 3.1) related to firmness, adhesiveness, gumminess and cohesiveness were extracted from the time/force curve (Muego and others 1990).

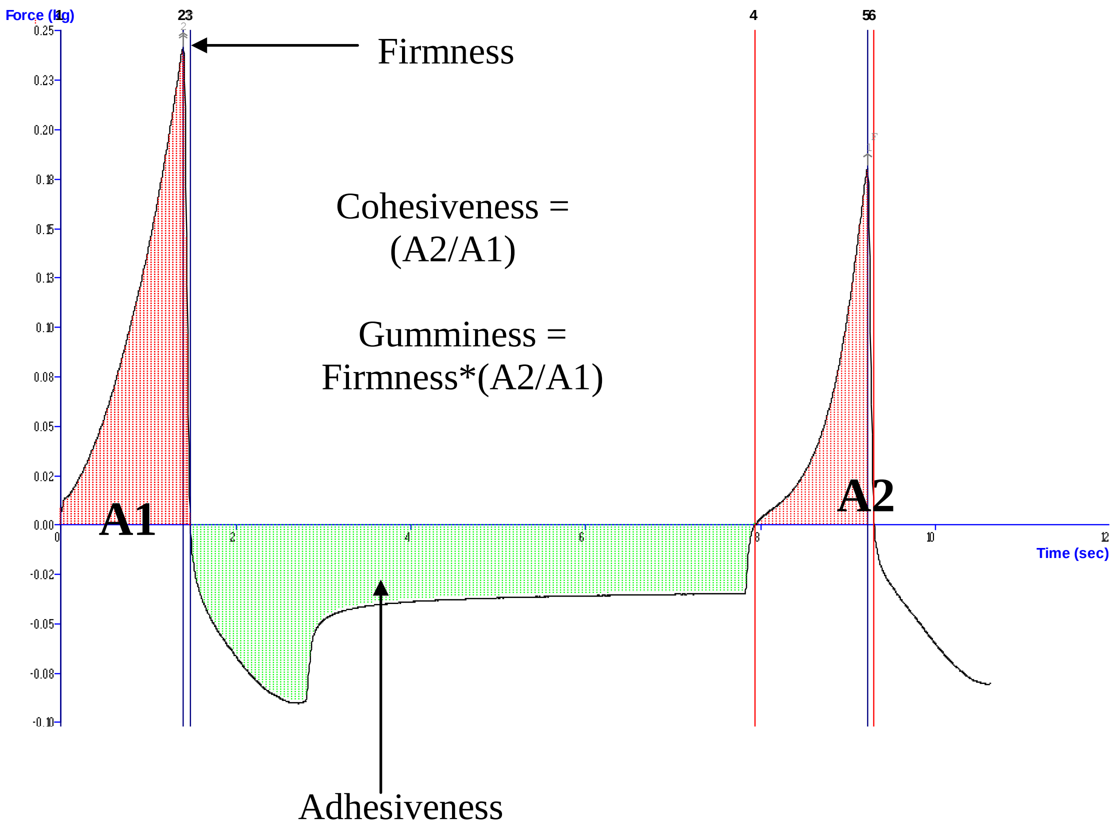

Figure 3.1: Time-force Curve for TPA Parameters

A 45˚ conical TTC spreadability rig with positive and negative cones was used for the spreadability test. The peanut butter samples (~11.7g) were packed, with no air bubbles, into a conical sample holder and leveled to give a uniform upper surface. The upper cone was then penetrated into the sample with the downward penetration ending 2 mm from the bottom of the sample holder. Data (Figure 3.2) related to firmness and spreadability were extracted from the time/force curve (Sanders and others 2011, Ahmed and Ali 1986).

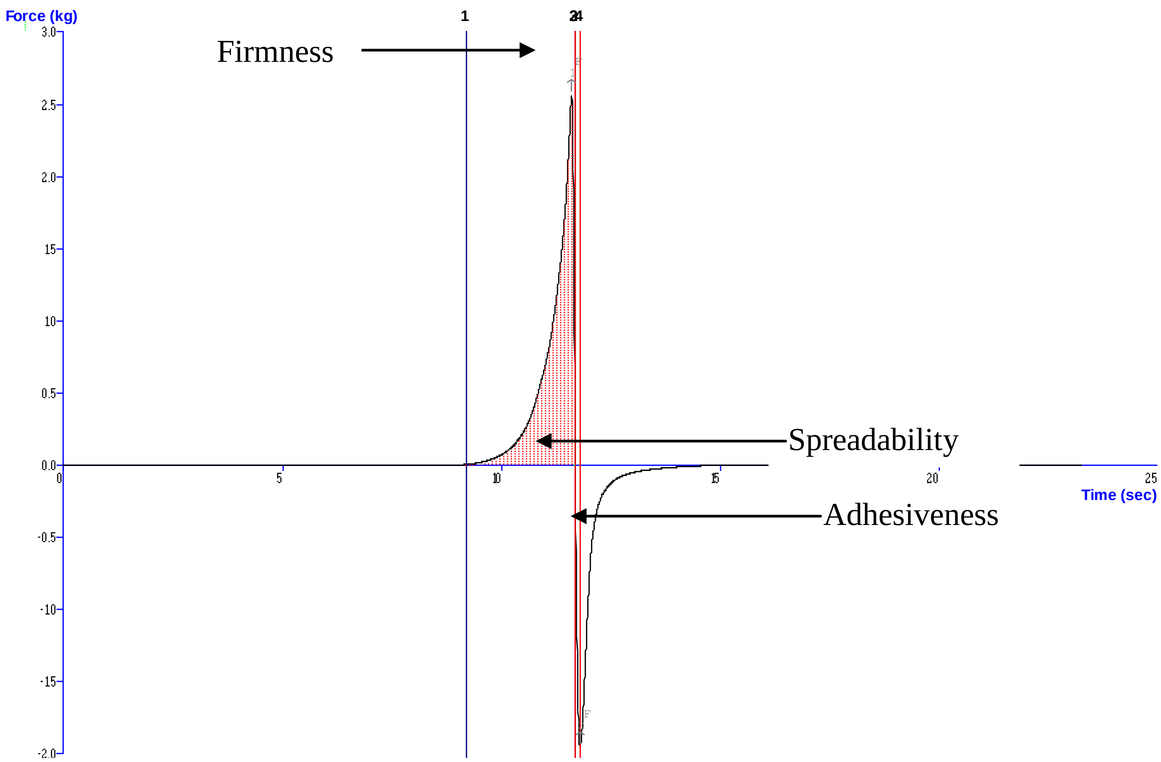

Figure 3.2: Time-force curve for the TCC Spreadability Rig Parameters

Consumer Subjective Analysis of Peanut Butters: Focus Groups

Three focus groups were conducted in order to detect common themes in consumer perception of peanut butters and functional foods. Methods employed by Barrios and others (2008) were used as a basis for the conduction of the focus groups. Six to twelve participants were involved in each focus group. A semi-structured interview guide (Table 3.4) was used. Questions were discussed with the research team and revised according to suggestions. Participants were seated around a table to facilitate discussion and each focus group lasted about one hour. Each focus group was audio or video recorded and permission to do so was obtained beforehand. Before discussions began, each focus group was informed that there were no right or wrong answers, only opinions. Perception of claims on all foods was discussed, followed by perception of potential claims on peanut butters. One focus group consisted of participants (n=9) in the Expanded Food and Nutrition Education Program (EFNEP), one consisted of consumers (n=7) who indicated they consume products labeled as “natural,” and the third focus group consisted of consumers (n=8) in the general population. Participants for the “natural” group and the general population group were recruited by emails, flyers, and electronic media. Any interested person was allowed to participate. EFENP participants were recruited by an EFNEP program agent. Focus group participants were screened for peanut allergies and consumption of peanut butter at least one time per month was a requirement for participation. Reformulated peanut butters in which dry blanched and light roasted peanut skins were incorporated at 0%, 2.5% and 5% were used as discussion aides. All peanut butter discussion aides were presented in unopened jar. Specially, the reformulated peanut butters were used to elicit consumer discussion of perception of appearance of peanut butters on consumer choices. Only reformulated products that were previously deemed acceptable by a sensory panel were included: a control sample devoid of peanut skins, light roast with 2.5% peanut skin additions, dry blanch with 2.5% peanut skin addition, dry blanch with 5% peanut skin addition. Impact of quality deviations from the traditional product on potential consumer selection was probed. All focus groups were presented with the same questions and the same information about the peanut butters.

In addition, focus group participants completed a short written questionnaire (Appendix B). Two questions related to demographic characteristics were used to profile the group members as a whole. Four questions were used to assess each person’s peanut butter purchasing decisions and one question was used as means to place participants in groups based on the purchasing of foods labeled as natural.

All methods and procedures had been approved by the University of Georgia Institutional Review Board on Human Subjects. The approved consent form is found in Appendix E.

Statistics

All data that were collected from the objective tests were analyzed using SAS version 9.1 (SAS, Inc., Cary, NC). Proc Univariate was used to identify outliers among sample values and to determine normal distribution. When appropriate, log transformations were used for analysis. The General Linear Models (PROC GLM) Procedure was used to calculate the descriptive statistics including LS-means and standard errors; significant differences due to sample and replication (production run) were determined with 2-way ANOVA ($p<0.05$); PDIFF was used for LS- means separation, when appropriate.

Focus groups were transcribed and then responses were analyzed for common themes and concepts that arose among the three groups. Two people independently read and analyzed the focus group transcriptions. The analysis of the focus group responses was then compared to verify each person’s interpretation of the data (Barrios and others 2008). Descriptive statistics were used to summarize demographic and peanut butter consumption information. This information was used to profile the focus group participants.

Table 3.4: Interview Guide for the Focus Group Sessions

(1) Introduction
  a. Welcome and introduction
  b. Explain how the focus group will work
  c. Explain equipment
  d. Assure confidentiality

(2) Attitudes and Opinions towards peanut butters
  a. What are all of the words that could be used to describe peanut butter? (Appearance, flavor, texture).
  b. Of these words you have listed, which are positive?
  c. Which are negative?
  d. What are some of the reasons you buy the brand/type of peanut butter that you currently buy? Please consider things that we have discussed and other factors that might affect your choices.
  e. (Show a reformulated peanut butter sample) This is a sample of a reformulated peanut butter. How important is appearance of peanut butters to you?

