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EVALUATING CONSUMERS' PERCEPTION OF GLUTEN-FREE/ CLEAN-LABEL MUFFINS

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ABSTRACT

The gluten-free-natural-ingredient (GF/NCL) product demand is globally increasing and driven by the growing prevalence of celiac-diseases. Nevertheless, the quality of GF product is often inferior compared to wheat-flour counterparts due to the removing of gluten, which, compromises the appearance, structure, and nutritional value. The addition of fiber into GF/NCL products has been considered to improve nutritional values while maintaining quality attributes. According to the US-FDA, a product containing ≥2.5 grams of fiber/serving can be claimed as a “good-source-of-fiber.” However, adding dietary fiber to baked products affects their qualities, and hence possibly lowering product acceptability.

The main objective of this research was to understand consumer perception of GF/NCL muffins and GF/CL/Fiber-Content ready-to-use premix products. Two experiments were conducted: I) Evaluation of the acceptability of GF/NCL Mango Muffins (MM) and the impact of Health Benefit Information (HBI) on Consumer Liking, Emotion, and Purchase Intent; II) Evaluation of the effects of added fiber in GF/CL Chocolate Muffin Mix on consumer perception, emotions, likings and purchase intent after health benefit information was given. Results in study I showed that compared to GF, the lower color-liking scores for GFNCL1&2 were due to lighter-yellow color. All liking scores were acceptable (>5.0) on a 9-hedonic scale, due to high liking scores for odor and taste (mango), while the lower overall liking (OL) score for GFNCL1&2 were due to taste and texture-related attributes (softness/moistness/stickiness). In general, MM was successfully developed and highly acceptable to consumers.

Results from study II, 0g, 1.7g. and 3.8g/serving (“good source of fiber”) showed that liking scores of all sensory attributes were between 5.91 to 7.45, meaning a high acceptance by consumers. The addition of fiber resulted in high scores in comparison with the control. The muffins “good source of fiber” statement indicated high purchase intent after the HBI was given. Finally, a dry-mix “good source of fiber” was developed as a ready-to-use product to evaluate acceptance and convenience. The product was successfully accepted by the participants, having a high willingness to purchase. This product would be potentially launched to the marketplace to cover the fiber gap that exists within the population.

CHAPTER 1. INTRODUCTION

1.1. Research overview

Sweet bakery is a category in which consumers have high expectations about the appearance, taste, and texture (Kvidahl, 2019). Muffins are commonly consumed as a sweet, spongy breakfast or evening snack foods prepared traditionally from wheat flour, sugar, oil/fat, milk, and eggs. However, people with celiac disease cannot eat this type of baked products due to the gluten content from wheat. Originally, gluten-free products were developed for people who suffer celiac disease (CD). Celiac disease is an autoimmune disease that represents 1.4% of the global population (J. Singh & Whelan, 2011; J. P. Singh, Kaur, & Singh, 2016). Person with celiac disease should avoid gluten, a protein found in wheat, rye, and barley; the main gluten-free cereals suggested for celiac people buckwheat, rice, corn, and sorghum (Shin, Gang, & Song, 2010; Yamsaengsung, Berghofer, & Schoenlechner, 2012). The only treatment to avoid complications related to gluten consumption is the strict adherence to a gluten-free diet (Matos, Sanz, & Rosell, 2014; Montemurro, Pontonio, & Rizzello, 2021).

However, gluten-free muffins are currently gaining attention due to increasing consumption by individual with health-related conditions such as nonceliac gluten/wheat sensitivity and wheat allergy, dermatitis herpetiformis, gluten ataxia, and other chronic inflammatory diseases. These products are also being consumed by people who are interested in gluten-free products as a novel trend (Bascunan, Vespa, & Araya, 2017).

However, it represents a challenge for food manufactures to develop acceptable gluten-free products because consumers seek the right balance between healthy and indulgent products. The GF products available in the marketplace often have poor quality

such as low volume, poor color, and hard crumb compared to the gluten-containing products (Matos et al., 2014). To overcome this problem previous research indicates that the quality of gluten-free products can be enhanced by the addition of different ingredients. There are three classifications of ingredients which help to improve the quality of the product such as i) water-binding (hydrocolloids), ii) structure-forming (proteins, fats) and iii) surface-active substances (emulsifiers), and this led to added additives to a final GF product (Rybicka, Doba, & Bińczak, 2019). However, as consumers are becoming aware and conscious about food ingredients, they are relating a large list of ingredients with highly processed food. Therefore, they are taking preventive measures by choosing healthier options to avoid food-linked diseases mainly related to artificial ingredients (Plasek, Lakner, Kasza, & Temesi, 2019). As people are getting more knowledges about how to read labels on food packages, Gluten-free/clean label options are increasing consumer's attention. Shortlist ingredients and claims such as "free-from" and "natural" are perceived as healthier products. In this study, we tried to remove artificial ingredients to make a shortlist because, according to Mintel research in 2019, 62% of US consumers agreed that a product that contain fewer ingredients, the healthier will be. Demand for Gluten-Free/Clean-label products has opened new market-niche opportunities in the bakery industry (FoodInsight, 2020b).

As rice has a bland flavor, it has become one of the most popular cereals used in gluten-free formulations; however, the lack of gluten and nutritive value represents manufacturer’s concern. To cover these challenges, manufacturers must find the right combination of alternative ingredients to improve nutritional quality (Matos et al., 2014). Previous studies pointed out that dietary fiber (DF) enrichment and gums such as xanthan

gum (XG) influence the overall quality of food by changing its physicochemical properties and significantly affect the sensorial properties because they contribute to the product's water-holding properties and viscosity of the gluten-free products (Gómez, Ronda, Caballero, Blanco, & Rosell, 2007; Kaczmarczyk, Miller, & Freund, 2012). This also can contribute to overcome the ‘fiber gap’ in the population around the world because people are consuming less fiber than the recommendations (Jones, 2014). The necessity to improve the product quality makes fiber an important ingredient to take advantages in the food industry. In addition, the demand for ready-to-use products with health benefits has been increasing due to the benefits that it brings to consumers such as time saving which provides convenience without losing texture and taste (MarketandMarket, 2020b). Convenience food has been evolving over time due to increasing concern about artificial ingredients by consumers. Therefore, manufacturers have been working to satisfy the demand. For example, Michael Moss, in his book “Salt, Sugar and Fat” exposed how convenience food is not the same as it was years ago, and neither is the consumer. Now consumers ask more questions about it. For example, “how is it convenient? what are the ingredients? what am I trading for the convenience?.” Therefore, the main objective of this study was focused on understanding consumer perception of GF/CL muffins and GF/CL ready-to-use premix labeled “a good source of fiber”.

CHAPTER 2. LITERATURE REVIEW

2.1. The gluten-free diet

Gluten-free diet eliminates products that contain cereals such as rye, wheat, and barley because for people with certain health related conditions the immune system strongly reacts to specific amino acid sequences present in the prolamin fraction of those cereals (Catassi & Fasano, 2008; Littlejohns et al., 2021). Currently, there are many reasons why people are demanding gluten-free products. The consumption of gluten-free products is not only due to celiac disease (genetic) but also due to health-related conditions (Nonceliac gluten/wheat sensitivity (NGGS); wheat allergy (WA)), and lifestyle (diet). A gluten-free diet could prevent malabsorption, nutrition deficiencies, relief of symptoms for those with non-celiac gluten/wheat sensitivity (NCGS), and wheat allergy (WA) (Bascunan et al., 2017).

First, celiac disease (CD) is an autoimmune condition, which is caused by the ingestion of products that contain gluten and causing damage to the villi (tiny hair) located in the small intestine (Mahmoud, Yousif, Gadallah, & Alawneh, 2013; Wardy et al., 2017; Wardy et al., 2018). The destruction of the mucosa causes malabsorption of crucial nutrients for the organism, such as folic acid, fat-soluble vitamins, iron, and calcium. Therefore, it affects the body's nutritional balance (Hill et al., 2005) and can cause dermatitis herpetiformis, a cutaneous manifestation of CD (Bascuñán et al., 2016). Diverse complications of CD include osteopenia, nutritional deficiency, and malignancy such as lymphoma (Ludvigsson, Osby, Ekbom, & Montgomery, 2007). The non-gastrointestinal symptoms of CD include weight loss and diarrhea (Arslan, Rakha, Xiaobo, & Mahmood, 2019).

The main factors for the development of the disease are immunological inflammation, genetic predisposition, and environment. In the past, CD was considered a malabsorption disorder initiated during childhood. Still, these days, it is known as a chronic disorder of the small intestine, which can appear at any stage of life Arslan, Rakha, Xiaobo, & Mahmood, 2019). Its prevalence has been reported to be 1–2 % of the population in North and South America, North Africa, Middle East, and India (Bascunan et al., 2017). According to the Celiac Disease Foundation, the incidence rate of celiac disease among Americans was at 0.5% in 2018. In addition, experts have anticipated that the number of celiac patients in the region is expected to double every 15 years (MarketandMarkets, 2020a). The only treatment for someone diagnosed with celiac disease is a strict gluten-free diet (Wardy et al., 2018).

Second, nonceliac gluten/wheat sensitivity (NCGS) is caused by consuming gluten-containing foods that induces symptoms in certain individuals without CD. The prevalence of NCGS ranges from about 0.5% to 6% (Reilly, 2016). The symptoms are irritable bowel syndrome, and small bowel bacterial overgrowth. Also, fructose and lactose intolerance may be responsible for symptoms in those self-diagnosed with gluten sensitivity (Tavakkoli, Lewis, Tennyson, Lebwohl, & Green, 2014). The NCGS is also described in the literature as gluten hypersensitivity or gluten intolerance. The diagnosis is made by excluding CD or IgE-mediated allergy to wheat and is based on the direct association between gluten ingestion and symptom onset (Tonutti & Bizzaro, 2014).

Thirdly, wheat allergy is a well-recognized but unsatisfactorily understood condition; some symptoms in wheat allergic patients can be immediate (typically IgE mediated) or nonimmediate (typically T-cell mediated) and frequently are respiratory,

cutaneous, or digestive in nature (Sicherer, 2000). Allergic reactions to wheat ingestion or inhalation are common, inflicting up to 1–3% of the population (Newberry, McKnight, Sarav, & Pickett-Blakely, 2017). For years it has been proposed that NCGS and CD are different clinical syndromes and that NCGS may be associated with gluten-induced activation of innate, instead of adaptive, immune response (Leonard, Sapone, Catassi, & Fasano, 2017; Sapone et al., 2012).

Nowadays, another consumers group is rising who eliminate gluten consumption due to their health consciousness; they are choosing gluten-free products as a healthier option (Bascunan et al., 2017). In addition, the increasing awareness of the parents for their children has been a factor for including this kind of product in their diets (Reilly, 2016). Consumers consider the gluten free claim to indicate that the product is healthy and beneficial (*Consumer Confusion over Free-from Allergen Labelling*, 2019). There has been a steady increase in the “free-from” concept shared in European food and drink launched between 2014 and 2019 (Schofield, 2019). About three million Americans have celiac disease, and a further estimated 40 million suffer from gluten intolerance or sensitivity (MarketandMarkets, 2020b). The “free-from” trend has led to a considerable increase in the gluten-free products market. Markets and Markets research service in 2019 reports that the global gluten-free products market size is estimated to account for about USD 5.6 billion in 2020 and is projected to reach a value of nearly USD 8.3 billion by 2025, growing at a CAGR of 8.1% from 2020 to 2025. Recently, the International Food Information Council (IFIC) Foundation’s 2019 performed Food and Health Survey and reported that clean eating, intermittent fasting, and gluten-free diet are the most common

eating patterns/diets. This fact represents a big, but challenging opportunity for the food industry (FoodInsight, 2020b).