(3) Attitudes and opinions towards functional foods
  a. What are your top nutrition/health concerns?
  b. Some products have health-related claims on the labels. Can you tell me any of these healthy claims that you are familiar with? (If not, prompt with examples such as soy protein and coronary heart disease, calcium and osteoporosis, sodium and hypertension, etc)
  c. What is your opinion of the sensory quality of these products?
  d. Do you think products with health claims cost the same, more than, or less than similar products without health claims?
  e. Do you believe eating food products that have a health-related claim can affect your health or the health of someone in your household?
  f. What kind of customer would be interested in purchasing foods with health claims?
  g. Are nutrition labels important in your purchasing decisions?
  h. Given two peanut butters with similar sensory characteristics (taste and texture), would you pick the one with an antioxidant claim or not? Why? Would you be willing to try these peanut butters (Show them the reformulated peanut butter samples – they will not be tasting, though)
  i. Would you be interested in a high fiber peanut butter? (Show them the fiber content of both)
  j. Would you be interested in a peanut butter that has a "natural" claim?
  k. On the sheets being handed out, please list which 3 things that we have discussed that are most important to you when purchasing peanut butter? Which 3 things are least important when purchasing peanut butter? (Paper data collection sheets)
  l. Finally, please fill out the table given about how important each factor is to you.

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CHAPTER 4: RESULTS AND DISCUSSION

Peanut Butter Quality Characteristics: Appearance

Consumers have indicated that appearance of peanut butters is extremely important to their quality perception (McNeill and others 2000), with purchasing decisions influenced by the visual inspection of color and particulates. Trained observers evaluated the extent of particulate presence and color was evaluated with instrumental techniques.

Particulate presence

Particulate presence is an important appearance characteristic for consumers. The presence of dark particulates in peanut butters often cause consumers to be skeptical and wary of the product (McNeill and others, 2000). The extent of particulate presence by production date in each peanut butter (Tables 4.1 and 4.2) was evaluated by 3-4 trained evaluators based on the techniques employed when USDA Inspection Aid No. 95 is used to assign USDA grades. A 6-point scale, where 1 is low and 6 is high, was used.

All laboratory-produced samples contained detectable levels of particulates. Significant differences in particulate presence based on production date for the laboratory produced samples (Table 4.1) were found for the 2.5% light roasted peanut butter and the 5.0% dry blanched peanut butter, but not for the control peanut butter or the 2.5% dry blanched peanut butter. Based on qualitative visual inspection by trained observers, the size of the particulates present in these formulations appeared to be smaller when the second production run was compared to the first. Because the weight of peanut skins incorporated remained constant across production runs, differences detected appear to be due to increased abundance of particulates due to decreased particulate size. However, even when significant differences were found, the differences were within a single unit on the 6-point scale, suggesting that while these differences may be statistically significant, they may be of little practical importance.

Table 4.1: Particulate Presence of Reformulated Peanut Butters by Production Date (n=3) [ab]

Peanut Butter	Production Date	Particulate Presence (SE=0.21)
0% Control	1	3.67
	2	3.75
2.5% Dry Blanched	1	4.25
	2	4.58
2.5% Light Roast	1	5.08a
	2	5.67b
5.0% Dry Blanched	1	4.58a
	2	5.17b

[a] Data were collected using a particulate presence scale anchored 1-6 by commercial peanut butters. Each sample was evenly spread onto particulate analysis sheets provided by the USDA covering an area of 4 ½ in x 2 7/8 in per product. Three to four trained panelists evaluated the formulations against the 1-6 particulate scale and gave each peanut butter formulation a grade of 1-6; with 1 being the least presence of particulates and 6 being the highest presence of particulates. Three samples were evaluated for each peanut butter.
[b] LS-means followed by different letters for each peanut butter are significantly different ($p<0.05$) according to General Linear Models (PROC GLM) and LS-means separation with PDIFF

For the commercially produced samples (Table 4.2), significant differences in particulate presence based on production lot were only found for Jif Natural, MaraNatha, and Planter’s peanut butters; differences found between production lots for these samples ranged from 0.92 to 1.25 units on the 6-point particulate presence scale. For the peanut butters that exhibited significant differences, the processors may be more lenient in the range of particulate presence that meets quality control standards. Overall, when present, the differences found due to production lot in the commercial samples exceeded those found when extent of particulate presence in the laboratory samples produced at two different times was examined.

Table 4.2: Particulate Presence of Commercial Peanut Butters by Production Lot (n=3) [ab]

Peanut Butter	Production Lot	Particulate Size (SE=0.21)
Jif Natural	1	4.58a
	2	3.33b
Jif	1	4.16
	2	4.08
MaraNatha	1	2.00a
	2	3.83b
Naturally More	1	6.00
	2	5.58
Peter Pan Natural	1	3.50
	2	3.41
Peter Pan	1	2.75
	2	2.33
Planter's	1	1.00a
	2	1.92b
Reese's	1	3.58
	2	3.41
Skippy	1	2.17
	2	1.67
Skippy Natural	1	1.94
	2	2.41
Smucker's	1	4.92
	2	5.42

[a] Data were collected using a particulate presence scale anchored 1-6 by commercial peanut butters. Each sample was evenly spread onto particulate analysis sheets provided by the USDA covering an area of 4 ½ in x 2 7/8 in per product. Three to four trained panelists evaluated the formulations against the 1-6 particulate scale and gave each peanut butter formulation a grade of 1-6; with 1 being the least presence of particulates and 6 being the highest presence of particulates. Three samples were evaluated for each peanut butter.
[b] LS-means followed by different letters for each peanut butter are significantly different ($p<0.05$) according to General Linear Models (PROC GLM) and LS-means separation with PDIFF

Evaluation of particulate presence in the commercially available peanut butters and the reformulated peanut butters with the addition of peanut skins across production lots is found in

Table 4.3. A wide range of perceived particulate presence was found in the peanut butters evaluated; all contained visible particulates. Naturally More was found to have the most particulate presence of all of the peanut butters evaluated with a score of 5.79 ± 0.148. Naturally More was followed by the reformulated 2.5% light roasted peanut butter and Smucker's with scores of 5.38 ± 0.148 and 5.17 ± 0.148, respectively; unlike the Naturally More, the Smucker's peanut butter was not identified as a "natural" formulation on the label. On the low end of the scale, Planter's was found to have the least particulate presence with a score of 1.46 ± 0.148 followed by Skippy and Skippy Natural at 1.91 ± 0.148 and 2.14 ± 0.148, respectively. Thus, peanut butters that carry the natural claim exhibit a wide range of particulate presence. Even within brand name, perception of particulates in the "natural" formulation was not necessarily greater than was found in the same brand that did not carry the natural claim. Perception of particulate presence in six of the eleven commercially prepared samples was above midpoint on the 6-point scale. All of the laboratory produced samples, including the control were above midpoint on the scale.

When compared to the laboratory control, reformulated peanut butters containing peanut skins were perceived as having a greater abundance of particulates (Table 4.3). Among the reformulated peanut butters, the 2.5% light roast was perceived as having the most particulates present, even though levels of peanut skin incorporation by weight in the 2.5% blanched sample equaled those in the 2.5% light roasted sample and was lower than those incorporated In the 5% blanched sample. These differences are attributed to the incorporation of roasted skins; roasting of the skins results in a darker product when compared to the blanched skins due to the Maillard browning. It has been found that perception of the abundance of particulates may increase as the particulates get darker, even though the actual abundance does not differ (Swanson and others 2005). Because of this color influence the evaluators may have perceived a difference between the 2.5% light roasted peanut butter and the 2.5% dry blanched peanut butter, even though the peanut skins were incorporated at the same level. At these levels of incorporation, the color influences exceeded those of actual abundance. There are also additional confounding factors in evaluating particulate presence; shape, density, and irregular areas will distort perceived abundance. Further, evaluators may find it difficult to distinguish the sizes of the particles. Therefore, it is difficult to accurately compare particulate presence using visual observation, even though evaluator training helps to produce more consistent results (Swanson and others 2005). It is likely that the same factors that influence evaluation by the oriented assessors will have an even greater impact on consumer perception of particulate presence.

Table 4.3: Particulate Presence results: Particulate presence of reformulated and commercially available peanut butters (n=6)[ab]

Peanut Butter	Particulate Presence (SE=0.148)
0% Control	3.71fg
2.5% Dry Blanched	4.42d
2.5% Light Roast	5.38b
5.0% Dry Blanched	4.88c
Jif	4.13de
Jif Natural	3.96ef
MaraNatha	2.92h
Naturally More	5.79a
Peter Pan	2.54hi
Peter Pan Natural	3.46g
Planter's	1.46k
Reese's	3.50g
Skippy	1.92j
Skippy Natural	2.18ij
Smucker's	5.17bc

[a] Data were collected using a 6-point particulate presence scale anchored by commercial peanut butters. Each sample was evenly spread over a 4 ½ in x 2 7/8 in area on a USDA particulate analysis sheet. Three to four oriented panelists assigned each peanut butter formulation a grade of 1-6; with 1 being the least presence of particulates and 6 being the highest presence of particulates.
[b] LS-means followed by different letters in a column are significantly different ($p<0.05$) according to General Linear Models (PROC GLM) and LS-means separation with PDIFF

Color

Peanut butter color has important implications in the consumer's assessment of quality. The characteristic golden brown color, which is attributed to the Maillard browning reaction, results from roasting of peanuts for production of the peanut paste that serves as the base of peanut butter (Pattee and others 1991). Instrumental assessment of color is commonly used in the peanut industry to monitor degree of roasting. Of the three instrumental color parameters, L*, which is related to how dark or light the sample is, has been linked to sensory assessment of color (Pattee and others 1991). Consumers associate desirable color and aroma exhibited by peanut butters with roasted peanuts (McNeill and others 2000)

Color of the laboratory produced peanut butters (Table 4.4) was determined for the two different production dates. Likewise, peanut butter color for the commercially available peanut butters (Table 4.5) was determined for two production lots. Significant differences in color were found between the two production lots for each of the laboratory produced peanut butters (Table 4.4). The consistent pattern suggests the color differences are due to the variation in the color of the peanut butter base rather than the addition of peanut skins. On the second production date, peanut butters were lighter, having L* values in the fifties while the first production batch had L* values around 40. Peanut butters from the second production date were also more red and more yellow than was found for the first production run.

Table 4.4: Lightness, redness, and yellowness of Reformulated Peanut Butters by Production Date [ab] (n=6)

Peanut Butter	Production Date	L* (Lightness) [c]	a* (Red-green axis) [d]	b* (Yellow-blue axis) [e]
0% Control	1	39.9 ± 2.16a	7.3 ± 2.16a	27.6 ± 1.40a
	2	57.87 ± 0.340b	8.64 ± 0.067b	39.47 ± 0.545b
2.5% Dry	1	41.1 ± 2.16a	7.9 ± 0.29a	26.6 ± 1.40a
Blanched	2	56.20 ± 0.340b	8.42 ± 0.067b	36.58 ± 0.545b
2.5% Light Roast	1	39.7 ± 2.16a	7.1 ± 0.29a	24.7 ± 1.40a
	2	53.42 ± 0.340b	8.06 ± 0.067b	34.39 ± 0.545b
5.0% Dry	1	38.1 ± 2.16a	7.4 ± 0.29a	25.6 ± 1.40a
Blanched	2	54.02 ± 0.340b	8.36 ± 0.067b	35.50 ± 0.545b

[a] Data collected using a Minolta spectrophotometer (model CM-700d, Minolta Corp., Ramsey, NJ) on two different locations on each 4 ½ X2-7/8 in sample, with 6 samples per peanut butter.
[b] LS-means followed by different letters for each peanut butter are significantly different ($p<0.05$) according to General Linear Models (PROC GLM) and LS-means separation with PDIFF
[c] Lightness on a 0-100 scale where 0 indicates black and 100 indicates white.
[d] Represents the red-green axis where positive values indicate red hues.
[e] Represents the blue-yellow axis where positive values indicate yellow hues.