2.1.2. Developing gluten-free products and its rise over time

As consumers are becoming aware of the diseases caused by consumption of gluten, most are now moving toward a gluten-free diet. Furthermore, enabling product manufacturers to develop gluten-free products helps cater to the dynamic demands across distinct product categories (Research and Markets, 2019a). Despite celiac disease affecting just 1% of the population, surveys showed that approximately 20% of consumers avoid gluten (Wang et al., 2021). Likewise**,** according to the National Health and Nutrition Examination Survey, the percentage of people without celiac disease avoiding gluten increased from 0.5% in 2009 to 1.7% in 2014, while the prevalence of celiac disease remained low during the same period (0.7%) (Choung et al., 2016). In 2015, the Hartman Group, a company that tracks consumer trends, recognized that 20% of consumers are avoiding/reducing gluten in their daily diet and 29 % of consumers say "gluten free" is an important label during selection of foods and beverages for purchase. In addition, according to Mintel, approximately two in five Americans eat gluten-free foods (38%) because they believe it's better for their overall health, and 25% eat them because of weight loss reasons (Hartman Group, 2015; Riffkin, 2021; Topper, 2021). Likewise, the influences for gluten-free products also have been increasing, because best-selling books such as Grain Brain and Wheat Belly associate gluten ingestion with health complications such as obesity, cardiac disease, and diabetes, and claim that those conditions can be "cured" with dietary avoidance (Wang et al, 2021; Davis, 2019; Perlmutter & Loberg, 2014).

2.1.3. Gluten-Free Companies

Table 2.1. Food companies with gluten-free options

Gluten-Free Companies			
Alessio Fasano, MD Almased Authentic Foods Bakers Barilla Bentilia Blonde Beard's Buffalo Sauce Blue Diamond Breadblok Brownie Brittle Bubbies Fine Foods BUKfoods Cabinet Caleb's Cooking Company California Pizza Kitchen Canyon Bakehouse Caulipower Celiac Cutie Celiac Disease Foundation Chosen Foods Complete Start Gluten-Free Instant Breakfast Shakes Cook's Gluten-Free Sourdough Cookies Con Amore Creation Nation Crispy Green Crown Prince Cup4Cup Daddy Sam's Daniel Leffler, MD MS	Flax 4 Life Flour Farm Fody Foods Free Freed Foodies Gabriel Cosmetics GeeFree Foods Gem City Fine Foods General Mills Germinal Organic GFF Magazine Gluten-Free Living Gluten-Free Prairie Glutenostics Hallie Rose Katzman, Rayna Mae Katzman, Lori Akawie Katzman Happy Family Brands HC Foods Health Heavenly Waffles Heavenly Waffles Hoss Soss Huga Bar Immaculate Baking Company Jessica's Natural Foods Jones Dairy Farm Joseph Murray, MD JumpstartBodyfuel Kate Farms King Arthur Baking Company La Tortilla Factory Lean Cuisine Life Cuisine Lilac Pâtisserie	Little Northern Bakehouse LiveKuna Magazine Manini's Mehl's Gluten Free MELI'S Monster Cookies Mikey's Mina Mom Made Foods Muffin Revolution MYBREAD Nairn's New Grains Gluten Free Bakery Oma's Own Foods Our Specialty Pamela's Products Path Of Life Peter H R Green, MD Phyllis Pearson Rachel Pauls Food Reason To Bake Richland Rum Rootz Nutrition Safely Delicious Schär Sheila Crowe, MD Shelley Case, BSc RD Shrewd Food Skinny Pizza Snowflakes	Sweet Sydney's Talenti Gelato Tasterie TH Foods (Crunchmaster) Three Granola Thrive Market Tito's Handmade Vodka TMGF Productions Trifecta True North Tuscon Tamale Udi's Gluten Ultimate Beauty Undercover Chocolate Co. Valisure Vanini Veggiecraft Farms Wasa Zego Zellee

Source: Celiac Organization, 2021a

All these reasons lead to the GF diet becoming one of the most popular diets in the modern history. Therefore, a gluten free is not also followed by people with celiac disease but also by people who wants to change their diets because of the tendency for healthy lifestyle (Newberry et al., 2017).

Hence, the global gluten-free products market size in growing fast (Research and Markets, 2019a). Products such as bread, rolls, buns, cakes, cookies, crackers, wafers, biscuits, baking mixes & flours, breakfast cereals, snack bars, confectionery products, noodles are under the gluten-free product segment. These products are widely accepted and consumed across regions. Manufacturers operating in the gluten-free market are mainly into producing the solid form of gluten-free products owing to the higher sales of these products, longer shelf-life, easier logistics required, convenience in manufacturing and formulating, and lower costs of production (MarketandMarkets, 2020a).

2.1.4. Challenges of gluten-free formulations

Wheat, which appeared about 10,000 years ago in the so-called “fertile crescent” in Southeast Asia, currently known as Turkey, Palestine, Lebanon, and northern Iraq, has been the most common cereal used by the food industry. People worldwide have learned its diverse uses related to the bakery (Gujral, Freeman, & Thomson, 2012). The widely used application is due to its gluten-content, an essential structure-forming protein; which helps form dough elasticity and contributes to the desired color, texture, and flavor (Gallagher, Gormley, & Arendt, 2004). It can retain air, contribute to water absorption, cohesivity, viscosity, and elasticity of dough, helping to bake and improve several characteristics of ultra-processed products (Wieser, 2007).

Therefore, as gluten is removed as in gluten-free products, it is vital to consider adding alternatives ingredients to ensure improvements in sensory characteristics, acceptance, and nutritional quality in the gluten-free formulations. Therefore, several considerations need to be taken by the manufacturers when developing any gluten-free products, such as the type of complimentary ingredients to assure the quality of the product, nutritional requirements, cost of the production and finally, the regulations (Aprodu & Banu, 2015).

2.1.5. Quality of the gluten-free products

The quality of gluten-free products has been compromised due to a lack of gluten, which is the forming structure of protein and plays an essential role during the baking process, providing the proper texture and sensory attributes. Therefore, consumers revealed dissatisfaction with GF bread due to a lack of variety and consistency. Manufacturers need to develop a solid gluten-free product portfolio to satisfy distinct product categories (Wardy et al., 2018). The number of ingredients found in gluten-free products was 28% lower than in gluten-containing products. Likewise, lower diversity of elements was being employed in the formulation of gluten-free food products compared with their gluten-containing counterparts. Gluten-free products were limited to rice, corn, cassava, and potato starch; these ingredients decrease protein content and nutritional quality (Amanda Bagolin do Nascimento, Fiates, dos Anjos, & Teixeira, 2014).

Various studies have been performed to improve the textural qualities of gluten-free products by using gluten alternatives. Components such as starch, plant proteins, animal proteins, hydrocolloids such as gums, pectins, hydroxy methylcellulose, xanthan gums, emulsifiers, enzymes, and fiber have also been incorporated into gluten-free

formulations (Aprodu & Banu, 2015; Jnawali, Kumar, & Tanwar, 2016). Likewise, many kinds of cereal, grains, seeds, legumes, and nuts may replace gluten, such as amaranth, quinoa, millet, sorghum, flax, and chickpeas, among others; the addition of them can improve the palatability and nutritional quality of gluten-free diet (GFD) (Bascunan et al., 2017). However, they are not frequently used because of their higher cost and reduced obtainability. Some companies have released processed foods containing amaranth, quinoa, and buckwheat due to their higher levels of protein, fat, fiber, and minerals than those found in rice and corn, and these has become good alternative ingredients for gluten-free products (Bascunan et al., 2017).

Nevertheless, the bakery industry demands healthy but indulgent products; hence, a common practice involves using rice flour together with a hydrocolloid to obtain the right balance between texture and tastiness. Rice flour has been used due to its hypoallergenic proteins, a bland soft taste, and its colorless properties, while hydrocolloid is usually used to improve the crumb structure, taste, acceptability, and shelf life (Aprodu & Banu, 2015; Arslan et al., 2019).

For example, Sae-Eaw et al. (2007) used broken rice, which is considered a by-product with low economic value. She stated that particle size distribution is an essential physical characteristic that affects food sensory attributes which are critical for designing food processing, final product quality, and consumers' need. Several researchers have studied the effects of rice flour particle size on processing conditions and absolute product quality (Wang et al., 2021).

2.1.6. Nutritional Requirements

Nutritionally, gluten-free products usually are not fortified with micronutrients as are their wheat-containing counterparts. According to Newberry et al. (2017), after evaluating celiac patients' nutritional intakes, he concluded that GFD alters macronutrient, micronutrient, and dietary fiber consumption, leading to adverse nutritional outcomes. Also, GF products indicated a lower amount of DF, folate, and iron (Thompson, 2000). As Table 2.2 shows, gluten-free products have faced some problems related to nutritional values, which may affect the wellness of celiac people or people who avoid gluten consumption. Fortification/enrichment of commonly consumed gluten-free commercial grain products should be encouraged. Dietitians specializing in CD play a critical role in the education and maintenance of the GFD for patients with CD (Thompson, 2000).

2.1.7. Nutritional concerns about gluten-free products

Table 2.2. Nutritional content of gluten-free products.

Author	Topic of research	Results
Wu et al. (2015)	Are gluten-free foods healthier than non-gluten-free foods? An evaluation of supermarket products in Australia.	"Lower dietary fiber in gluten free cereals, Lower protein content in gluten free cereals, breads, and pastas."
Thompson (2000)	Folate, iron, and dietary fiber contents of the gluten free diet.	"Lower dietary fiber, folate, and iron content across categories such as bread, pastas and cold cereals compared to gluten-containing products."

(table cont'd)

(table cont'd)

Author	Topic of research	Results
Miranda, Lasa, Bustamante, Churruca, and Simon (2014)	Nutritional Differences Between a Gluten-free Diet and a Diet Containing Equivalent Products with Gluten	"Women resulted in a lower dietary protein intake."
Estevez, Ayala, Vespa, and Araya (2016)	The gluten-free basic food basket: a problem of availability, cost, and nutritional composition.	"Lower protein in gluten free bread and cereal, lower dietary fiber in gluten free pastas."
Vici, Belli, Biondi, and Polzonetti (2016)	Gluten free diet and nutrient deficiencies: A review	"Results showed that GF-diet was poor in alimentary fiber due to the necessary avoidance of several kinds of foods naturally rich in fiber and the low content of fiber of GF product that are usually made with starches or refined flours." Poor in micronutrients (Vit. D, Vit. B12 and folate). "Poor in minerals (iron, zinc, magnesium, and calcium) The inadequate macronutrient is triggered by the avoidance of gluten and the less importance of nutritional quality of choice."

2.1.8. Improvement on gluten-free products

Table 2.3. Improvements on gluten-free products

Author	Topic of research	Results
Rai, Kaur, and Singh (2014)	Quality characteristics of gluten-free cookies prepared from different flour combinations	"The highest sensory overall acceptability scores were found for cookies prepared from a combination of pearl millet and sorghum flour followed by rice and sorghum, maize and sorghum, rice and maize, maize and pearl millet, rice, and pearl millet and control cookies. All gluten-free cookies had higher nutritional value as compared to control cookies and were acceptable by panelists."
Arslan et al. (2019)	Complimenting gluten free bakery products with dietary fiber: Opportunities and constraints	"Addition of DF significantly affects the color, firmness, moistness, crumb staling and microstructural feature of GF products."
Aprodu and Banu (2015)	Influence of Dietary Fiber, Water, and Glucose Oxidase on Rheological and Baking Properties of Maize Based Gluten-free Bread	"Glucose oxidase improved the specific volume of bread for all fiber types. Crumb firmness was improved only by addition of Psyllium and pea fibers."
Yildiz and Gocmen (2021)	Use of almond flour and stevia in rice-based gluten-free cookie production	"Protein and dietary fiber contents of the cookie with almond flour (AF) and stevia were enriched to 82 and 96% It has found that physicochemical, nutrition and sensorial properties of gluten-free cookies that were developed with *AF* + stevia supplementation provided more acceptable products."
Wardy et al. (2018)	Gluten-free muffins: effects of sugar reduction and health benefit information (HBI) on consumer liking, emotion, and purchase intent.	"HBI had a positive effect on overall liking, consumer acceptability and emotional responses of the GF muffin with 50% sucrose reduction were comparable to those with 100% sucrose."