There were also significant differences in color parameters found for some of the commercially available peanut butters (Table 4.5). Jif, Jif Natural, MaraNatha, and Skippy Natural peanut butters all were found to exhibit significant differences in lightness (L*), redness (a*), and yellowness (b*). Other commercial peanut butters evaluated exhibited differences in one or two of these color parameters.

Table 4.5: Lightness, redness, and yellowness of Commercial Peanut Butters by Production Lot[ab] (n=6)

Peanut Butter	Production Lot	L* (Lightness)[c] (SE=0.241)	a* (Red-green axis)[d] (SE=0.047)	b* (Yellow-blue axis)[e] (SE=0.386)
Jif Natural	1	55.35a	6.92a	33.79a
	2	52.89b	8.03b	36.94b
Jif	1	57.73a	6.15a	33.33a
	2	59.18b	6.52b	34.52b
MaraNatha	1	57.06a	6.02a	32.43a
	2	58.62b	7.01b	36.91b
Naturally More	1	57.76	7.50	36.29
	2	57.87	7.59	37.62
Peter Pan	1	56.22	8.31a	39.33a
Natural	2	55.47	8.56b	41.09b
Peter Pan	1	55.38a	8.49	38.20
	2	56.40b	8.54	39.38
Planter's	1	60.49	7.34a	37.34a
	2	61.17	7.81b	39.41b
Reese's	1	58.85	7.70	37.70
	2	58.73	7.71	38.13
Skippy	1	57.63	8.06a	38.07
	2	57.61	8.41b	39.32
Skippy Natural	1	57.35a	8.10a	37.40a
	2	56.11b	8.32b	40.20b
Smucker's	1	56.08	7.87a	37.30a
	2	55.56	9.19b	40.24b

[a] Data collected using a Minolta spectrophotometer (model CM-700d, Minolta Corp., Ramsey, NJ) at two different locations on each 4 ½ X 2-7/8 in sample, with 6 samples per peanut butter.
[b] LS-means followed by different letters for a peanut butter are significantly different ($p<0.05$) according to General Linear Models (PROC GLM) and LS-means separation with PDIFF
[c] Lightness on a 0-100 scale where 0 indicates black and 100 indicates white.
[d] Represents the red-green axis where positive values indicate red hues.
[e] Represents the blue-yellow axis where positive values indicate yellow hues

Across production periods (Table 4.6), peanut butter L*, a*, and b* differed significantly due to sample. For the lightness value, L*, values between 53.42 and 60.83 were found. All samples were slightly above midpoint on the black (0) to white (100) scale. Planter's peanut butter was found to be the lightest peanut butter with an L* value of 60.83 ± 0.241, while the addition of peanut skins resulted in some of the darkest peanut butters. Both level of skin and heat treatment influenced lightness. Among the commercial samples, only Jiff Natural was as dark as the laboratory prototypes that contained 2.5% roasted peanut skins or 5% blanched skins. Four commercial formulations did not differ from the laboratory prototype containing 2.5% blanched skins. McNeill and others (2000) suggest that consumers may perceive dark colored samples as burnt whereas very light samples are perceived as having a bland flavor. Although Pattee and others (1991) suggest that a L* value of 58-59 is optimal for sensory attributes associated with roasted peanut flavor, commercial as well as laboratory produced samples were found outside this optimal range.

For the red-green axis, a*, significance was again found amongst the peanut butters. Each peanut butter had a positive a* value, indicating the presence of red hues as previously reported (Pattee and others 1991). The range for the red-green axis for all of the peanut butters was 6.33 ± 0.047 to 8.64 ± 0.067, with Jif being the least red and the reformulated control peanut butter, Smucker's and Peter Pan being the most red. Therefore, the incorporation of peanut skins did not alter the redness of the peanut butters such that they varied significantly from the commercially available peanut butters. Based on consumer sales data (Mintel Reports 2010), the differences found fell within the range consumers find acceptable. Similarly, all of the b* values were found to be positive, indicating that all of the peanut butters evaluated fell in the yellow range of the axis. Jif was the least yellow, with a b* value of 33.92 ± 0.386, while Peter Pan was the most yellow, with a b* value of 40.21 ±0.386. When compared to the commercially available peanut butters, the reformulated peanut butters were less yellow than many of the commercial peanut butters evaluated; however, they still fell within the range found for commercially available peanut butters and would, therefore, sales data suggest, be acceptable to consumers (Mintel Reports 2010). The heat treatment of the peanut skins significantly affected lightness, redness, and yellowness of the peanut butters (Table 4.6): incorporation of 2.5% dry blanched peanut skins resulted in a product that differed significantly from that formulated with 2.5% light roasted peanut skins. However, each peanut butter formulated with high phenolics peanut skins fell within the range found for the commercially available peanut butters.

Table 4.6: Significant differences in lightness, redness, and yellowness of reformulated and commercially available peanut butters[ab] (n=12)

Peanut Butter	L* (Lightness) [c]	a* (Red-green axis) [d]	b* (Yellow-blue axis) [e]
0% Control	57.87 ± 0.340cb	8.64 ± 0.067a	39.47 ± 0.545ab
2.5% Dry Blanched	56.20 ± 0.340d	8.42 ± 0.067b	36.58 ± 0.545de
2.5% Light Roast	53.42 ± 0.340e	8.06 ± 0.067d	34.39 ± 0.545f
5.0% Dry Blanched	54.02 ± 0.340e	8.36 ± 0.067bc	35.50 ±0.545ef
Jif	58.45 ± 0.241bc	6.33 ± 0.047h	33.92 ± 0.386f
Jif Natural	54.12 ± 0.241e	7.47 ± 0.047f	35.37 ± 0.386ef
MaraNatha	57.84 ± 0.241bc	6.52 ± 0.047g	34.67 ± 0.386f
Naturally More	57.81 ± 0.241bc	7.55 ± 0.047ef	36.96 ± 0.386cde
Peter Pan	55.89 ± 0.241d	8.52 ± 0.047ab	38.79 ± 0.386ab
Peter Pan Natural	55.85 ± 0.241d	8.43 ± 0.047b	40.21 ± 0.386a
Planter's	60.83 ± 0.241a	7.57 ± 0.047ef	38.38 ± 0.386bc
Reese's	58.79 ± 0.241b	7.71 ± 0.047e	37.92 ± 0.386bcd
Skippy	57.62 ± 0.241c	8.23 ± 0.047cd	38.70 ± 0.386ab
Skippy Natural	56.64 ± 0.225d	8.22 ± 0.044cd	39.00 ± .0361ab
Smucker's	55.82 ± 0.241d	8.53 ± 0.047ab	38.77 ± 0.386ab

[a] Data collected using a Minolta spectrophotometer (model CM-700d, Minolta Corp., Ramsey, NJ) at two different locations on each 4 ½ X 2-7/8in sample, with 6 samples per peanut butter.
[b] LS-means followed by different letters for a peanut butter are significantly different ($p<0.05$) according to General Linear Models (PROC GLM) and LS-means separation with PDIFF
[c] Lightness on a 0-100 scale where 0 indicates black and 100 indicates white.
[d] Represents the red-green axis where positive values indicate red hues.
[e] Represents the blue-yellow axis where positive values indicate yellow hues.

Peanut Butter Quality Characteristics: Texture

Consumers indicate that they expect peanut butter to be smooth and firm. Although adhesiveness is desirable, the peanut butter should not be too sticky; rather, the product should melt in the mouth and slide easily down the throat (McNeill and others 2000). Significant correlations have been found between the instrumental assessment of texture using the Texture Profile Analysis approach and the assessment of texture by descriptive sensory panelists (Muego and others 1990).

Spreadability, a related attribute, is related to the ease with which the product can be applied in an even layer to bread or crackers in preparation for consumption. Although the peanut butter should stick to the knife, it should also spread easily and thickly on a piece of bread without tearing the bread (McNeill and others 2000). Because spreadability of peanut butters is an important characteristic of peanut butters to consumers, the measure is included in the grading standards for peanut butters set by the USDA (1983) and instrumental techniques have been developed for the assessment of this parameter (Ahmed and Ali 1986). Even though firmness of the peanut butter is also a discrete textural property, it like adhesiveness, influences the ease with which peanut butter is spread.

<u>TTC Spreadability Rig</u>

Maximum force, an indicator of firmness, and work of shear, a direct assessment of spreadability, are two parameters that can be extracted from the peanut butter time/force curve that is generated with the TTC spreadability rig (Ahmed and Ali 1986). Spreadability, or work of shear, is associated with the positive area under the curve. Negative area under the time/force curve is an indication of adhesiveness of the peanut butters. Results based on production date for the reformulated peanut skin enhanced peanut butters or lot for the commercially available peanut butters, are presented in tables 4.7 and 4.8.

Table 4.7: TCC spreadability rig results of Reformulated Peanut Butters by Production Date (n=10) [ab]

Peanut Butter	Production Date	Firmness (g)	Spreadability (g/sec)	Adhesiveness (g/sec)
0% Control	1	1000.00 ± 70.00a	800.00 ± 70.00a	-90.00 ± 4.00a
	2	2764.83 ± 92.58b	1428.70 ± 44.02b	-168.25 ± 6.00b
2.5% Dry	1	1300.00 ± 60.00a	1100.00 ± 70.00a	-98.00 ± 4.00a
Blanched	2	2859.09 ± 92.58b	1563.67 ± 44.02b	-170.78 ± 6.00b
2.5% Light Roast	1	1400.00 ± 60.00a	1200.00 ± 70.00a	-112.00 ± 4.00a
	2	3467.10 ±92.58b	2048.05 ± 44.02b	-208.12 ± 6.00b
5.0% Dry	1	1100.00 ± 60.00a	1100.00 ± 70.00a	120.00 ± 4.00a
Blanched	2	3301.04 ±92.58b	1922.06 ± 44.02b	-188.45 ± 6.00b

[a] Data were collected using the texture analyzer (TAX-T2 Plus, Texture Technologies Corp., Scarsdale, NY) equipped with Texture Exponent 32 software (Stable Micro Systems Lt., Godalming, Surrey, England) and a 5 kg load cell at a pretest, test and posttest speed of 5 mm/sec. Ten samples were used from each peanut butter and each sample was penetrated with the TTC spreadability rig once to a distance of 2 mm above the bottom of the holder. Maximum force was extracted as the highest peak in the time/force curve, spreadability was the area under the curve associated with the removal of the cone after penetration, and adhesiveness was the area under the curve associated with the peanut butter adhering to the cone.