(table cont'd)

(table cont'd)

Kaur, Singh, and Singh (2018)	Functional, pasting, nutritional and gluten free muffin making properties of plantain flour (PF).	"PF muffins had more content of Ca; were lighter in color and liked more by sensory panel as compared to WF muffins. The possibility of developing gluten free products with PF can expand the product supply for people with celiac disease and contribute to a more diverse diet."
Jatinder Pal Singh, Kaur, Shevkani, and Singh (2015)	Influence of jambolan (Syzygium cumini) and xanthan gum (XG) incorporation on the physicochemical, antioxidant and sensory properties of gluten-free eggless rice muffins.	"XG improved muffin quality characteristics (appearance, specific volume, and resilience). Sensory analyses revealed that JFP incorporation improved the consumer acceptability of the muffins."
Sabanis, Lebesi, and Tzia (2009)	Effect of hydrocolloids on selected properties of gluten-free dough and bread.	"The addition of hydrocolloids contributed to bread with higher loaf volume and better color compared to control GF bread as well as to increased shelf life due to its moisture-absorption ability. Sensory evaluation by a trained panel revealed a preference for bread containing 1.5% HPMC because of its loaf volume, appearance, and firmness characteristics."

2.1.9. Cost of gluten-free products

The economic implication is another factor to consider in developing gluten-free products that are highly nutritious and demand high ingredients. Sometimes, food companies use a more extensive list of ingredients to satisfy consumer demand (Jnawali et al., 2016). At the same time, as consumers are concerned about their health, there is a critical need to develop gluten-free products that are highly nutritious and, at the same time, economical (Jnawali et al., 2016). Generally, the cost of GF bread and flours are higher than gluten-containing products, which results in enormous challenges for

manufacturers. For instance, according to do Nascimento et al. (2014), they found that on average gluten-free foods are three times more expensive than similar gluten-containing foods.

In a study conducted in commercial establishments in the United Kingdom, Singh & Whelan (2011) identified a limited availability of GF products and verified that the prices of these products were significantly higher than those of equivalent conventional products, costing between 76 and 518% more. Similar results were reported by Lee, Ng, Zivin, and Green (2007), in the United States. The authors also identified that all GF products were significantly more expensive than their conventional counterparts, costing on average 240% more.

Nowadays, the provision of gluten-free products is expanding around the world compared to the late 1960s situation; however, the high price of the products makes them unavailable for low-budget consumers. Meanwhile, regular and quality supermarkets are offering increasing numbers of gluten-free products because consumers are willing to pay (Burden et al., 2015; Capacci, Leucci, & Mazzocchi, 2018). For example, in Australia and Canada, GF consumers spend more than twice as much as those buying 'regular' wheat-based products (Pinto-Sanchez et al., 2015). In Chile, it has been estimated that people who follow a Gluten-Free-Diet (GFD) spend €80.00 more monthly, while in Greece, it amounts to €48–112. In the U.K usually GF products are 159% more expensive than gluten-containing products, for example (€4.82 versus €1.25 per kg). In general, the celiac consumer pays on average an extra €11 each week compared to their pre-diagnosis spending level, corresponding to 29% of their food budget (Capacci et al., 2018; Estevez et al., 2016; Fry, Madden, & Fallaize, 2018).

2.1.10. Regulations of gluten-free products

For gluten-free products industries need to consider some other considerations, including the product's safety, acceptability, and affordability and that they are in line with the guidelines approved by the FDA (Food and Drug Administration) (*Center for Food Safety and Applied Nutrition*, 201). In 1976, the standard for gluten-free food was adopted by the Codex Alimentarius Commission (CODEX) of the World Health Organization (WHO) and by the Food and Agricultural Organization (FAO). Then, in 2000 they established that "gluten-free foods" can be described as:

(a) A product that only is made from ingredients which do not contain prolamins from wheat or all *Triticum* species such as spelled, kamut or durum wheat, rye, barley, oats, or their hybridized varieties; also does not excess 20 ppm of gluten level (Jnawali et al., 2016); (b) “Consisting of ingredients from wheat, rye, barley, oats, spelled or their crossbred varieties, which have been rendered gluten-free; with a gluten level not exceeding 200 ppm” (Jnawali et al., 2016); (c) “Any mixture of two ingredients as in (a) and (b) mentioned with a level not exceeding 200 ppm (ppm or milligrams of gluten per kilogram of product” (Bascunan et al., 2017; *Commission*, 2007; Jnawali et al., 2016).

In August 2013, the U.S. Food and Drug Administration (FDA) issued a regulation defining "gluten-free" for food labeling. Gluten-free products should be labeled as either "gluten-free," "no gluten," "free of gluten," or "without gluten" (Celiac Organization, 2021b). For example, the FDA in 2017 released the results of an analysis of 702 samples from more than 250 products labeled "gluten-free." Only one of the products did not comply with the labeling requirements. A recall was carried out, and subsequent testing did not find any products that violated the regulation (Celiac Organization, 2021b).

Therefore, the products must be labeled explicitly and correctly to allow consumers to better understand and assure a safe consumption (Hobbs & Kerr, 2006).

2.2. Clean label

2.2.1. What is Clean Label and What is Driving Interest?

There is not a legal or commonly accepted definition for “Clean Label.” Ms. Sanders, a senior vice-president of government relations and public affairs, American Bakers Association, Washington, DC, mentioned that “When you talk about the clean label, it’s the consumer’s perception of clean label,” “Those are recognizable ingredients and shorter ingredient lists. I think in the consumers’ minds, fewer ingredients mean less processed.” (Atkinson, 2015). According to Stephanie Mattucci, Associate Director, Food Science at Mintel, she said that clean eating refers to eating whole, natural, unprocessed foods and avoiding artificial ingredients and highly processed foods (Mattucci, 2018).

According to research from Cargill in 2018, it was found that 60% of responders said they were aware of clean label products, but they didn’t know how to define them, and almost 80% said they looked at these products but did not know what the term means (Natural Product Insider, 2019). The meaning of “clean label” may involve natural ingredients, simplicity, transparency, and minimal processing (Hutt &Sloan 2015).

According to a report “Guide to Clean Label” from Tate & Lyle, published in the *Journal of Food and Nutrition* there are five features that people expect to see in a clean label product. Beginning with a short and simple list of ingredients, 76% of consumers read ingredient labels (Tate & Lyle, 2019). Transparency doesn't only mean having easy-to-recognize components. Nowadays, people are asking about “Clean” on the outside, which means having transparent packaging to that consumer can see what's inside before

buying. Mainly millennials are asking for packaging options such as plant-based and recyclable materials (Churchil, 2020). "Clean" Language, people are looking for words like "100% Natural," "Real Fruit," or "Five Servings of Vegetable" “Hormone-free”, “Pure and Whole”, "No MSG," "Non-GMO," and "Nothing Artificial."

However, it depends on consumer perception, but those claims can help understand the concept of “Clean-Label” (Brenntag, 2020). Clean Symbols and logos could be informative to consumers. Clean label manufacturers are improving their logos by adding natural or realistic images on the front of the package. For example, fruit-filled breakfast food can feature pictures of real fruit, or a carton of organic milk can feature a picture of a farmer standing next to a few cows—signifying freshness. Clean-label consumers want to feel that they are eating fresh products even when wrapped in a package, for instance, including fresh fruits in a yogurt, whole grain bakery goods, or raw honey (Schofield, 2019). Nielsen (2017) categorized the clean label trend into five segments: conventional, free from, clean, simple, and sustainable. Between these five segments, clean label products reject artificial ingredients, hormones, antibiotics, and GMOs and are seen as organic, fair trade, humane, with an ingredient list of less than ten recognizable ingredients (The Nielsen Company, 2017).

2.2.2. Regulatory Involved with Clean Label Products

There is no regulatory definition of a clean label. There are no enforcement concerns. If claims for clean labels are made, they should be truthful and not misleading. However, the organic, NON-GMO’s implications can be involved in Clean Label criteria. Any existing “definitions” for either term position “natural” and “clean label” close together. However, there are key differences: FDA’s expectation statement and USDA’s guidance

on “natural” clearly limit additives for color, despite their natural or synthetic origins. Natural pigments such as carotenoids, beet, anthocyanin, and chlorophyll are not permitted in a “natural” food product but are acceptable in a “clean label” product. Natural products should be free of preservatives, but many natural ingredients have antimicrobial agents. Natural antimicrobials/preservatives, including cultured dextrose, cultured vegetable juice, cherry powder, vinegar, are not allowed to be included in foods carrying a “natural” claim. However, they are acceptable for clean-label products. (Note that ingredients added for “flavor” with antimicrobial properties are good in natural foods.)

The FDA has no regulatory definition for “natural”-related labeling. Still, it states that “The agency has not objected to the use of the term if the food does not contain added color, artificial flavors, or synthetic substances” (FDA, 2017). Meanwhile, in the European Union, “natural” is only defined in EU regulations related to flavorings (Scott, 2013). The U.S. Department of Agriculture states that “natural” is a “product without an artificial ingredient or added color and is only minimally processed.” A Minimal processing product means that the product was processed in a manner that does not fundamentally alter the outcome. The label should include a statement explaining the meaning of the term “natural,” such as “no artificial ingredients; minimally processed” (USDA, 2015). According to the FDA and USDA, the significant difference between “natural” and “clean label” claims relies mainly on food colorings. Natural colorants (like carotenoids and anthocyanins) are not allowed in natural labeling but are acceptable in clean labeling (Wang & Adhikari, 2015).

2.2.3. Consumer Behavior in Relation to Demographics

In the past years, Michael Pollan started influencing people and changing their mindsets by sharing the idea about eating clean and selecting the right food for the body in his books “Omnivore's Dilemma”, published in 2016 (Pollan, 2007). In his 2008 book "In Defense of Food," it suggested several rules for eating, including: "Don't eat anything with more than five ingredients, or ingredients you can't pronounce." Another statement was, "the best foods have an ingredient list with five items or less, and that none of those would be unrecognizable to your grandmother." And "Eat food. Not too much. Mostly plants." These words have motivated people to look for clean-label options. The former Wall Street Journal reporter's suggestion that consumers look for products with five ingredients or less (and a related prohibition on stuff your grandmother wouldn't recognize) has helped created the legacy known as the clean label (Pollan, 2009).

According to the most recent online Food & Health Survey carried out by the International Food Information Council, conducted by Greenwald & Associates, and completed by 1,012 Americans ages 18 to 80, years, the most common diet patterns are clean eating, intermittent fasting, and gluten-free. In this survey, the eating pattern was added (FoodInsight, 2020b). Clean Label Foods during the last years have been motivated by health, wellness, sustainability, or production concern (Stanton & Nan, 2020). Parents and younger shoppers are driving this Clean Label trend. Interest in eating clean is highest among the 18-29 years old shoppers and declines with age (FoodInsight, 2020b). The population was between the Millennials and Generation Z, who are concerning about eating healthier (1 in 4 consumers look for health benefits from food). Similar to another study called "Clean Label Values" Phase I Focus Group Report,

Millennials and Gen Z by Food Insight claimed that Millennials and Gen Z consumers have little awareness of clean food labels. Still, most understand the concept of clean eating and clean food. One of the responses was, "It's a peace of mind thing. You feel better about yourself if you buy that item compared to another option." Nowadays, millennials are driving this shift; however, a number of baby boomers are also joining the movement (FoodInsight, 2018). That is why many companies seek to fit into the new trend products by launching clean label products (Ingredion, 2014).

Some parents prefer to buy cheap products to obtain healthy food for their children because of the cost (FoodInsight, 2018), and they know that Clean Label products are expensive most of the time. However, according to the result obtained by the Global Clean Conscience Report in 2019, 70% of parents said a clean/natural product is a driver attribute for purchasing the product for their children. For example, four out of ten parents desire to have better options for pure/natural products within all essential mealtimes such as breakfast, lunch, dinner, and snacks, and this has become the second most important influence for children, just below nutrition (FoodInsight, 2020b).

2.2.4. Perception of what is a healthy food

The more ingredients that are added to the food, the more artificial the food becomes. Consumers demand natural and organic ingredients for a better lifestyle and to minimize the risk of losing health and developing disease due to synthetic and manufactured food items (Montemurro et al., 2021). Problems linked with artificial ingredients have increased consumers' concerns about food quality and promoted a growing desire for natural food products (Nunes, 2016).

According to the Clean Conscious Eating survey published in 2019, the consumer’s paradigm has changed over time; the old consumer's paradigm was "I choose to eat what is good for me and good for the planet," meanwhile, currently they say, "what is good for the planet is also good for me." In this study, the consumers identified four pillars to eating clean: health, safety and avoiding negatives, transparency and trust, and environmental impact. The main health concerns in the US are overweight (34.2%), obesity (33.8%), more than a third of adults have heart disease, and more than a third have high blood pressure, also increased risk of developing high blood pressure during their lifetimes (1.5%); also, weight and health problems are often linked to poor dietary choices (Health Focus International, 2019).

These problems that people currently face explains why people are aware of their health and have become conscious about proper diets (Arslan et al., 2019). Nowadays, clean-related terms have emerged as part of consumers' vocabulary as a new way to say "healthy" (Mattuci, 2018). According to Lynn Dornblaser, director of innovation and insight for consumer research group Mintel, consumers are focused on achieving overall health in various ways. Looking for whole ingredients and food that comes directly from nature without being processed or otherwise altered is one significant way people define "healthy”. Consumers are interested in natural and organic ingredients and products free from artificial preservatives, colorings, or unrecognizable ingredients (Global Food Forums Editors, 2021).

"Natural has always been interesting to shoppers on labels," says Julie Johnson, a senior project manager with Health Focus International, St. Petersburg, Fla. "Most consumers agree that a food or beverage is more likely to be natural if the label contains

fewer ingredients than normal”. Two in five US consumers agreed "no artificial ingredients" are important when shopping for food and drink (Mattuchi, 2018). "Consumers now are trying to keep the right balance of indulgence and healthy; furthermore, they are considering "wholesome" and "natural" said Marisa Churchill, who has been working with plant-based nutrition at Cornell University. Stauffer, in her research, tittle "Clean Conscious Eating," published by Health Focus International, said that being familiar with the list of ingredients is a top attribute that allow consumers to feel confident and choose the product. "The big takeaway here is that consumers tend to associate 'natural' with 'healthy,' and this explains why companies are removing artificial colors and flavors and replacing them with natural colors and flavors," said Mr. Vierhile. "Perception is everything, and natural is perceived to be better and more healthful, regardless of whether or not this is the case" (Baltazar, 2018).

2.2.5. Perception and purchase intent of clean label products

As consumers are getting smart about reading labels, many food companies are focusing on developing more specific, cleaner products with innovative ingredient solutions. "According to [Natural Marketing Institute] (NMI), two-in-three consumers were reading labels last year (del Buono, 2017). A survey conducted by IFIC 2019 showed that 3 out of 10 consumers said that taste, recognizing the ingredients, and trust in the brand significantly impact purchases (FoodInsight, 2020b).

According to Ingredion, consumers are now actively seeking products with some form of clean label claim (Ingredion, 2021). In contrast, 70% of those purchasing dairy and bakery products know clean label claims and say these claims influence their buying decision. Familiarity plays a significant role in buying decisions. Some people are quick

with their decision when it is about picking a product, but there are people who take much energy and time because they are label readers and try to compare between options. This also is related to unfamiliar ingredients that can cause a wrong impression of the product. Consumers find it necessary to recognize the ingredients in the foods and beverages and 81% of consumers find it essential to have a shortlist of ingredients (Gersonde & de Vernal, 2013).

Consumers are not willing to accept a change in taste for a favorite product even if it had a clean label. For this reason, it has become the biggest challenge for the food industry to obtain a Clean Label alternative. Meal and eating occasions dictate which factors are considered and what products the participants ultimately purchase. For instance, if the consumers are looking for snacks, they will prefer something that tastes good instead of being a healthy food (Petrun, Flood, Sellnow, Edge, & Burns, 2015). On the other hand, when it is about a special meal, they will have a healthy choice because the use of pesticides and hormones in foods like meat, fruits, and vegetables are more heavily considered in these types of products. Eating clean is especially important to parents with children under 18 years of age living at home (FoodInsight, 2020b).

There are six pillars regarding clean eating: health, safety, avoiding negatives, transparency, trust, and environmental. The health pillar includes mental and emotional well-being, a healthy weight, a balanced diet, and an active lifestyle. Safety is defined as basic product safety and avoiding artificial ingredients and chemicals in food (Nunes, 2016). Clean label claims have also led people to look for plant-based meat alternatives that contain ingredients considered not only planet-friendly but also healthier.

As consumers think that healthy is equal to eating clean, many people are avoiding those compounds that have alarmed consumers for decades, like fats, salts, and sugars, which are standard components of almost all foods within the marketplace. According to Tate & Lyle Proprietary Research, 71% of consumers read nutrition labels; this was because FDA in 2016 updated the label claim regulations (Stanton, 2019), which has helped consumers make better choices. For example, currently, they are aware of the sugars added to the product. This awareness has led manufacturers and restaurants to act and seek the suitable clean label ingredient to reformulate the product or remove the unwanted ingredient (Stanton, 2019; Tate & LyLe,2019).

At the same time, according to Kerry for many countries around the globe, governmental bodies have helped to reduce sugar through education campaigns and, increasingly, sugar taxes on products, especially sugar-sweetened beverages (Kerry 2020). For example, the Irish Government introduced a sugar tax in 2018, which was taken to reduce childhood obesity (Milner, Kerry, O'Sullivan, & Gallagher, 2020).

Attributes of clean label product

Kalsec Consumer Research in 2019 after conducting a survey on US consumers explains that the top five attributes related with clean label products are:

1. No artificial ingredients
2. Fresh Ingredients
3. Short Ingredients list
4. Ingredient origin
5. Minimally processed

2.2.6. A growing market for clean-label products

According to the report by Research and Markets, as this trend is becoming more important, the industry of clean label ingredients globally was estimated at $38.83 billion in 2018 and is expected to reach $64.1 billion by 2026, with a compound annual growth rate (CAGR) of 6.8% from 2019 to 2026 (Research and Markets, 2019b). The expansion of this type of product has given consumers a variety of healthful and fresh options. Nowadays, consumers can easily find kid's food (since parents tend to put their kids' health first), functional beverages, and meal replacer bars. For example, active people who are also seeking the cleanest of labels are important niches to explore (Baltazar, 2018). Christina Bechtold, CEO of Prime Label Consultants Inc, said that several trends have arisen in combination with the clean label movement as opportunities for manufacturers to connect and captivate their target (Shelke, 2018).

Patricia Kim, general counsel, and vice-president of regulatory affairs for Swanson Health Products Co., points out that "clean label is not going away." Many facts ensure that despite the time and rigorous testing required to ensure the safety and quality of alternative ingredients, an increasing number of food manufacturers will follow the clean labeling movement. For instance, "Food Business News" reported an estimated $165 billion in global clean-label foods and beverages sales in 2015, with $62 billion from North America. Global sales may reach $180 billion by 2020 (Nunes, 2016). Food companies (like Campbell Soup, Nestlé, and Mars) have committed to removing artificial food additives, and clean labeling is driving innovations in food product development. Currently, the practice of creating clean labels is becoming more of a necessity than a trend in the U.S. and across the world (Watrous, 2015)

2.2.7. Go Clean Label certification scheme

A new “Clean Label “certification scheme designed as a web-based resource was launched in the U.S. market in 2016. This resource provides information about the origin of the ingredients by companies such as Trader Joes’s, ALDI, H.E.B., Whole Foods, Panera, and Kroger. This certification is good for 12 months because, in the future, the consumer’s perceptions may change. For example, Stevia cannot be considered a clean label if, in the end, the extraction, purification techniques, and sourcing strategies change (Perishable News, 2018; Watson, 2017). For this certification, the manufacturers send specification sheets to Go Clean Label. They decide according to their criteria if they meet or not. After that, the products can use the Go Clean Label certified logo on their packaging (Watson, 2017).

2.2.8. Challenges for clean-label ingredients and further product development

Specific sources like Documentaries, talk shows, social media, news, food companies, and restaurants influence consumers' decisions. As everyday people are more familiar with technology, they can get information quickly. According to results in the IFIC's Food and Health Survey in 2017, consumer confusion is widespread: the idea that consumers encountered conflicting information about health and nutrition and were confused about their own choices. For example, one participant described his desire to learn what he should and should not eat, but the more he read, the less confident he became. In the end, he pointed out: "clean food is a little foggy." So, understanding what a Clean Label product is could be crucial to choosing a product (FoodInsight, 2018). Also, when people find an unfamiliar ingredient or they can't pronounce its name, it led to being hesitant about the products. For example, Mary Mully, PhD., food scientist

and product development consultant at Foodwise One LLC said, "That doesn't work if you are talking about thiamin hydrochloride, which is Vitamin B. It will be on every cereal box, and there is nothing wrong with it but sounds chemical and for people who haven't been in chemistry since high school, it sounds bad." (Natural Product Insider 2019). This is also word as "tocopherol" or "tocotrienol" which is "vitamin E" (Shelke, 2018). Hilton, a co-founder of BrandHive a Utah based branding agency specializing in the ingredients space, claimed that "people are becoming more proactive about their health and more conscious about what they eat". But he noted that the abundant information and misinformation can lead to getting confused about healthy foods (Shelke, 2018).

On the other hand, a big challenge to develop a clean label product is finding the proper formulation with pure ingredients to obtain quality, stability, pricing, and the most crucial, good taste (Baltazar, 2018). A lot of companies have been switching to natural ingredients to satisfy the new trend Clean Label. For example, if they want to use natural colors, they need to consider some factors said Christine O'Keefe, an analyst with the Freedonia Group, Cleveland, OH. Synthetic dyes are highly stable, whereas natural colors tend to be less intense. For example, Ms. O'Keefe from General Mills said that artificial color can be overcome by using greater dosages of natural colors, but this may affect other qualities of the final product." However, this brings another set of problems since some natural colors have associated off-flavors at higher dosages, such as anthocyanins from red radishes (Baltazar, 2018). All these factors can lead to a shorter shelf-life product. She pointed out an example of Carmine, which gives an orangey-yellow color that is stable to heat but can migrate badly. For instance, many manufacturers are

starting to replace it with lycopene, which allows stability without migration and sustain a longer shelf life (Baltazar, 2018). According to shelf life, for instance, essential oils from herbs and spices have been proven to have antimicrobial properties, making them promising substitutes for preservatives (Quinto et al., 2019). However, their efficacy must be thoroughly investigated before replacing current preservatives (Cheng & Hart, 2016).

Another consideration is that with natural colors, it is hard to obtain the large array of colors as they can with artificial colors (Raterman, 2019). Switching to clean labeling involves more than removing ingredients because these ingredients may not work alone in food products. Taking flavored beverages as an example: the oil-based flavor agent needs the help of an emulsifier to disperse it throughout the water-based drink. Without the emulsifier it will lead to a considerable change in the sensory characteristics, including appearance and flavor (Marrapodi, 2015).

Finally, but not least important, it is the expensive cost for switching from artificial to a natural production. Natural ingredients are more expensive than synthetic ones. For example, according to Technavio, "for natural coconut flavorings, a chemical called Massoia lactone is required (Baltazar, 2018). This chemical is obtained from the bark of the Massoia tree in Malaysia. The process of obtaining this chemical is expensive from harvesting the tree, removing the bark, and then extracting the lactone. For example, natural vanilla flavor costs three to four times more than artificial vanilla flavor; natural colors cost about 15 times more than synthetic alternatives (Baltazar 2018). Besides costs, it is time-consuming because manufacturers need to take care of regulations like labeling, usage limit, and GRAS, Generally Recognized as Safe (Chen & Hart, 2016).

2.2.9. Food companies with clean label options

Table 2.4. Companies that are switching to clean label options.