[b] LS-means for each parameter followed by different letters for each peanut butter are significantly different ($p<0.05$) according to General Linear Models (PROC GLM) and LS-means separation with PDIFF.

Each parameter- firmness, spreadability, and adhesiveness- was found to be significantly different between production dates for all of the reformulated peanut butters tested (Table 4.7). For all reformulated peanut butters, the second production run resulted in firmer peanut butters that were less spreadable and more adhesive. This could be due to a difference in the production procedure or ingredients even though sources were consistent across production runs.

Table 4.8: TCC spreadability rig results of Commercial Peanut Butters by Production Lot (n=10)[ab]

Peanut Butter	Production Lot	Firmness (g) (SE=92.58)	Spreadability (g/sec) (SE=44.02)	Adhesiveness (g/sec) (SE=66.21)
Jif	1	2113.02	1092.00	-1655.77
	2	2110.16	1076.04	-1669.78
Jif Natural	1	2112.39	1025.35a	-1506.82
	2	1887.23	849.11b	-1531.83
MaraNatha	1	2059.96a	942.77a	-1650.70a
	2	947.19b	346.49b	-743.21b
Naturally More	1	2112.34a	817.02a	-1468.92a
	2	1544.23b	550.07b	-1038.65b
Peter Pan	1	1930.16a	907.17a	-1550.20a
Natural	2	1444.26b	633.31b	-1151.54b
Peter Pan	1	1724.13	883.12	-1341.23
	2	1751.88	867.76	-1381.42
Planter's	1	2184.13a	1127.55a	-1708.57a
	2	2538.08b	1399.95b	-1904.23b
Reese's	1	2766.12	1516.88	-2141.54a
	2	2575.04	1413.18	-1947.74b
Skippy	1	2407.19	1340.19	-1852.73a
	2	2633.07	1347.06	-2105.32b
Skippy Natural	1	2255.59	1200.86	-1747.77
	2	2270.36	1142.80	-1799.14
Smucker's	1	1387.54	587.91	-1099.07
	2	1567.60	578.10	-1112.06

[a] Data were collected using the texture analyzer (TAX-T2 Plus, Texture Technologies Corp., Scarsdale, NY) equipped with Texture Exponent 32 software (Stable Micro Systems Lt., Godalming, Surrey, England) and a 5 kg load cell at a pretest and posttest speed of 5 mm/sec. Ten samples were used from each peanut butter and each sample was penetrated with the TTC spreadability rig once to a distance of 2 mm above the bottom of the holder. Maximum force was extracted as the highest peak in the time/force curve, spreadability was the area under the curve associated with the removal of the cone after penetration, and adhesiveness was the area under the curve associated with the peanut butter adhering to the cone.

[b] LS-means for each parameter followed by different letters for each peanut butter are significantly different ($p<0.05$) according to General Linear Models (PROC GLM) and LS-means separation with PDIFF

TCC spreadability rig parameters were also evaluated by production lot for the commercially available peanut butters (Table 4.8). Significant differences between production lots were found for each textural parameter for four (MaraNatha, Naturally More, Peter Pan

Natural and Planter's) of the 10 peanut butters that were evaluated. Two additional samples (Reese's and Skippy) differed only in adhesiveness. As found with the reformulated peanut butters (Table 4.7), peanut butters that were found to be firmer also tended to be less spreadable and more adhesive. Significant results found between production lots for these peanut butters in the marketplace suggest that a range of values related to spreadability meet the quality control standards set by individual processors and sales data suggest this variation in spareadability is acceptable to consumers.

All of the peanut butters also were evaluated and characterized across the two production dates. Maximum force, spreadability, and adhesiveness of each peanut butter evaluated are presented in Table 4.9.

Firmness, or the maximum force required to penetrate to 2 mm above the bottom of the holder, was found to be significantly increased in the 2.5% light roasted and the 5.0% dry blanched peanut butters when compared to all of the other peanut butters evaluated. The 2.5% dry blanched peanut butter was also firmer than most of the other peanut butters that were evaluated; however, it did not differ from Reese's peanut butter or the laboratory control prototype. Firmness for the commercially available peanut butters ranged from 1477.6 ± 65.45 g to 2670.6 ± 65.46 g.

The range of spreadability values (work of shear) for all of the peanut butters evaluated ranged from 583.0 ± 31.13 to 2048.1 ± 40.0 g/sec, with the commercially available peanut butters ranging from 583.0 ± 31.13 to 1465.0 ± 31.13 g/sec. Each reformulated peanut butter in which peanut skins were incorporated was significantly more difficult to spread than were the commercially available peanut butters and the laboratory produced control. The 2.5% light roasted peanut butter was the most difficult to spread, followed by the 5.0% dry blanched peanut butter and the 2.5% dry blanched peanut butter. It is noteworthy that the laboratory produced control fell at the upper end of the spreadability values found for the commercial samples.

Table 4.9: TTC spreadability rig results: Firmness, spreadability, and adhesiveness of reformulated and commercially available peanut butters (n=20)[ab]

Peanut Butter	Firmness (g)	Spreadability (g/sec)	Adhesiveness (g/sec)
0% Control	2764.8 ± 60.0bc	1428.7 ±40.0de	-168.2 ± 4.00f
2.5% Dry Blanched	2859.1 ± 60.0b	1563.7 ± 40.0c	-170.8 ± 4.00f
2.5% Light Roast	3467.1 ± 60.0a	2048.1 ± 40.0a	-208.1 ± 4.00h
5.0% Dry Blanched	3301.0 ± 60.0a	1922.1 ± 40.0b	-188.5 ± 4.00g
Jif	2111.6 ± 65.46fg	1084.0 ± 31.13h	-117.8 ± 4.24cd
Jif Natural	2005.2 ± 63.96gh	941.4 ± 30.41i	-105.4 ± 4.15c
MaraNatha	1503.6 ± 65.46j	644.6 ± 31.13k	-78.5 ± 4.24ab
Naturally More	1813.3 ± 67.26hi	676.5 ± 31.98jk	-77.0 ± 4.36ab
Peter Pan	1738.0 ± 65.46ij	875.4 ± 31.13i	-85.8 ± 4.24b
Peter Pan Natural	1687.2 ± 65.46ij	770.2 ± 31.13j	-87.4 ± 4.24b
Planter's	2361.1 ± 65.46de	1263.8 ± 31.13fg	-137.7 ± 4.24e
Reese's	2670.6 ± 65.46bc	1465.0 ± 31.13d	-164.3 ± 4.24f
Skippy	2521.1 ± 65.46cd	1343.6 ± 31.13ef	-150.1 ± 4.24e
Skippy Natural	2263.0 ± 65.46ef	1171.8 ± 31.13gh	-121.5 ± 4.24d
Smucker's	1477.6 ± 65.45j	583.0 ± 31.13k	-63.1 ± 4.24a

[a] Data were collected using the texture analyzer (TAX-T2 Plus, Texture Technologies Corp., Scarsdale, NY) equipped with Texture Exponent 32 software (Stable Micro Systems Lt., Godalming, Surrey, England) and a 5 kg load cell at a pretest and posttest speed of 5 mm/sec. Twenty samples were used from each peanut butter and each sample was penetrated with the TTC spreadability rig once to a distance of 2 mm above the bottom of the holder. Maximum force was extracted as the highest peak in the time/force curve, spreadability was the area under the curve associated with the removal of the cone after penetration, and adhesiveness was the area under the curve associated with the peanut butter adhering to the cone.
[b] LS-means for each parameter followed by different letters within a column are significantly different ($p<0.05$) according to General Linear Models (PROC GLM) and LS-means separation with PDIFF.

Adhesiveness values were also ascertained from this time/force curve. Peanut skin incorporation resulted in peanut butters that had higher values for adhesiveness than was found for most other samples. The 2.5% light roasted peanut butter had the highest adhesiveness value. The 5.0% dry blanched peanut butter and the 2.5% dry blanched peanut butters followed with adhesiveness values of -188.5 ± 4.00 g/sec and -170.8 ± 4.00 g/sec, respectively. The 2.5% dry blanched peanut butter, however, was not statistically different from Reese's Creamy peanut butter which exhibited the highest adhesiveness among the commercial samples, with a value of -164.3 ± 4.24 g/sec. Adhesiveness of the commercially available peanut butters ranged from -164.3 ± 4.24 to -63.1 ± 4.24 g/sec.

In general, it was found that when firmness increased, the peanut butters were more difficult to spread and more adhesive. Sanders and others (2011) found similar results for the prototype formulations and reported that despite these significant differences detected instrumentally, consumer sensory panelists found ease of spreadability on a saltine cracker of the first production run of the laboratory produced prototypes to be acceptable.

Texture Profile Analysis

Texture Profile Analysis (TPA) has been found to describe the texture of spreadable peanut products during mastication better than does textural assessment using the TTC spreadability rig (Muego et al., 1990). TPA results by parameter for each production lot for the laboratory produced peanut butters are presented in table 4.10. Similarly, TPA parameters for the commercially produced samples by production lot are found in table 4.11. Data are reported for firmness, adhesiveness, cohesiveness and gumminess as described by Muego and others (1990).

Table 4.10: Texture Profile Analysis Results of Reformulated Peanut Butters by Production Date (n=10) [ab]

Peanut Butter	Production Date	Firmness (g) (SE=22.85)	Adhesiveness (g/sec) (SE=22.14)	Cohesiveness (SE=0.03)	Gumminess (g/sec) (SE=10.04)
0% Control	1	118.7	-140.6	0.4	63.6
	2	110.6	-138.25	0.35	57.3
2.5% Dry	1	215.3	-191.1	0.4	144.2
Blanched	2	225.1	-195.63	0.35	140.6
2.5% Light	1	249	-139.1	0.4	144.1
Roast	2	251.3	-150.64	0.35	148.2
5.0% Dry	1	317.2	-197.3	0.4	126.3
Blanched	2	298.4	-193.12	0.35	126.9

[a] Data were collected using the texture analyzer (TAX-T2 Plus, Texture Technologies Corp., Scarsdale, NY) with Texture Exponent 32 software (Stable Micro Systems Lt., Godalming, Surrey, England) equipped with a 5kg load cell. Ten samples were used from each peanut butter and each sample was compressed twice with a 7.6 cm diameter compression disc with a pre-test, contact and post-test speed of 5 mm/sec. Samples were portioned onto a base-plate using a #100 scoop (~11.7 g). Values were extracted from the time/force curve (Bourne 1978).