Food Manufacturer	Statement on Ingredients
Kraft	Kraft removed artificial preservatives, flavors, and dyes from Kraft Macaroni & Cheese (Wang & Adhikari 2015).
Nestle	Nestlé USA removed all artificial colors, remove GMO ingredients, high fructose corn syrup and artificial flavors from chocolate candy products, and removed artificial flavors from entire line of frozen pizza and snacks and ice cream (Brenntag, 2017).
Panera	Panera Bread has a "no-no" list that contains artificial preservatives, sweeteners, and flavors, as well as colors from artificial sources (Wang & Adhikari 2015).
Papa Jhons	Papa John's Pizza removed 14 artificial ingredients (Wang & Adhikari 2015).
Simple Truth's	Simple Truth's "Free From 101" removed 101 artificial preservatives and ingredients (Wang & Adhikari 2015).
Whole Foods	Whole Foods Market banned many artificial colors, flavors, preservatives, and sweeteners (Wang & Adhikari 2015).
Cambell's	Campbell's Soup Company removed artificial colors and flavors from its North American products in 2018 and launched Well Yes! soups, which have no artificial colors, flavors, ingredients, or modified starches (Wang & Adhikari 2015).
Dannon	Dannon is using more natural ingredients in Dannon, Oikos, and Danimals branded products (Wang & Adhikari 2015).
General Mills	General Mills removed artificial ingredients from all of its cereal products in 2017 (Wang & Adhikari 2015).
Kellogg's	Kellogg's removed artificial colors and flavors from its products in 2018 (Wang & Adhikari 2015).
Mars	Mars removed artificial colors from its human food products (Wang & Adhikari 2015).
Subway	Subway removed artificial flavors, colors, and preservatives from its North American food products in 2017 (Wang & Adhikari 2015).
Unilever	Unilever removed artificial colors and flavors from many products (Wang & Adhikari 2015).
Haagen-Dazs	The Haagen-Dazs reduced to five ingredients in its ice cream line (Wang & Adhikari 2015).
La Brea Bakery	La Brea bakery shift to completely GMO-free.

Source: Vierhile, 2016; Hutt & Sloan, 2015.

2.2.10. Clean Label Opportunities

There are many opportunities for clean label ingredients that manufacturers can exploit. For example, based on type, the starch and sweetener segments held the largest share in 2018, generating more than two-fifths of the global clean label ingredients market. At the same time, the natural color segment is expected to grow at the fastest Compound Annual Growth Rate (CAGR) of 9.6% from 2019 to 2026, owing to the rise in consumer preference for organic label products and the surge in awareness regarding the harmful effects of chemicals used in artificial colors. Also, based on applications, the beverage segment contributed to more than one-fourth of the global clean label ingredients market share in 2018 and is expected to be the biggest contributor to market by the end of 2026 (Gersonde & de Vernal, 2013). This increase is due to the rise in beverage consumption and preference for beverages with natural ingredients. At the same time the bakery product category has increased this demand. According to Ayisha Koyenikan, Global Food and Drink Analyst Mintel, in 2019, 'natural' claims show on 40% of all European bread product launches, while in 2015 it was 35%. On the other hand, the dairy and frozen dessert segment would showcase the fastest CAGR of 9.2% during the study period. The rise in the consumption of dairy products is expected to boost the growth of the segment (Watrous,2015; Koyenikan, 2020).

Based on geography, North America accounted for more than two-fifths of the global clean label ingredients market revenue in 2018 and will increase by 2026. The increase was due to consciousness of the harmful effects of synthetic ingredients and the surge in demand for natural food products in this region. According to a report from Mintel research in 2020, 66% of Spanish consumers disagreed that lab/cultured/synthetic meat

was appealing, 47% of US consumers agreed that non-GMO foods were healthier than GMO foods, and 42% of Chinese parents of children aged 0-3 years would be interested in non-GMO baby nutritional products. At the same time, the region across Asia-Pacific would register the fastest CAGR of 8.7% throughout the forecast period. (Mintel, 2020). Overall, Tate & Lyle in its research, showed that the global market with clean labels claim has been increasing during the past years. According to the location, Latin America has increased by 13%, North America 7%, Middle Africa 8%, Europe 4%, and Asia Pacific 4% (Tate & Lyle, 2020; Allied Market Research, 2020).

Among the food companies that sell clean label Ingredients are Cargill Inc.,Corbion Inc.,Frutarom, Ingredion Incorporated, Kerry Group Plc, Koninklijke Dsm N.V.,Sensient Technologies,and Tate & Lyle (Allied Market Research, 2020).

2.2.11. Possible Clean Label Ingredients, by type

Table 2.5. Clean-label ingredients

Natural Color	Astraea Allulose (IFT), Lycored's carotenoid (demonstrating stability to UHT and homogenization processes, as well as UV light and heat). Curcumin extract from Naturex * Caramelized sugar, turmeric root powder, and apple juice powder are stepping in as cleaner replacers for caramel color.
Natural Starch	BI Neutraceuticals' sweet potato powder adds essential vitamins and minerals, protein, and fiber to any application* Tate&Lyle with a Claria Starch line. Ingredion with a Novation functional starches. Pulse flours, including lentil, fava beans, pea, and cheackpea (Churchill, 2020)
Natural fibers	Fibersol from ADM/Matsutani is a line of corn-based soluble fiber

(table cont'd)

(table cont'd)

Natural Flavor	Prova's vanilla*
Natural Sweetener	Bestevia Reb M stevia leaf sweetener* Tasteva and monk fruit.
Natural Preservatives	Among Kemin's newest shelf-life extension and food safety solutions are the Fortium, NaturFort and GT-Fort lines of plant extracts and synergistic blends* Gellan gum, oat fiber, citrus fiber, sunflower lecithin, and konjac (Shelke, 2018). (Asian yam) flour is popping up as replacer of carragenaan. Rosemary extract, licorice extract, green tea, and acerola extract. Dough Conditioners. Bellarise BellaSOFT Organic 1500 Plus and Bellarise WP 1000 Organic Dough Conditioner (Friedberg 2019). Chia mucilage in powder or gel format which can be used in meat products. Kiwifruit puree (Yi, 2018)
Natural Emulsifier and hydrocolloids	Corbion, SweetPro. TIC Gums has hydrocolloid solutions including GuarNT USA and Ticaloid PRO 192 AGD* Rice dextrin, fruit juices, and date, fig, and prune pastes are stepping in as replacers ingredients for *glycerin* (Shelke, 2018) Citri-Fi from Fiberstar, upcycled ingredient, produced from byproduct of the citrus juicing process (Friedberg 2019) Egg replacers. Derivers ingredients from faba, algal flour, and pea protein (Churchill, 2020)

Source: IFT, 2017 Food Expo; Shelke, 2018; Churchill, 2020.

2.3. Fiber addition

Dietary fiber is defined as "Intrinsic and intact" in plants and added isolated or synthetic non-digestible soluble and insoluble carbohydrates that FDA has determined to have beneficial physiological effects on human health (Salehi, 2019; FDA, 1998). The consumption of fiber has several benefits, such as decreasing the risk for type 2 diabetes mellitus (T2D), obesity, cardiovascular disease (hypertension and stroke), and colon cancer by reducing the digestion and absorption of macronutrients and reducing the contact time of carcinogens within the gastrointestinal tract (Arslan et al., 2019; Kaczmarczyk et al., 2012; Lattimer & Haub, 2010).

Based on data from an analysis of food consumption, most consumers choose low-fiber foods frequently. Usually, a serving of many common foods provides 1–3 g of DF; individuals who eat according to the MyPlate guidelines constructed by USDA can ingest on average 20–24 g/d. Nevertheless, only 3-8% of the US population eats following MyPlate guidelines, and the foods that provide fiber are not commonly chosen (Jones, 2014). According to the Food and Health Survey conducted in 2019 by the International Food Information Council, more than 85% of respondents said fiber is healthy (FoodInsight, 2020b). Nowadays, consumers are more concerned about ingesting healthy foods with high DF and low energy contents (Garcia-Amezquita, Tejada-Ortigoza, Serna-Saldivar, & Welti-Chanes, 2018).

Dietary guidance universally recommends diets higher in fiber for health promotion (Slavin, 2005). The growing health concerns and advancements in R&D activities led to the growth of the dietary fiber market. According to a report from MarketsandMarkets in 2020, the dietary fibers market is estimated to be valued at USD 5.3 billion in 2020. It is projected to reach USD 9.6 billion by 2025, recording a CAGR of 12.5% in terms of value. Hence, food companies worldwide are shifting to ingredients that help enrich gluten-free products by adding dietary fiber (Aprodu & Banu, 2015; MarketandMarket, 2020b).

The addition of fiber not only enhances the nutritional value of the products but also improves the products' physicochemical characteristics, texture, and shelf life due to its gel-forming ability, fat mimetic, water binding capacity, thickening, and texturizing effect (Arslan et al., 2019). Previous findings indicate that the quality of the final product will depend on the type of fiber used, level of enrichment, and its interaction with other ingredients (Marco & Rosell, 2008). Water plays an important role in starch gelatinization,

protein denaturation, flavor, and color development. Adding fiber into the gluten-free formulations helps absorb and retain moisture in the dough due to the hydroxyl group present in the fiber molecule, which results in hydrogen bonding. Health benefits may result from improving dietary fiber intake. Recent financial modeling found that increasing dietary fiber consumption may lead to considerable annual savings for operating constipation-related health care costs (Quagliani & Felt-Gunderson, 2017).

2.3.1. Fiber claim/ labelling

In May 2016, the FDA published two updates to CFR 21 Part 101 related to nutrition facts labeling and official serving sizes. These changes are focused on increasing dietary fiber in the average American diet. Therefore, dietary fiber's recommended daily reference value went from 25 g to 28 g for a 2,000-calorie diet (Center for Food Safety and Applied Nutrition, 2018). Then, for dietary fiber nutrient content claims, based on the % DV present in the RACC for any given product; the FDA established that 10-19% of DV (2.8-5.4 g for dietary fiber) in the RACC allows "good source" claim and >20% of DV (> 5.5 g for dietary fiber) in the RACC allows "high" or "excellent" source claim. At the same time, the FDA has approved health claims supporting the role of DF in the prevention of cancer and coronary heart disease (CHD) (Kaczmarczyk et al., 2012).

CHAPTER 3. ACCEPTABILITY OF GLUTEN-FREE/NATURAL-CLEAN-LABEL MANGO MUFFINS AND IMPACT OF HEALTH BENEFIT INFORMATION ON CONSUMER LIKING, EMOTION, AND PURCHASE INTENT

3.1. Introduction

The gluten-free product demand is globally increasing and driven by the growing prevalence of celiac diseases. Celiac disease (CD) is an autoimmune disease. According to a study "Global Prevalence of Celiac Disease: Systematic Review and Meta-analysis" published in 2017, the global prevalence of celiac disease was found to be around 1.4% of the worldwide population. A person with celiac disease cannot eat gluten, a protein found in wheat, rye, and barley. CD is a genetic condition, and the only treatment is to remove gluten-containing foods from their diets (Wardy et al., 2018). The main gluten-free cereals suggested for celiac people are corn, rice, sorghum, and buckwheat (Shin et al., 2010).

Rice (*Oryza sativa L)* has become the most popular option due to its attributes, such as bland taste, white color, easy to digest, and hypoallergenic properties. But the lack of gluten which acts as a glue in baked goods and promotes the quality of the product, constitutes a big challenge when developing gluten-free options (Wardy et al., 2018). The quality of gluten-free alternatives is often inferior compared to wheat flour counterparts. To mimic the properties of gluten in baked goods, some hydrocolloids such as gums, starch, modified starch, enzymes with protein, and Hydroxypropyl methylcellulose (HPMC) have been added (Shin et al, 2010). In this case, the addition of hydrocolloids such as Xanthan gum is suggested from previous studies. Xanthan gum (XG) is a polysaccharide secreted by *Xanthomonas campestris*. It has been commonly used as a

thickening agent in foods and improves the final product texture (Jatinder Pal Singh et al., 2015).

To obtain a simple, natural, tasteful, and consumer-friendly product, we decided to add mango flesh to our bland rice muffins because of their tropical flavor. Mango (*Manguifera indica L*.) Ataulfo is a highly perishable seasonal fruit with a tropical flavor. However, enormous quantities are wasted during the peak season or even during commercialization because of poor post-harvest handling (Aziah, Min, & Bhat, 2011). It is one of the varieties with significant characteristics such as high antioxidant compounds like polyphenols anthocyanin, flavonoids, and dietary fiber (Garcia-Amezquita et al., 2018). Mango contains high levels of bioactive compounds such as vitamin C and carotenoids (Lebaka, Wee, Ye, & Korivi, 2021). Its properties and tropical flavor play an essential role in many physiological processes and in the prevention of illnesses such as constipation, hypertension, liver cirrhosis, diabetes, and cancer (Lario et al., 2004). Currently it has become popular to develop products that contain mango. Therefore, the objectives of this study were to characterize physicochemical properties (color and texture) among gluten free muffins with and without being natural clean label and to evaluate and compare consumer acceptance and purchase intent of these gluten muffins after consumers were given health benefit information (HBI).