More variability due to production lot was observed for the commercially produced peanut butter samples (Table 4.11) than was found for those produced with the addition of peanut skins in the laboratory (Table 4.10). For the commercially produced samples, Planters was the most consistent from production lot to production lot, differing only in cohesiveness. For the remaining commercially processed samples, all, except Jiff, exhibited significant differences due to lot in at least three of the four parameters evaluated; Jif differed significantly in adhesiveness and cohesiveness (Table 4.11). No significant differences for any parameter evaluated by production lot were found for the peanut skin enhanced laboratory produced samples (Table 4.10). It is apparent that textural measurements with the spreadability rig and the TPA compression plates are assessing different aspects of texture.

Table 4.11: Texture Profile Analysis of Commercial Peanut Butters by Production Lot (n=10) [ab]

Peanut Butter	Production Lot	Firmness (g) (SE=9.09)	Adhesiveness (g/sec) (SE=9.94)	Cohesiveness (SE=0.016)	Gumminess (g/sec) (SE=18.22)
Jif Natural	1	168.61a	-169.50a	0.56a	299.65a
	2	134.53b	-139.96b	0.38b	353.49b
Jif	1	126.34	-169.68a	0.56a	222.79
	2	108.76	-139.94b	0.49b	223.57
MaraNatha	1	184.06a	-152.46a	0.52a	357.62a
	2	59.77b	-38.40b	0.36b	167.92b
Naturally More	1	119.94a	-63.22	0.69a	172.79a
	2	72.89b	-42.46	0.31b	236.72b
Peter Pan Natural	1	177.50a	-175.80a	0.61a	293.36
	2	113.81b	-102.70b	0.35b	328.18
Peter Pan	1	119.85a	-151.47a	0.57a	210.26
	2	84.08b	-112.61b	0.44b	193.1
Planter's	1	111.72	-156	0.54a	205.28
	2	124.42	-170.16	0.49b	253.86
Reese's	1	234.15a	-252.40a	0.52a	454.59a
	2	132.19b	-171.31b	0.46b	286.94b
Skippy	1	161.46a	-211.08a	0.55a	298.71
	2	104.39b	-131.93b	0.41b	252.49
Skippy Natural	1	168.18a	-220.89a	0.56a	300.24
	2	126.37b	-139.46b	0.42b	300.46
Smucker's	1	118.05a	-83.73a	0.70a	167.99
	2	60.99b	-40.82b	0.42b	147.15

[a] Data were collected using the texture analyzer (TAX-T2 Plus, Texture Technologies Corp., Scarsdale, NY) with Texture Exponent 32 software (Stable Micro Systems Lt., Godalming, Surrey, England) equipped with a 5kg load cell. Ten samples were used from each peanut butter and each sample was compressed twice with a 7.6 cm diameter compression disc with a pre-test, contact and post-test speed of 5 mm/sec. Samples were portioned onto a base-plate using a #100 scope (~11.7 g). Values were extracted from the time/force curve (Bourne 1978).

[b] LS-means for each parameter followed by different letters within a column are significantly different (p<0.05) according to General Linear Models (PROC GLM) and LS-means separation with PDIFF

TPA data for adhesiveness, cohesiveness, gumminess, and firmness across production lots for all samples evaluated are presented in Table 4.12.

Table 4.12: Textural Profile Analysis results: Adhesiveness, cohesiveness, gumminess, and firmness of reformulated and commercially available peanut butters (n=20)[ab]

Peanut Butter	Firmness (g)	Adhesiveness (g/sec)	Cohesiveness	Gumminess (g/sec)
0% Control	118.7 ± 22.85cd	-140.4 ± 22.14cd	0.40 ± 0.03e	63.6 ± 10.04i
2.5% Dry Blanched	215.3 ± 22.85f	-191.1 ± 22.14g	0.40 ± 0.03e	144.2 ± 10.04h
2.5% Light Roast	249.0 ± 22.85f	-139.1 ± 22.14cd	0.40 ± 0.03e	144.1 ± 10.04h
5.0% Dry Blanched	317.2 ± 22.85g	-197.3 ± 22.14g	0.40 ± 0.03e	126.3 ± 10.04h
Jif	117.5 ± 6.43cd	-154.8 ± 7.03de	0.53 ± 0.011b	223.18 ± 12.887f
Jif Natural	151.6 ± 6.43b	-154.7 ± 7.03de	0.47 ± 0.011d	326.57 ± 12.887b
MaraNatha	121.9 ± 6.43c	-95.4 ± 7.03b	0.44 ± 0.011e	262.77 ± 12.887de
Naturally More	97.5 ± 6.28de	-53.3 ± 6.87a	0.51 ± 0.010bcd	203.23 ± 12.590f
Peter Pan	102.9 ± 6.60de	-133.1 ± 7.22c	0.51 ± 0.011bcd	202.13 ± 13.240f
Peter Pan Natural	145.7 ± 6.43b	-139.3 ± 7.03cd	0.48 ± 0.011d	310.77 ± 12.887bc
Planter’s	118.1 ± 6.43cd	-163.1 ± 7.03ef	0.52 ± 0.011bc	229.57 ± 12.887ef
Reese’s	183.2 ± 6.43a	-211.9 ± 7.03g	0.49 ± 0.011cd	370.76 ± 12.887a
Skippy	132.9 ± 6.43bc	-171.5 ± 7.03ef	0.48 ± 0.011d	275.60 ± 12.887cd
Skippy Natural	147.3 ± 6.43b	-180.2 ± 7.03f	0.49 ± 0.011cd	300.35 ± 12.887bc
Smucker’s	88.2 ± 6.28e	-61.3 ± 6.87a	0.55 ± 0.011a	157.08 ± 12.590g

[a] Data were collected using the texture analyzer (TAX-T2 Plus, Texture Technologies Corp., Scarsdale, NY) with Texture Exponent 32 software (Stable Micro Systems Lt., Godalming, Surrey, England) equipped with a 5kg load cell. Twenty samples from each peanut butter was compressed twice with a 7.6 cm diameter compression disc with a pre-test, contact and post-test speed of 5 mm/sec. Samples were portioned onto a base-plate using a #100 scoop (~11.7 g). Values were extracted from the time/force curve (Bourne 1978).

[b] LS-means for each parameter followed by different letters within a column are significantly different ($p<0.05$) according to General Linear Models (PROC GLM) and LS-means separation with PDIFF.

Firmness, also referred to as hardness, is a primary textural attribute that is measured as the peak force during the first compression on the instrumental TPA curve. From a sensory perspective, it is the force required to penetrate a substance with molar teeth (Szczesniak and others 1963, Bourne 1978). All of the reformulated peanut butters enhanced with peanut skins were found to be statistically firmer than were the commercially available peanut butters evaluated. The commercially available peanut butters exhibited firmness values that ranged from 88.2 ± 6.28 to 183.2 ± 6.43 g. Firmness of the reformulated peanut butters reflected level of peanut skin incorporation; samples prepared with 2.5% blanched and 2.5% light roasted skins did not differ. Incorporation of peanut skins at the 5% level produced the firmest peanut butter.

According to Szczesniak and others (1963), adhesiveness, from the sensory perspective, is the force required to remove the material that adheres to the mouth. On the TPA curve, the negative force area for the first compression is defined as adhesiveness (Bourne 1978). The commercially available peanut butters exhibited adhesiveness values (Table 4.12) that ranged between -53.3 ± 6.87 and -211.9 ± 7.03 g/sec. All of the reformulated peanut butters had values that fell within the range found for the commercially available peanut butters. For the reformulated peanut butters, heat treatment of the peanut skins appears to affect adhesiveness; the adhesiveness of peanut butters in which dry blanched skins were incorporated was significantly increased when compared to those prepared with light roasted skins or when formulated with the absence of skins.

Cohesiveness in TPA is defined as the ratio of the positive force area during the second compression to the area of the first compression. According to Szczesniak and others (1963), cohesiveness is the "deformation undergone by a material before rupture when biting completely through the samples using molars." The cohesiveness for all of the laboratory produced peanut butters (Table 4.12) was found to be 0.40 ± 0.03. Statistically, these samples exhibited the same cohesiveness as MaraNatha creamy peanut butter, although they were statistically different from all of the other commercially processed peanut butters that were evaluated. Because of the insensitivity of the teeth, researchers have found that this parameter is difficult to perceive as a sensory rating when chewing (Szczesniak and others

1963, Bourne 1978) and these statistical differences are unlikely to be practically significant, when the range of values obtained and human sensitivity are considered.

Gumminess is defined as the denseness of food that lasts throughout chewing (Szczesniak and others 1963). A secondary textural attribute, gumminess is calculated from TPA instrumental data as the product of firmness and cohesiveness (Muego and others 1990). Gumminess of the commercially available peanut butters ranged from 157.08 ± 12.590 to 370.76 ± 12.887 g/sec. The reformulated peanut butters were found to exhibit significantly lower levels of gumminess than was found for the commercially available peanut butters. Incorporation of peanut skins increased the gumminess of the laboratory produced prototypes when compared to the laboratory produced control.

TPA analysis for these peanut butters revealed that peanut butters in which peanut skins were incorporated exhibited increased firmness and decreased gumminess when compared to the commercially available peanut butters. Adhesiveness of the reformulated peanut butters was not statistically different from the commercially available peanut butters and cohesiveness of the reformulated peanut butters resulted in statistically significant but not practically different differences. In general, it was found that when firmness increased, gumminess and adhesiveness also increased. Cohesiveness decreased as firmness increased, however, within the range of values found this was not practically significant. Previously, Sanders and others (2011) reported that consumer sensory panelists found texture of the first production run of the laboratory produced prototypes to be acceptable although the formulation in which 5.0% peanut skin were incorporated was less acceptable than was the control formulation.

Focus Groups

Profile: Three focus groups (n=25; 4 M, 21 F) were conducted in order to assess consumer perceptions of peanut butter, nutrition, and label claims. Of the participants, 64% were 18 to 27 years old, 20% were 28 to 35 years old, 12% were 53-61 years old, and 4% were 36 to 43 years old. All panelists consumed products containing peanuts at least one time per month. All but one participant purchased either Jif or Peter Pan peanut butters with the one person who did not purchase these brands choosing to purchase Reese's. This is consistent with national sales data which indicate that Jif and Peter Pan peanut butters are the most commonly purchased peanut butters in the United States (Mintel Reports 2010). Participants were divided into focus groups based on their participation in the Expanded Food and Nutrition Education Program (EFENP) (n=10), consumption of foods labeled as natural (n= 7), and general consumers (n=8). These groups were defined based on sales data and the potential influence of income and children on purchasing patterns. In addition, there has been growth in the sales of natural peanut butter products in the past several years and the reformulated peanut butters might be of interest to consumers of natural products. EFNEP participants are a low-income population with children enrolled in a nutrition education programming. Reformulated peanut butters that are "better-for-you" and are of similar cost as the traditionally formulated peanut butters may be of interest for this population. However, few differences in opinions on peanut butters and functional foods in general were found due to group.

When discussing the sensory characteristics of foods, it is important that everyone in the group has a common set of terminology to use. This allows everyone to speak about the product and know what is meant by each word (Murray and others 2001). Participants were asked to describe peanut butter unaided and each group came up with words such as creamy, chunky, roasted peanut flavor, sticky, speckled, sweet, and salty. Each focus group indicated that peanut butters should be brown, but there is an acceptable range of brown hues within which peanut butters can fall. They are skeptical of peanut butters that are too dark, too light, or too orange. Peanut butters should be a rich, caramel color. For peanut butters, oily, overly sweet or salty, or an "off" color are perceived as negative attributes. Each group indicated that appearance of peanut butters was not important to them as long as the color fell within the "acceptable" range. This is consistent with results found in previous focus groups on desirable and non-desirable characteristics of peanut butter (McNeill and others 2000). Further, participants in these three focus groups indicated that having increased particulates is expected and even desired in natural peanut butters, which is also consistent with previous results reported by McNeill and others (2000). This brief description of peanut butter served as a tool so that each participant had an idea of the meaning of the words associated with peanut butter and got them thinking about peanut butter and the sensory qualities of peanut butters (Murray and others 2001).

Interestingly, members of each group indicated heart disease is a major health concern for themselves or someone they know; however, they did not feel that label claims affected their purchasing decisions. Members of each group stated that they felt that changing one aspect of their diet would not affect their health; it would take a more drastic, lifestyle change, to truly have any impact on their overall health. For example, one person stated that changing one item in their diet to a low sodium variety would not affect their blood pressure, but changing their whole diet to a low sodium diet could affect their blood pressure. This opinion is counter to the intent of the NLEA which was to make it easier for consumers to improve the nutritional quality of their diet by identifying individual foods with nutritional profiles consistent with dietary guidance (Todd and Variyam, 2008). Further, members of each focus group stated that exercise would have a more profound impact on health than food alone. Each group noted that eating a healthy diet alone was not sufficient to greatly affect health; exercise is essential for health. Conversely, according to the 2011 IFIC Foundational Functional Food and Health Survey, 73% of Americans believe that foods and nutrition play the greatest role in maintaining or improving health, exceeding the percentage that identified exercise (63%) and family history (39%) as most influential (IFIC 2011). It has been found in previous studies that consumers are becoming increasingly more likely to read nutrition information on packaging (Drichoutis and others 2005). These participants indicated they used nutrition-related information on the labels with the Nutrition Facts box and the ingredient lists used most frequently. Claims were sometimes used but much less frequently than were the other two sources of nutrition information. This finding was consistent for all three focus groups.

There is not a positive perception of the sensory qualities of foods with health-related label claims, especially those that have low-sugar or low-fat labels. People feel these products do not “taste” as good as the traditionally formulated products and often cost more. This is consistent with previous studies that have found that label claims, especially low-fat claims, impact consumer perception of quality (Solheim and Lawless 1996, Tuorila and Cardello 1994). Because of this perception, each group indicated that they would rather purchase foods without the label claims because they feel the item will taste better than the one with the label claim. This is not true for label claims that people do not feel affect flavor and texture of the specific product, such as fiber. The participants indicated that if they felt the modification of the food would not impact the overall sensory quality of the food, they would be willing to purchase that item. This is consistent with findings that consumers are increasingly unwilling to select functional foods with sensory attributes that do not meet their expectations (Siro and others 2008, Verbeke 2005). According to Hall and Fong (2007), acceptability of the product is the key to selection and distal benefits, such as health effects.

When asked about peanut butters having high antioxidant or high fiber labels, each group stated that they would be interested in the high fiber, but not the high antioxidant claim. Participants were generally unaware of what antioxidants do in the body. They knew that antioxidants were good for them, but they did not know why or how they worked in the body. Further, participants felt that antioxidants would not help their health as much as fiber would. When probed about having a fiber claim, participants were able to identify the link between fiber and digestive health. Many of the participants also knew that fiber would help them feel full. Because of the increased knowledge of fiber, participants were more interested in having a high fiber peanut butter in the marketplace, rather than a high antioxidant peanut butter. The amount of knowledge about the associated health benefit has been found to influence attitude and use of functional foods, in general. Consumers want information about composition and possible benefits as well as the endorsement by recognized authorities (Barrios and others 2008; Siro and others 2008).

Participants had mixed feelings about “natural” claims on peanut butters. About half of the people indicated that they would not be interested in a “natural” peanut butter while the other half stated that they would be extremely interested in this product. Interestingly, no one in the focus group whose members consumed products labeled as natural was interested in a peanut butter with a natural claim. This group indicated that they would not be interested in a natural claim on peanut butter because they have a perception of natural peanut butters as being grittier and coarser than other peanut butters. Because flavor and texture of peanut butters was important to them, these perceptions would inhibit their purchasing of the new product that carried the natural label. Conversely, some people in the other two focus groups indicated that they would be interested in a natural peanut butter because they felt the product would be less processed and have less additives and would contain more natural ingredients. Parents of small children were especially interested in this concept because they felt it was better for their children than a more processed product. One major issue with "natural" labels is that natural means different things to different people. Rozin (2005) researched what "natural" means to Americans, and found that additives and genetically modified foods resulted in a reduction of perceived naturalness as did the removal of fat from foods, pasteurization, and boiling. Freezing and thawing had little or no impact on perceived naturalness, however. Rozin (2005) found that removal of fat from peanut butter resulted in a 23.8% reduction in perception of naturalness for consumers. However, freezing and thawing of peanuts resulted in only a 14.7% reduction in perceived naturalness. This shows that consumers feel that increased processing of foods results in a decrease in naturalness of that food, especially when the relative level of macronutrients are manipulated, but the extent of the effect is specific to the processing technique employed. "Functional fresh" products, specifically, were not addressed in this study. "Functional fresh" products contain added ingredients that consumers associate with positive health outcomes and with the product itself;

this concept does not exclude processed products but rather relates more closely to the fortification ingredients chosen to impart the desired health benefits (Sloan, 2009).

Finally, each participant was asked to indicate, using pen and paper, what the most and least important factors were that were considered when purchasing peanut butters. Results from participant responses across all three focus groups are presented in Table 4.13. Differences due to groups were not found (Appendix C).

Table 4.13: Factors that are most important and least important when purchasing peanut butters (n=25)

Factor	Percentage saying…		
	Important	Neutral	Not Important
Price	88	12	0
Ease of Use (convenience)	28	44	20
Possible Health Benefits	40	24	28
Label Claims	16	32	48
Trying New Foods	32	32	28
Taste	100	0	0
Appearance	92	4	4

Participants indicated that taste, appearance, and price were the most important factors when purchasing peanut butters, with taste being the most important; these factors were followed by possible health benefits. According to the 2011 IFIC Survey, perceived healthfulness of the product (65%) followed taste (88%) and price (72%) as influences on purchasing decisions. Convenience was also identified as important by 55% of the consumers in the IFIC Survey. Everyone in these focus groups indicated that taste was the most important, followed closely by appearance with 92% saying this was important and 88% stating that price is important. Appearance may have had a slightly lower importance than taste because some participants indicated that they did not care as much about appearance as long as they or their family liked the taste and would be willing to eat the product. For peanut butters specifically, a range of appearance characteristics appear to be acceptable which likely increases tolerance for variation in appearance. Label claims, possible health effects, trying new foods, and ease of use had the highest percentage of people indicate that these were not important with 48%, 28%, 28%, and 20%, respectively. This could be because many people view peanut butter as a staple item. People in each focus group indicated that they would buy peanut butter regardless of health benefit or labels because they like peanut butter and find it an easy food to keep in their homes. Dietary behaviors tend to be habitual without a conscious evaluation of the options, suggesting that consumers must be given a reason to alter their behaviors; habitual behavior rather than intention has been found to have a greater influence on choices that are expected to provide long-term benefits (Collins and Mullan, 2011).

The Theory of Planned Behavior explains the responses from the three focus groups. Participants indicated, indirectly, that attitudes, subjective norms, and perceived behavior control influenced their purchasing behaviors. By stating that they consider possible health benefits, social pressures (i.e. family preferences), and available resources, the participants demonstrated the Theory of Planned Behavior in their purchasing decisions. Further, each group stated that they tended to purchase the same peanut butter every time they shopped and would need a reason to alter their purchasing behavior (Ajzen 2005, Collins and Mullan 2011, Verbeke 2005).

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CHAPTER 5: CONCLUSIONS

Polyphenols are compounds found in many foods including peanuts and peanut products that can help decrease the risk of developing chronic diseases such as cardiovascular disease, cancer, inflammation, and neurodegenerative diseases (Scalbert and others 2005, Jensen and others 2006, Ullah and Khan 2008). By incorporating polyphenols into commonly consumed foods, consumers would have the opportunity to increase their intake of these beneficial compounds without having to drastically change their diets or purchasing habits. Peanut skins, which are often removed during the processing of peanut butter, are a rich source of phenolics, a class of polyphenols. These peanut skins can be added to peanut butters to create a functional food high in antioxidants for consumer consumption, while maintaining the standard of identity.

The purpose of this study was to determine the quality characteristics of traditionally formulated peanut butter products currently in the marketplace and compare the quality characteristics of these products to reformulated peanut butters enhanced with high phenolic peanut skins. These reformulated peanut butters met USDA (1983) standard of identity for peanut butter. Consumer responsiveness to high antioxidant and high fiber health claims on the reformulated peanut butters was also assessed in this study. Each reformulated and commercially available peanut butter was assessed for textural characteristics including firmness, spreadability, adhesiveness, gumminess, and cohesiveness, and the appearance characteristics color and presence of particulates.

Firmness, spreadability, and adhesiveness were assessed using the TCC spreadability rig, which is used to assess ease of manipulation with a knife or straight-edge. The reformulated control peanut butters exhibited textural properties that fell within the range that was found for the commercially available peanut butters for each of these parameters, although this control laboratory produced formulation tended to be at the end of the range found. All peanut skin enhanced peanut butters were firmer, more adhesive and more difficult to spread than were the array of peanut butters currently in the marketplace that were evaluated. Therefore, the hypothesis that there is a range of textures available in commercially available peanut butters and reformulated, high phenolic peanut butters would fall within this range was rejected. Although a range of textural calues was found among the commercial peanut butter samples, the reformulated samples enhanced with peanut skins did not fall within this range. However, Sanders and others (2011) reported that consumers found the spreadability characteristics of these peanut skin enhanced peanut butters acceptable, suggesting that a broader range of spreadability characteristics than those found among this array of commercial samples may be acceptable.