3.2. Material and methods

3.2.1. Formulation

Rice flour was used as a base for muffins; Ataulfo mango (Brand: Mangos bunny; product of Mexico; Packed by Mangos APYC Higuera de Zaragoza Sinaloa; PLU 4312) was used as a flavor source, gluten free xanthan gum (Judee's Company) used as a

stabilizer; sodium bicarbonate (Bob Red Mill) was used to leaven dough and batters, and salt provided salty taste and enhanced flavor; unsalted butter and vanilla added essence to flavor; medium grade A eggs (average weight of 50 g per egg) were used like a leavening agent (adding volume), In this study, we used egg whites and egg yolks for separate purposes. Egg whites are moisture agents and stability, and egg yolks contribute to texture and flavor; sugar is used to maintain consistency, keeping the baked foods soft and moist.

2.2.2. Experimental Design and Preparation of Gluten-Free mango muffins and Gluten-Free/Natural Clean Label formulations

Muffins were prepared following the method described by Wardy et al. (2018) with some modifications. The experimental design is shown in Table 3.1. To start with the preparation of muffins, rice flour, baking soda, xanthan gum, and salt were added gradually and mixed for 1 minute at a first speed and 1 minute at a second speed (In a Kitchen Aid®, Benton Harbor, MI, USA). On the other side, ingredients including melted butter, vanilla, egg, and sugar were mixed manually in a container and added gradually to the dry ingredients and mixed for about 4 minutes at a first speed and 30 seconds on a second speed. Finally, mango ataulfo flesh was added and mixed for 2 minutes at a first speed and 1 minute at a second speed. Then the dough was left for 2 hours in the refrigerator (this step was omitted for the Gluten-Free/Natural Clean label two because whipped-egg-white was folded into the prepared dough) and then was placed into a paper baking cup (1.25 in diameter 350 count Package WILTON-Mini Baking Cups; Great Value; Walmart), then baked in an electrical oven (ALTO-SHAAM Combitherm, USA)

using the convection setting for 21 minutes at 375 ºF. Finally, the muffins were cooled at room temperature (25 ºC) for 30 minutes and stored for further analysis.

Table 3.1. Experimental Design and Preparation of Gluten-Free mango muffins

TREATMENTS		VARIABLES
Control	GF	Including artificial ingredients
Trt. 1	GF/NCL1	No artificial ingredients. Whole egg mixed during dough preparation
Trt. 2	GF/NCL2	No artificial ingredients Whipped-egg-white folded into prepared dough

*GF= Gluten Free
*NCL= Natural-Clean Label

3.2.3. Color and texture measurement

The color of muffins was measured at the top and its center by using a portable Konica Minolta colorimeter (Model BC-10, Minolta camera Co. Ltd., Osaka, Japan); the results were reported as L* (0= black, 100= white), a*(+ value = red, - value = green) and b* (+ value = yellow, - value = blue). Three replicates of each sample from the crust and the inner of muffins samples were evaluated. Texture harness (N), cohesiveness, and springiness (%) were determined by a Texture Analyzer (Texture Technologies, Hamilton, MA, USA) by using the texture profile analysis (TPA) using a compression test according to the AACC standard 74-09 method (AACC, 2000).

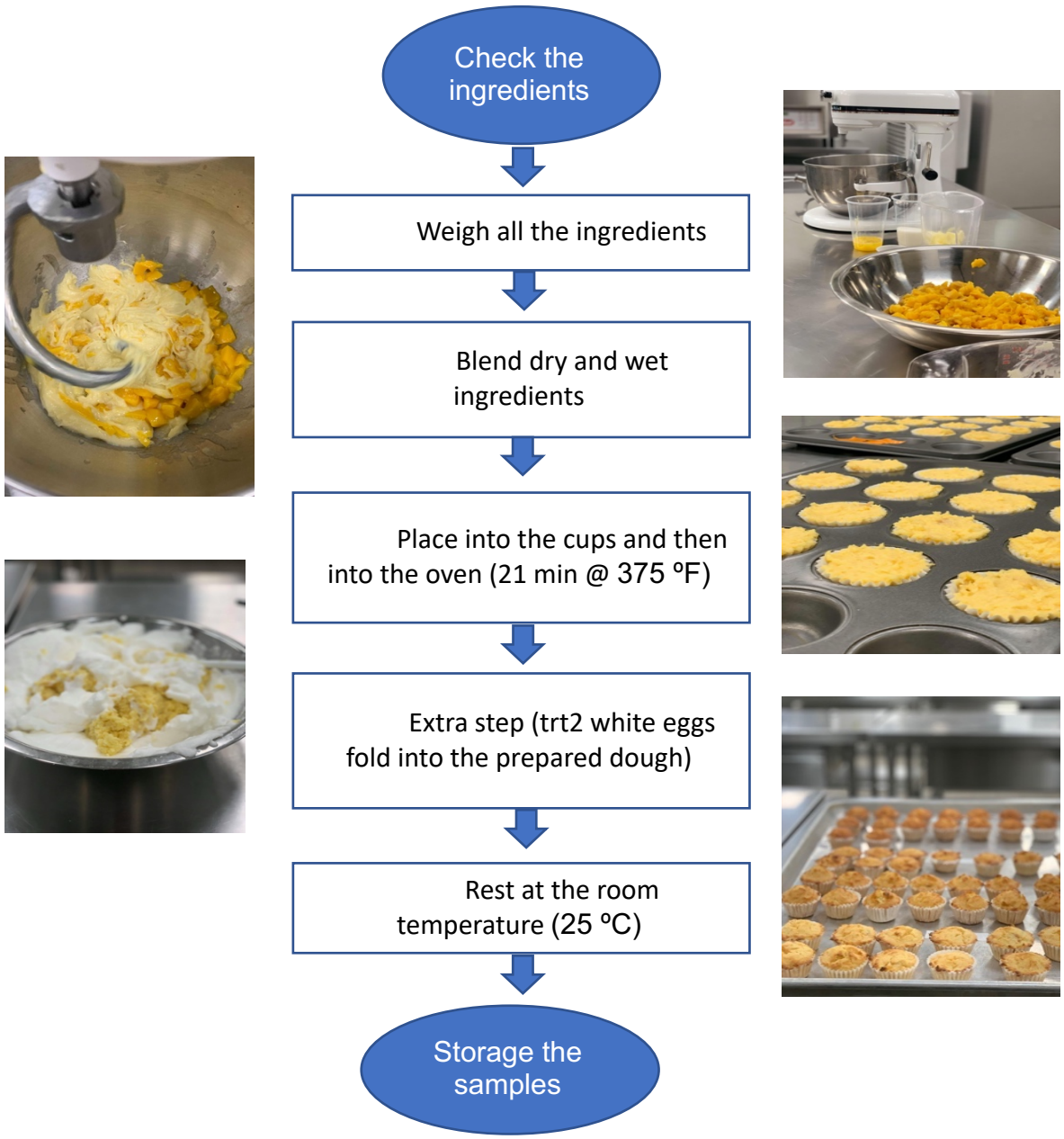


Figure 3.1. Mango Muffins manufacturing process

From the central part of each muffin, cubes with 3x3x3 cm (L*W*H) were cut using a sharp knife to avoid structural damage. Ten replicates for each sample of treatment were measured (Figure 3.2).

Figure 3.2. Texture and Color Analysis

3.2.4. Consumer study

Consumer evaluation was conducted at the Sensory Analysis Laboratory in the Animal and Food Sciences Laboratory Building, Louisiana State University, Baton Rouge, LA, USA. The sensory evaluation study protocol was previously approved by the Institutional Review Board (IRB# HE15-9). The evaluation protocols were based on the earlier study (Wardy et al., 2018). A total of 112 consumers (age ≥ 18 years) were recruited and they were informed about all ingredients from the product to avoid allergic reactions.

The gluten-free/clean-label samples: Gluten-Free (GF), GF and NCL (GFNCL1; whole-egg mixed during dough preparation), and GFNCL2 (whipped-egg-white folded into the prepared dough) were placed in foam white plates codified with three-digit numbers and served at room temperature (25 ºC). The samples were presented to the panelists using a randomized complete block statistical design to minimize any serving order effect. The tests were conducted during the whole day.

Crackers and water at room temperature were provided to each tester for cleansing their palates between samples to avoid bias. Panelists were seated in sensory booths and the reason of the project was explained. It was important that all consumers completed the demographic questionnaire, including age, gender, and purchase of gluten-free products (yes/no). The acceptability, emotional response, and purchase intent of the muffins were evaluated after taste testing (Figure 3.3.).

Figure 3.3. Consumer study

3.2.5. Evaluation of likings, emotions, and purchase intent

To evaluate the acceptability, consumers evaluated eight sensory attributes (color, odor, taste, softness, moistness, stickiness, mango-flavor, and overall liking) using a hedonic rating test on a 9-hedonic scale (1= dislike immensely, 5= neither like nor dislike, 9= like extremely).

First, to perform Penalty analysis, the measurement of overall acceptability on a 9-point hedonic scale and JAR scale responses were collected from the same panelists. Then, for each of the selected attributes, the mean decrease in liking was calculated by subtracting the liking values obtained from the hedonic scores of the consumers in the

not-JAR category from those in the JAR category (mean decrease = JAR liking − not-JAR liking).

Then, to evaluate consumer emotions, the emotional profile by CATA was used. The emotional terms (calm, good, happy, healthy, pleased, pleasant, satisfied, wellness, guilty, unsafe, and worried) were pre-selected. The PI (Purchase intent) was evaluated based on a (Yes/No) scale using a binomial method. After tasting, the PI was collected before and after the consumers were informed about the health benefits of Gluten-Free and Gluten-Free/Natural Clean Label muffins in comparison with other products that are available in the market.

3.2.5. Data Analysis

One-way Analysis of Variance (ANOVA) with an alpha level of 0.05 was used to compare formulations on instrumental color measurements (L*, a*, b*) and texture variables (Chewiness, Hardness and Springiness). A Randomized Block Design model of the treatments (Gluten-Free/Clean-Label (GF/CL); GF/CL1; whole-egg mixed during dough preparation, and GF/CL2; whipped-egg-white folded into prepared dough) was used to investigate the effect of formulation on the sensory liking of the muffins using panelists as blocks. One-way ANOVA with a mixed effects (formulation as a fixed effect and panelists as a random effect) model and a post-hoc Tukey's honestly significantly different (HSD) test ($p \leq 0.05$) were used to assess significant differences in the hedonic ratings of the muffins. Two-sided Cochran's Q test (asymptotic p-value) followed by the Marascuilo and McSweeney procedure (based on the minimum required difference) for multiple comparisons were used to investigate if significant ($P \leq 0.05$) purchase intent (PI) differences exist among the formulations for each tasting condition (before and after the

HBI) (Sheskin, 2003). McNemar tests (exact p-value) were conducted to determine the significance of the HBI on each formulation PI (comparing the proportion of PI=Yes before and after the HBI for each formulation). Penalty analysis on the JAR ratings was performed to determine the effects of the sensory attribute intensity on the liking of treatments. Finally, logistic regression models were used to predict the odds of PI = Yes based on hedonic responses and formulation (for the PI before HBI condition), and hedonic responses, formulations, and emotions (for the PI after HBI condition). Data analyses were performed using the XLSTAT (Addinsoft, New York, USA) statistical software version 2020 and the Statistical Analysis Software (SAS) version 9.4 (Statistical Analysis System NC, USA).

3.4. Results and discussions

Table 3.2. Mean consumer acceptability scores and purchase intent (PI)[A] for Gluten-Free Mango-flavored Muffins.

Attribute	GF[B]	GF/NCL1[B]	GF/NCL2[B]
Color	6.81 ± 0.15 a	6.17 ± 0.15 b	6.19 ± 0.15 b
Odor	6.99 ± 0.14 a	6.04 ± 0.14 b	5.78 ± 0.14 b
Taste	8.00 ± 0.14 a	5.93 ± 0.14 b	5.56 ± 0.14 b
Softness	6.48 ± 0.17 a	5.44 ± 0.17 b	5.40 ± 0.17 b
Moistness	6.41 ± 0.16 a	5.41 ± 0.16 b	5.42 ± 0.16 b
Stickiness	6.44 ± 0.15 a	5.57 ± 0.15 b	5.33 ± 0.15 b
Mango-flavor	6.39 ± 0.17 a	6.08 ± 0.17 a	5.53 ± 0.17 b
Overall Liking	6.79 ± 0.16 a	5.74 ± 0.16 a	5.37 ± 0.16 b
PI (%)[C]			
Before	68.86 A	39.29 B	35.71 B
After	71.43 a	46.43 b*	36.61 b

[A]Mean ± SD values of liking scores from N =112 consumers rated on a 9-point hedonic scale. Mean values in the same row followed by different lower letters are significantly different (P<0.05). PI was based on yes/no scale.

[B]Gluten-Free (GF), GF/NCL1; whole-egg mixed during dough preparation, and GF/NCL2; whipped-egg-white folded into prepared dough.

[C]PI were obtained from before and after consumers had been given HBI related to GF/NCL claim. *Significant differences of overall liking based on the dependent sample t-test, and of purchase intent based on the McNemar's test (P<0.05), comparing before and after consumers had been given HBI.

One of the biggest challenges during gluten-free production is to ensure a final product having good sensory attributes primarily related to texture, according Jnawali et al., (2016). The two main components of gluten, glutenin, and gliadin, play a crucial role in baking quality characteristics, giving the dough the capacity to absorb water, cohesivity, viscosity, and elasticity. However, many studies have shown that xanthan gum has been widely used in gluten-free products to replace the properties of gluten (Jnawali et al., 2016). This gum provides elasticity and stability by forming air bubbles in the dough mixture during baking (Lazaridou, Duta, Papageorgiou, Belc, & Biliaderis, 2007). Table 3.2 shows that consumer acceptability scores of GFNCL1&2 were significantly lower ($P<0.05$) than GF (5.33-6.19 vs. 6.39-8.0). However, sensory attributes were still acceptable, and all were greater than 5.0. Also, Sae-Eaw et al. (2007) and Singh et al. (2015), indicated that all gluten-free product sensory attributes were scored greater than 6.0 for likings scores.

The higher OL score (6.79) for GF was likely due to high liking scores for odor and taste (6.99-8.00), in which mango plays an essential role. The mango flavor attribute was well accepted in GF/CL1 formulation, and the results were similar between GF and GF/CL1 (Table 1). Mango ataulfo promotes overall health because of the bioactive compounds and has been generally used as a flavoring agent in the food industry (Lebaka et al., 2021). Therefore, combining rice flour with mango flesh resulted in an acceptable and flavorful product. On the other hand, the lower OL scores (5.37-5.74, Table 1) for GFNCL1&2 were due to taste and texture-related attributes (softness/moistness/stickiness). According to results from the survey conducted by Food

Insight 2018, the consumers were not willing to accept a change in taste for a favorite product even if it had a clean label.

Then, as the hydrocolloid was removed, which helped with the texture, the clean label formulations were negatively affected. According to Zarringhalami et al. (2016), gluten-free bread prepared by adding xanthan gum showed the highest pseudoplastic behavior and was more acceptable in sensory attributes. Compared to GF, the lower color-liking scores for GFNCL1&2 were due to lighter-yellow colors (higher L* and b*). This result was also found by Mahmoud et al. (2013), who reported that the crucial visual characteristic of gluten-free bread impacted overall consumer acceptance (Mahmoud et al., 2013).

Purchase intent results (Table 3.2) shows that significant differences ($p<0.05$) were seen among treatments GF/CL1&2 versus GF muffins before and after the Health Benefits Claim, respectively. On the other hand, the only treatment with higher PI after the Health Benefit claim was presented was that PI for GF/CL1 which significantly increased ($P < 0.05$ based on the McNemar's test) from 39.29% to 46.43%. These results are corroborated by Wardy et al. (2018), who indicated that HBI about gluten-free information influenced the "yes" purchase decision. Also, Petrun et al. (2015), in their article "Shaping Health Perceptions: Communicating Effectively about Chemicals in Food," indicated that consumers linked pure foods to positive health outcomes; they also related foods with artificial food ingredients to adverse health outcomes. De Magistris (2020) said consumers are willing to pay for health claims rather than nutrition claims. Claims such as natural and "free-from" lead consumers to prefer the product and pay a premium price (de-Magistris, 2020; Hartmann, Hieke, Taper, & Siegrist, 2018).

Table 3.3. Color and texture properties[A] of gluten-free (GF) mango muffins made with different clean-label formulations.

Color	GF[B]		GF/CL1[B]		GF/CL2[B]	
At top						
L	55.88±1.13	b	62.02±3.78	a	59.71±1.5	a
a*	13.94±0.87	a	10.27±1.52	b	8.69±0.97	c
b*	20.91±0.85	b	25.04±2.9	a	23.72±1.99	a
At the center						
L	63.62±1.42	a	64.18±2.69	a	64±1.53	a
a*	4.35±0.31	a	2.94±0.78	b	2.8±0.37	b
b*	21.74±1.54	a	22.9±1.61	a	21.79±1.27	a
Texture profiles						
Hardness (N)	41.48±2.27	a	42.48±1.95	a	42.75±2.47	a
Springiness (%)	46.26±8.2	a	24.26±11.45	b	44.11±7.32	a
Chewiness (N)	14.75±2.35	a	8.78±4.44	b	15.59±2.52	a

[A]Mean ± SD from three independent replications for color and ten replications for texture. Mean values in the same row followed by different letters are significantly different ($P<0.05$).

[B]Gluten-Free (GF), GF/NCL1; whole-egg mixed during dough preparation, and GF/NCL2; whipped-egg-white folded into prepared dough.

3.4.1. Color

Color is an essential parameter for baked products because it gives indication of texture and aroma. Color depends on the physicochemical characterization of the dough resulting from the interaction of the ingredients and on the baking conditions (Sabanis et al., 2009). Generally, a lower L* value indicates a darker crust, whereas a higher b* value correlates to higher crust yellowness. Color of the three GF mango muffins are presented in Table 3.3; no considerable difference ($P>0.05$) in crust lightness (L* values) was found between clean label formulations (GF/CL1; GF/CL2), in which xanthan gum and baking soda were removed (Figure 3.5). Color (at top) for GF/CL1&2 were a lighter-yellow color than the GF muffins based on L* (59.71; 62.02, and b* values 23.72; 25.04), which indicates higher values than GF (55.88; 20.91). On the other hand, the a* values (at top)

for all three GF muffins were different (Table 3.3.). Therefore, the lighter appearance of the muffins affected consumer acceptability for GFNCL1&2, as shown in Table 3.2 for color liking attributes.

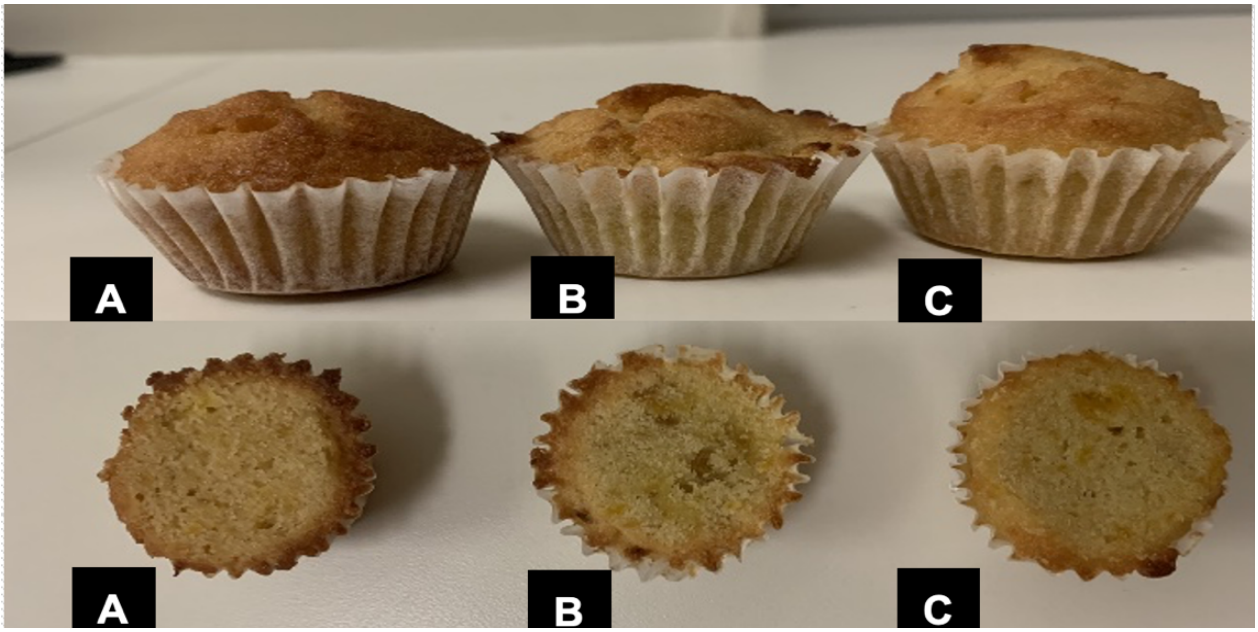


Figure 3.5. Color and texture of gluten-free (GF) mango muffins made with different clean-label formulations. A) Gluten-Free (GF); B) GF/NCL1; whole-egg mixed during dough preparation; C) GF/NCL2; whipped-egg-white folded into prepared dough.

However, the color of all muffins was acceptable (scores ≥ 6.1). The internal color lightness (L*) and yellowness (b*) values were similar, but the redness (a*) of GF/CL1&2 muffins were significantly lower ($P<0.05$) compared with the GF muffin. This is similar to the results found by Estellar et al., (2004) and Pagliarini et al. (2010), who also obtained high values of L* for gluten-free bread made with rice flour. This could be attributable to the effect of hydrocolloids on water distribution, which impacts Maillard reaction and caramelization (Naji-Tabasi et al., 2014, Mezaize et al., 2009). The same color results were found by Mahmoud et al. (2013).

3.4.2. Texture

The lack of gluten in rice flour can lead to a product with poor physicochemical characteristics because there is no main protein (gluten) network required for the desired viscoelasticity (Mahmoud, 2013). Typically, the product will have dry and crumble texture with poor mouthfeel, color, and shorter shelf life (Marconi & Carcea, 2001). Hydrocolloids are usually added to the formulations (Demirkesen, Mert, Sumnu, & Sahin, 2010) to create a synergistic interaction between starches and gums and improve the texture (de Morais, Cruz, & Bolini, 2013). In this case, for texture results in Table 3.3, the only significant differences were observed ($P<0.05$) for Springiness and Chewiness where GF/NCL1 had lower values (24.26; 8.78), respectively compared to GF/NCL2 (44.11; 15.59) and GF (46.26; 14.75). According to Sanz, Salvador, Baixauli, and Fiszman (2009), springiness is associated with fresh and elastic products; usually, the high springiness values show high quality in muffins.

In terms of hardness, there were no significant differences among treatments. Also, in GF and GF/CL2 formulation, by observing Figure 3.5, a greater volume was noticed compared to the GF/CL1 formulation. For GF muffin, a possible explanation for these results is that xanthan gum provides stability to the interface dough system and forms aeration by deliberating extra strength to the gas cells through the baking; this increased the gas holding and helps to have a better volume (Zarringhalami, Ganjloo, & Mokhtari Nasrabadi, 2021). Similar results were reported when XG was added to the batters of eggless cakes, the viscosity increased, which is a desirable characteristic in gluten-free muffins (Ashwini, Jyotsna, & Indrani, 2009; Noorlaila, Hasanah, Asmeda, & Yusoff, 2020).