Texture as perceived during mastication was assessed through texture profile analysis (TPA). Adhesiveness, cohesiveness, gumminess, and firmness parameters were determined through this instrumental assessment. The reformulated peanut butters enhanced with peanut skins were found to be significantly more firm, more adhesive, and less gummy when compared to the commercially available peanut butters. Although the control peanut butter prepared in the laboratory fell within the range of the commercially available products for firmness, adhesiveness and cohesiveness, it tended to fall at the end of the range exhibited by products currently in the marketplace, suggesting that factors other than the addition of peanut skins impacted the TPA results found. The hypothesis that the reformulated high phenolic peanut butters would fall within the range found for texture parameters for the commercially available peanut butters was rejected. Again, however, consumers have indicated that peanut butters reformulated with peanut skin incorporation at these levels were acceptable (Sanders and others 2011).

Appearance has been identified as an important attribute for consumers when choosing peanut butter (McNeill and others 2000). L*a*b* color assessments were done using a Minolta Reflectance Spectrophotometer. Although significant differences were found among the samples evaluated, the peanut skin enhanced peanut butters fell within the color range found for the commercially available peanut butters for all parameters evaluated. Thus, the hypothesis that there is a range of appearance (color) characteristics in commercially available peanut butters and that the reformulated peanut butters would fall within this range was accepted. Particulate presence for each of the peanut butters was assessed using trained evaluators and was based on a 6-point scale that was developed based on the USDA Inspection Aid No. 95. Particulate presence increased with the incorporation of peanut skins in the reformulated peanut butters; however, each of the reformulated peanut butters still fell within the range for particulate presence that was found for the commercially available peanut butters. The hypothesis that there is a range of appearance characteristics (particulate presence) in commercially available peanut butters and that the reformulated peanut butters would fall within this range was accepted.

Although three focus groups were conducted: a group that purchased natural products, a low-income group and a cross-sectional group, few differences were noted in their response to the peanut skin enhanced peanut butters. Conduction of focus groups revealed that people only use labels and label claims in their purchasing decisions when they believe that the quality characteristics of that food are not affected by the claim. If people believe that the reformulated food will have the same taste and texture as the traditional product, they are more likely to try the new product. Although people want foods that can benefit their health, they will not switch to a reformulated healthier product if the sensory qualities of these products differ significantly from the traditional product. Because of a lack of knowledge and a lack of belief by these consumers that antioxidants will help their health, they were not interested in antioxidant claims on peanut butters. They are, however, interested in fiber claims because they feel fiber is good for themselves and their families. Therefore, the hypothesis that consumers will be accepting of antioxidant labels on peanut butters and explanatory themes will emerge was rejected. This response suggests that additional consumer education will be necessary if consumers are to realize any potential benefits associated with consumption of antioxidants in peanut skin enhanced peanut butter.

The focus groups revealed mixed feelings about products labeled as natural. Some people felt that natural peanut butters would be better for them because of the perception that natural products are less processed and contain fewer additives. However, other people felt that peanut butters labeled natural would deviate too far from the quality characteristics that they look for in peanut butter and these individuals indicated that they would rather purchase peanut butters that they knew they liked. Interestingly, it was current natural consumers who were least interested in a peanut butter labeled natural. This response reflected in part, previous experience with peanut butters that carried a natural label. Through the focus groups, it was revealed that taste and texture of peanut butters were the most important factors when deciding what to purchase. These two characteristics affected whether a person would be willing to try the peanut butter. Price was also identified as a major factor in people's purchasing decisions. Importance of appearance was identified as relatively unimportant during the discussion but emerged as important to most consumers when the pen and paper survey was completed. Associated comments suggest that appearance becomes important only when it falls outside the wide range of acceptable appearance characteristics.

High antioxidant foods may significantly impact health for future generations. By making a commonly consumed food, such as peanut butter, a high phenolic food, the amount of antioxidants consumed in the typical American diet could be increased and this may help prevent some chronic diseases such as heart disease, cancer, and chronic inflammation. Peanut skins are currently discarded as waste during processing; however, by adding them into the peanut butter, a high-antioxidant, high-fiber acceptable peanut butter can be made (Sanders and others 2011) that would potentially benefit consumer health. The incorporation of peanut skins into peanut butters has the potential to help people to increase their intake of antioxidants without having to change their diet.

The previous consumer sensory work conducted by Sanders and others (2011) suggests that the instrumental assessments used in this study may be detecting smaller differences than those required to impact consumer acceptability of the product. These peanut butters enhanced with peanut skins- 2.5% light roasted, 2.5% dry blanched, and 5.0% dry blanched--

had been deemed acceptable by a previous consumer sensory panel. Further studies should confirm consumer acceptability of flavor and texture of these reformulated peanut butters prototypes when compared to commercially available peanut butters. Results from these future comparisons can reveal if changes need to be made to the reformulated peanut butters prototypes in order for these new products to be competitive in the marketplace. If so, tweaking of the high phenolic formulations could result in peanut butters that fall within the range of characteristics for textural and appearance of peanut butter products currently in the marketplace and would ensure that consumer quality expectations are met. Further investigation into marketing both through packaging and through market channels is warranted. Studies should also be done to test acceptability of the reformulated peanut butters as a food ingredient.

Finally, efforts to increase consumer awareness and knowledge about the health benefits of antioxidants should be undertaken if a cross-section of consumers is to realize the potential health benefits associated with consumption of a high phenolic peanut butter. It is not enough to reformulate and make available in the marketplace a food with both the desired quality characteristics and health benefits. For selection and consumption of these functional foods, knowledge and understanding of the associated distal health benefits by a broad range of consumers also will be necessary.

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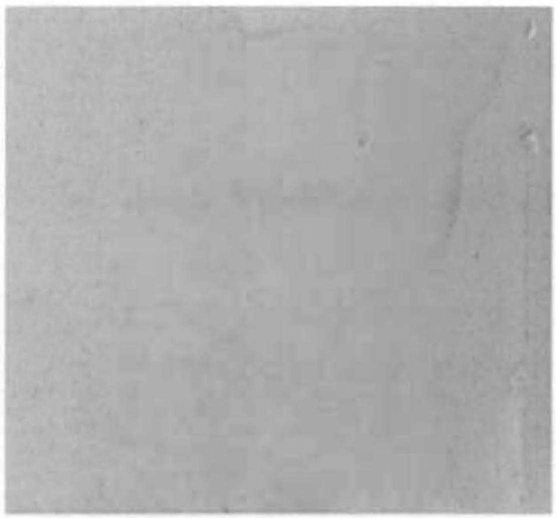
APPENDIX A: PARTICULATE PRESENCE ANCHORS



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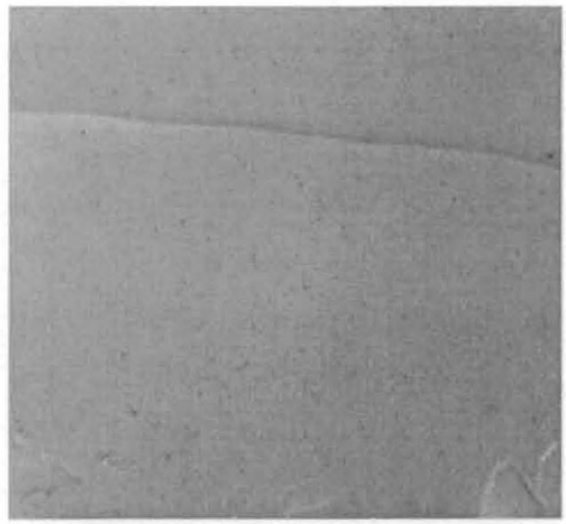

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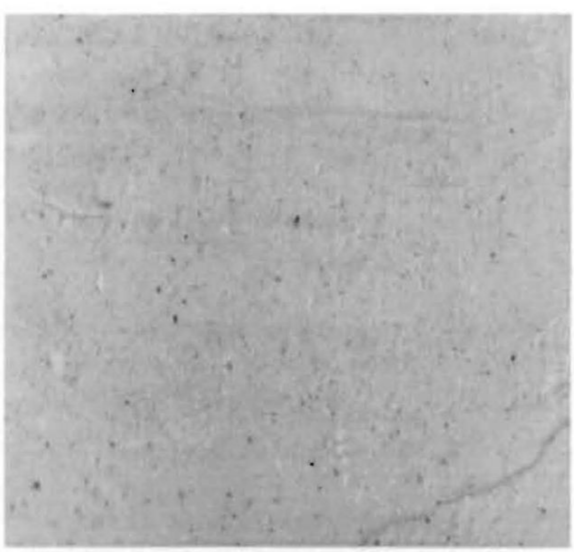

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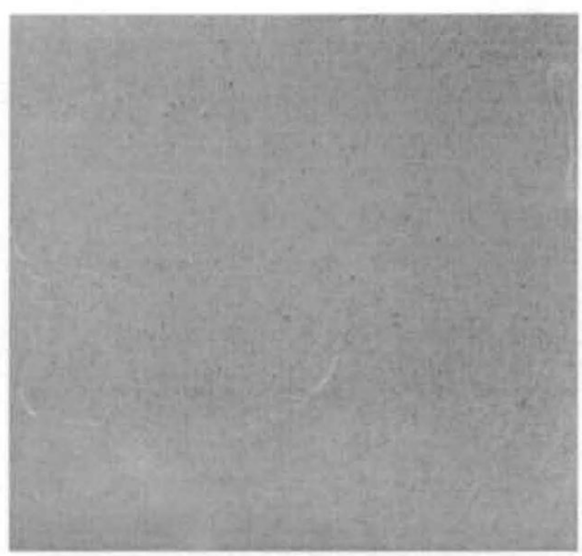

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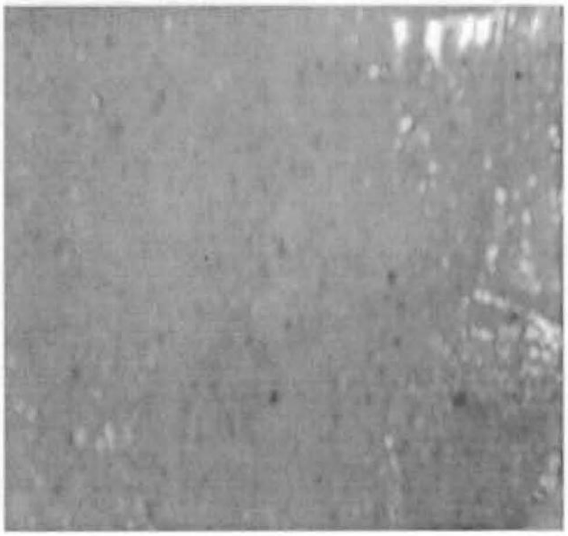

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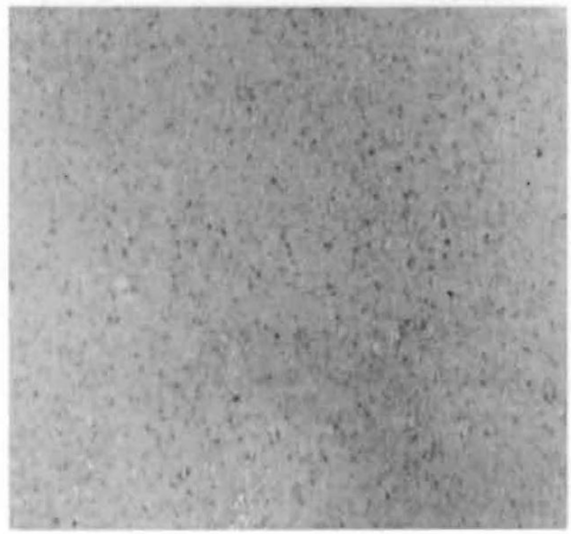

Anchor 6

APPENDIX B: FOCUS GROUP PRESCREENING QUESTIONNAIRE

Participant Questionnaire

Thank you for being interested in our study! We would like to know a little more about you in order to assign you to a focus group. Please answer the questions below as best as you can. Information you give will only be used for research purposes and no identifiable information will be shared with anyone.

1. Your gender (check one): ________male ________female

2. Your age category (check one):

________18-27 ________44-51
________28-35 ________52-61
________36-43 ________62 and above

4. Food allergies that I have include:____

3. How often do you eat peanut butter, on average (check one)?

________ 5+ times/week
________ 2-3 times/week
________ 1-2 times/week
________ 1-2 times/month
________ Several times/year
________ Once per year

4. What type and brand of peanut butter do you usually buy?
____

5. I would rate the peanut butter I usually buy as….

_________________ Extremely acceptable
_________________ Very acceptable
_________________ Acceptable
_________________ Slightly acceptable
_________________ Not acceptable

5. Who in your household would eat this product? (Select all that apply)

_______ Yourself
_______ Your spouse/ roommates
_______ Children ages 11-18
_______ Children under 10
_______ No one

6. Do you eat natural food products? ______ Yes ______ No

If yes, which products?____

7. Please provide your name, email, and times you will be available to participate. We anticipate the focus groups will be help between the dates of XXXX and XXXX.

NAME:____

EMAIL:____

AVAILABILITY:

SUNDAYS:____

MONDAYS: ____

TUESDAYS: ____

WEDNESDAYS: ____

THURSDAYS: ____

FRIDAYS:____

SATURDAYS: ____

Thank you for making our study a success!

APPENDIX C: FOCUS GROUP PRESCREENING QUESTIONNAIRE RESPONSES- GENERAL POPULATION

Participant Questionnaire

Thank you for being interested in our study! We would like to know a little more about you in order to assign you to a focus group. Please answer the questions below as best as you can. Information you give will only be used for research purposes and no identifiable information will be shared with anyone.

1. Your gender (check one): ___4_____male ____4____female

2. Your age category (check one):

____3____18-27 ________44-51
____3____28-35 ____2____52-61
________36-43 ________62 and above

4. Food allergies that I have include:____

3. How often do you eat peanut butter, on average (check one)?

____1____ 5+ times/week
____5____ 2-3 times/week
____2____ 1-2 times/week
________ 1-2 times/month
________ Several times/year
________ Once per year

4. What type and brand of peanut butter do you usually buy?
_________Jif(8)____

5. I would rate the peanut butter I usually buy as….

________4_________ Extremely acceptable
________4_________ Very acceptable
_________________ Acceptable
_________________ Slightly acceptable
_________________ Not acceptable

5. Who in your household would eat this product? (Select all that apply)

___8____ Yourself
___5____ Your spouse/ roommates
_______ Children ages 11-18
_______ Children under 10
_______ No one

6. Do you eat natural food products? ______ Yes ___8___ No

If yes, which products?____

7. Please provide your name, email, and times you will be available to participate. We anticipate the focus groups will be help between the dates of XXXX and XXXX.

NAME:____

EMAIL:____

AVAILABILITY:

SUNDAYS:____

MONDAYS: ____

TUESDAYS: ____

WEDNESDAYS: ____

THURSDAYS: ____

FRIDAYS:____

SATURDAYS: ____

Thank you for making our study a success!

FOCUS GROUP PRESCREENING QUESTIONNAIRE RESPONSES- NATURAL CONSUMERS

Participant Questionnaire

Thank you for being interested in our study! We would like to know a little more about you in order to assign you to a focus group. Please answer the questions below as best as you can. Information you give will only be used for research purposes and no identifiable information will be shared with anyone.

1. Your gender (check one): ________male ____7____female

2. Your age category (check one):

____7____18-27 ________44-51
________28-35 ________52-61
________36-43 ________62 and above

4. Food allergies that I have include:____

3. How often do you eat peanut butter, on average (check one)?

____1____ 5+ times/week
____4____ 2-3 times/week
____3____ 1-2 times/week
________ 1-2 times/month
________ Several times/year
________ Once per year

4. What type and brand of peanut butter do you usually buy? ________Jif(4), Peter Pan (3)____

5. I would rate the peanut butter I usually buy as….

________5_________ Extremely acceptable
________2________ Very acceptable
_________________ Acceptable
_________________ Slightly acceptable
_________________ Not acceptable

5. Who in your household would eat this product? (Select all that apply)

____7___ Yourself
____5___ Your spouse/ roommates
_______ Children ages 11-18
_______ Children under 10
_______ No one

6. Do you eat natural food products? ___7___ Yes ______ No

If yes, which products?___a variety of products were identified including fruits, vegetables, and meats__

7. Please provide your name, email, and times you will be available to participate. We anticipate the focus groups will be help between the dates of XXXX and XXXX.

NAME:____

EMAIL:____

AVAILABILITY:

SUNDAYS:____

MONDAYS: ____

TUESDAYS: ____

WEDNESDAYS: ____

THURSDAYS: ____

FRIDAYS:____

SATURDAYS: ____

Thank you for making our study a success!

FOCUS GROUP PRESCREENING QUESTIONNAIRE RESPONSES- EFNEP

Participant Questionnaire

Thank you for being interested in our study! We would like to know a little more about you in order to assign you to a focus group. Please answer the questions below as best as you can. Information you give will only be used for research purposes and no identifiable information will be shared with anyone.

1. Your gender (check one): ______male ___9___female

2. Your age category (check one):

____6____18-27 ____1____44-51
____1____28-35 ________52-61
____1____36-43 ________62 and above

4. Food allergies that I have include:_____wheat___________________________________

3. How often do you eat peanut butter, on average (check one)?

_______ 5+ times/week
____8___ 2-3 times/week
____1___ 1-2 times/week
________ 1-2 times/month
________ Several times/year
________ Once per year

4. What type and brand of peanut butter do you usually buy? _Jif(6), Peter Pan (2), Reese's (1)_

5. I would rate the peanut butter I usually buy as….

_______7_________ Extremely acceptable
______2__________ Very acceptable
_________________ Acceptable
_________________ Slightly acceptable
_________________ Not acceptable

5. Who in your household would eat this product? (Select all that apply)

____9___ Yourself
_______ Your spouse/ roommates
_______ Children ages 11-18
____9___ Children under 10
_______ No one

6. Do you eat natural food products? _____ Yes ____9__ No

If yes, which products?____

7. Please provide your name, email, and times you will be available to participate. We anticipate the focus groups will be help between the dates of XXXX and XXXX.

NAME:____

EMAIL:____

AVAILABILITY:

SUNDAYS:____

MONDAYS: ____

TUESDAYS: ____

WEDNESDAYS: ____

THURSDAYS: ____

FRIDAYS:____

SATURDAYS: ____

Thank you for making our study a success!

APPENDIX D: FOCUS GROUP DATA COLLECTION SHEET

When selecting different brands of the same food product, how important is each factor below?			
	Important	Neutral	Not important
Price			
Ease of Use (convenience)			
Possible Health Benefits			
Label Claims			
Trying New Foods			
Taste			
Appearance			

APPENDIX E: FOCUS GROUP CONSENT FORM

All products today contain peanuts or peanut-based products

Consent Form

I, ____________________, agree to participate in a research study Quality Characteristics and Consumer Perception of Peanut Butters conducted by Dr. Ruthann Swanson (706-542-4843) and graduate student Jackie Harrison, Department of Foods and Nutrition, University of Georgia. I am at least 18 years of age or older. I understand my participation is voluntary. I can refuse to participate or stop taking part without giving any reason and without penalty or loss of benefits to which I am otherwise entitled. I can ask to have all of the information about me returned to me, removed from the research records, or destroyed immediately after my participation.

The purpose of this study is to investigate consumer perception of peanut butters. All ingredients are currently available commerically in the United States and are included in these products at levels at or below those found to be safe by FDA. Further, all products are produced in facilities in which Good Manufacturing and ServSafe procedures are followed. If I volunteer to take part in this study, I will be asked to do the following things:

- Read and sign the consent form (1-2 minutes)
- Complete the demographic and food choices questionnaire (5-8 minutes)
- Respond to questions in a group setting that will be video and/or audio recorded, concerning product characteristics and labeling (1 hour)

Food allergies that I have include:
____
____
____

This study is confidential. No individually-identifiable information about me, or provided by me during the research, will be shared with others, without my written permission, except if it is necessary to protect my welfare (for example, if I were injured and need physician care) or if required by law. Recordings will be stored in a locked cabinet which can only be accessed by Dr. Ruthann Swanson or Jackie Harrison. No direct benefits to participants are expected.

There are no expected risks or discomforts associated with participation for any person who does not have allergies to ingredients in the products. However, in the event that my participation in this study results in a medical problem, treatment will be made available. However, my insurance company or I will be billed for the cost of any such treatment. No provision has been made for payment of these costs or to provide me with other financial compensation. As a participant, I do not give up or waive any of my legal rights.In the event I suffer a research-related injury, I will seek treatment at an appropriate medical facility. However, my medical expenses will be my responsibility or that of my third-party payer, although I am not precluded from seeking to collect compensation for injury related to malpractice, fault , or blame on the part of those involved in the research. If I have further questions about this study, I can call Dr. Ruthann Swanson at 542-4834.

I understand the procedures described above and my additional questions have been answered to my satisfaction. I agree to participate in this research study, and I have received a copy of this consent form for my records.

Ruthann Swanson___	________________________	_________
Name of Researcher	Signature	Date
Jacqueline Harrison___	________________________	_________
Name of Researcher	Signature	Date
__________________	________________________	_________
Name of Participant	Signature	Date

Please sign both copies, keep one and return one to the researcher.

Additional questions or problems regarding your rights as a research participant should be addressed to Chairperson, Institutional Review Board, University of Georgia, 629 Boyd Graduate Studies Research Center, Athens, Georgia 30602-7411; Telephone (706)542-3100; Email address IRB@uga.edu.