On the other hand, the slight leavening of the crumb for GF/CL2 could be due to the egg-white folded process. According to Ryan (2020), the air is naturally incorporated; then, when the air gets trapped, the heat allows the dough to expand. This provides leavening, which results in a lighter, fluffier texture. It is essential not to crush the air during the folding process. Table 3.2 showed that attributes related to the texture (stickiness, softness, and moistness) were acceptable for the consumers because the likings were scored greater than 5.0 on a 9-point hedonic scale. According to Larrosa, Lorenzo, Zaritzky, and Califano (2012), hydrocolloids may enhance color and textural aspects of the dough, becoming crucial during gluten-free formulations.

Table 3.4. Mean consumer emotion scores[A] of gluten-free (GF) mango muffins made with different clean-label formulations.

Emotion[C]	GF[B]		GF/NCL1[B]		GF/NCL2[B]	
Calm	2.84±1.12	a	2.62±1.22	b	2.51±1.11	b
Good	3.18±1.08	a	2.68±1.15	b	2.66±1.14	b
Guilty	1.46±0.87	a	1.46±0.83	a	1.48±0.88	a
Happy	3.07±0.98	a	2.68±1.22	b	2.5±1.15	b
Healthy	2.87±1.24	a	2.77±1.29	ab	2.52±1.17	b
Pleasant	3.15±1.04	a	2.71±1.23	b	2.48±1.12	b
Pleased	3.21±1.04	a	2.7±1.22	b	2.41±1.13	c
Satisfied	3.28±1.14	a	2.78±1.23	b	2.49±1.14	c
Unsafe	1.32±0.69	a	1.33±0.8	a	1.23±0.64	a
Wellness	2.82±1.31	a	2.59±1.28	ab	2.57±1.24	b
Worried	1.26±0.68	a	1.28±0.69	a	1.27±0.64	a

[A]Mean ±SD from 112 consumer responses based on a 5-point scale. Mean values in the same row followed by different letters are significantly different ($P < 0.05$).
[B]Gluten-Free (GF), GF/NCL1; whole-egg mixed during dough preparation, and GF/NCL2; whipped-egg-white folded into prepared dough.
[C]Emotion scores were obtained after consumers had been given HBI related to GF/NCL of the muffin.

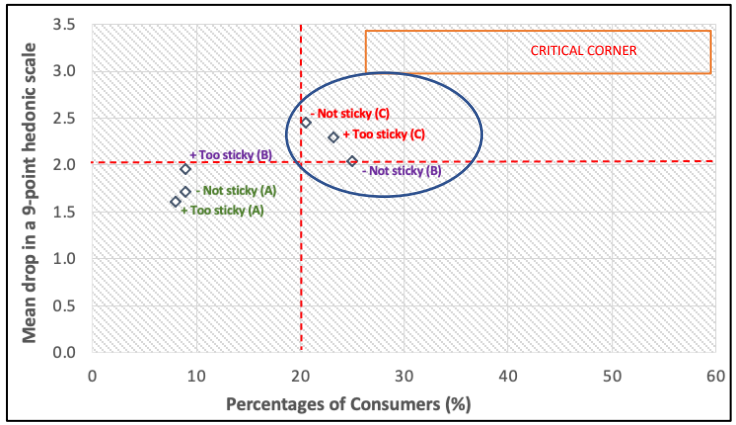
3.4.3. Emotions

Effects of gluten-free/clean-label formulation and HBI on consumer emotional responses is shown in Table 3.4. The emotional profiles of GF and GFNCL1&2 were different ($p<0.05$). After giving GF/NCL claims, positive emotions such as good, happy, pleasant, pleased, and satisfied and wellness-related emotions like health and wellness scores decreased. In contrast, negative emotion like guilty, unsafe, and worried scores was not improved for GFNCL1&2, and no significant differences ($P>0.05$) were found among all treatments; this implied that potential effects of GF/NCL claims were compromised by the less-desirable sensory quality (Table 3.4). These results are found by Wardy et al. (2018), who said that HBI did not affect emotions like unsafe and worried. Also, they reported that emotions and sensory properties could have a direct impact on likings of the product.

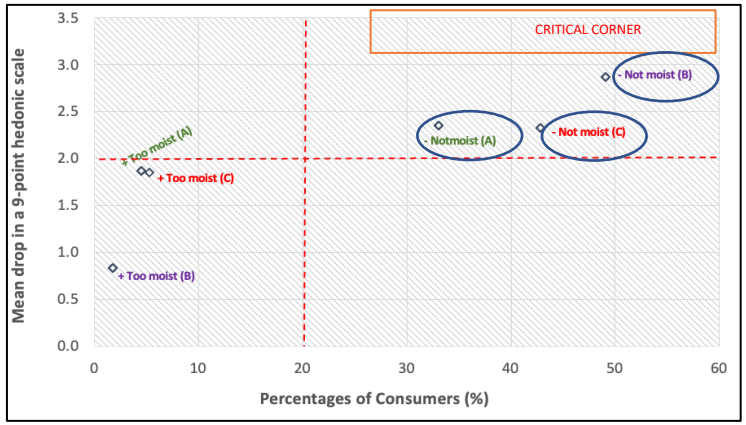
3.4.4. Penalty Analysis

Penalty analysis helps to determine how much the acceptability score is decreased by attributes that are not optimal; therefore, those attributes are penalized. In the Penalty analysis, the proportion of the respondents is plotted against the mean drop scores. A critical corner (located at the top right section) is usually set to highlight those attributes that have the most significant negative impact on liking. According to American Society for Testing and Materials (ASTM), attributes that impacted by more than 20% of participants, causing a drop more than two units are included in the critical corner (ASTM, 2009).

Stickiness



Moistness



Softness

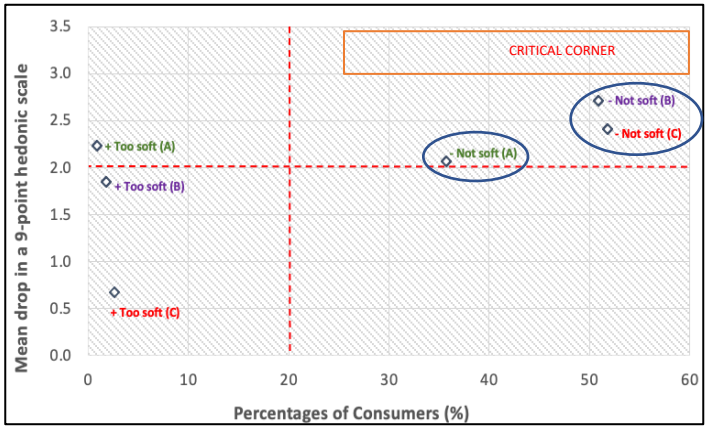


Figure 3.6. Penalty plots showing mean drops in Overall Liking as affected by non-JAR responses for softness, moistness, and stickiness attributes: Gluten-Free (GF), GF/NCL1; whole-egg mixed during dough preparation, and GF/NCL2; whipped-egg-white folded into prepared dough.

In this case, attributes contained in the upper right section of each perceptual map (Figure 3.6) were considered susceptible to modification in the formulation when at least 20% of the consumers reported that they were "not soft enough, not moist enough and not sticky enough," decreasing more than two units on a 9-point hedonic scale. Figure 3.6., confirms the attributes that were penalized more than one point by 20% of the consumers and were related to the texture characteristic. The consumers penalized the overall liking scores for stickiness by dropping 2.04 units for GF and 2.4 and 2.3 units for GF/CL1 & GF/CL2, which represented the responses "not sticky enough. " These contradicting results were found by Jatinder Pal Singh et al. (2015), where he reported that when xanthan gum was added to the formulation, the product becomes non-sticky due to the ability of the gum to absorb moisture present on the surfaces.

Then, for the moistness attribute, all the products were penalized by dropping 2.4, 2.8, and 2,3 units for GF, GF/CL1, and GF/CL2, respectively, representing the responses "not moist enough." Results may be compromised by the lack of xanthan gum that did not contribute to the water retention (Mahmoud et al., 2013). Finally, for the softness attribute, more than 35% of the consumers said that the product was "not soft enough," penalizing all the products by dropping 2.01, 2,7, and 2.4 units, respectively. Therefore, this represents a more significant impact on the mean drop in acceptance influenced by the product's texture, suggesting a potential improvement in the texture, mainly in GF/CL1 and GF/CL2 muffins (Figure 3.6). Therefore, penalty analysis aids detect probable sensory enhancements in the product by identifying the increase or decrease of intensity of a sensory attribute to be close to "just about right" (Agudelo, Varela, & Fiszman, 2015).

Table 3.5. Combined odds ratio estimates[A] for predicting purchase intent of gluten-free (GF) mango muffins after providing health benefit information (HBI).

Variables		Purchase intent before		Purchase intent after	
		Odds ratio	Type 3 LRT	Odds ratio	Type 3 LRT
Sensory attributes	Color	0.9660	0.7241	–	–
	Odor	1.0800	0.5093	–	–
	Taste	1.4540	0.032*	–	–
	Softness	1.2170	0.1113	–	–
	Moistness	1.3160	0.0282*	–	–
	Stickiness	1.0000	0.9987	–	–
	Mango flavor	1.6890	<.0001*	–	–
Emotions	Calm	–	–	0.9490	0.9330
	Good	–	–	2.0570	0.2775
	Guilty	–	–	5.2960	0.0028*
	Happy	–	–	1.8380	0.4348
	Healthy	–	–	2.2580	0.0974*
	Pleasant	–	–	0.8790	0.8619
	Pleased	–	–	0.4990	0.4957
	Satisfied	–	–	2.3380	0.2087
	Unsafe	–	–	0.3410	0.2823
	Wellness	–	–	1.0440	0.9146
	Worried	–	–	0.1110	0.0879*

[A]Based on logistic regression analysis, using seven sensory attributes and eleven emotions. Analysis of maximum-likelihood estimates was used to obtain parameter estimates. *Significance of parameter estimates was based on the Wald chi-square value at $P < 0.05$.

3.4.5. Purchase intent

Based on LRA results, purchase Intent Before (PIB) was influenced by liking attributes including taste, moistness, and mango flavor (significant PI predictors; $p<0.005$) because it increased by 45%, 32%, and 69%, respectively, when increasing 1 unit in liking score (Table 3.5). For GFNCL1&2, for every one-unit increase on the liking scores of tastes, moistness, and mango flavor (on a 9-points hedonic scale), the probability of “yes

Purchase Intent" would increase by 1.4 (taste), 1.3 (moistness), and 1.6 (mango flavor) times higher than not being purchased, respectively. Research from Martínez-Monzó, García-Segovia, and Albors-Garrigos (2013) reported that trend flavors such as salty/sweet, sweet/spicy, and tropical fruits are the nontraditional flavors used for innovation in the bakery industry; in this study, mango flavor led to having more acceptability and increasing purchase intent. Similarly, consumers also perceived taste as a somewhat more critical attribute to purchase intent (Sae-Eaw et al., 2007).

Likewise, the emotions "healthy" ($p<0.09$) and "guilty" ($p<0.05$) became significant predictors with odds values of 2.2 and 2.3, respectively, after HBI; this means for every one-point increase in the intensity of both emotions on a 5-point scale, the probability of the products being purchased would be 2.2 and 5.2 times higher than not being purchased (Table 3.5). These results were corroborated by Hartmann et al. (2018), who reported a willingness to pay extra for "free-from" products among those who looked for information and prefer natural products. Also, according to Carabante et al. (2018) and Asioli et al. (2017), giving consumers health benefits information (HBI) can enhance the acceptability of the product. HBI positively influences consumers' perception of a given product.

Researchers have shown that health consciousness can influence food attitudes and purchase intent (Mai & Hoffmann, 2015). Similarly, previous showed that health-conscious consumers based their food decisions on health-related attributes, whereas those with less health-consciousness were guided mainly by taste and other attributes unrelated to health (Mai & Hoffmann, 2012). According to Mai & Hoffmann (2015) in their article "How to Combat the Unhealthy = Tasty Intuition: The Influencing Role of Health

Consciousness," the relationship between healthiness and tastiness negatively affected people's nutrition because they will choose more unhealthy products due to their belief "The unhealthier it is, the tastier it will be"; therefore, they will eat less healthy food products and eat more unhealthy products.

On the other hand, another segments of consumers are those who are health motivated, and choose products based on health-related attributes with a lack of taste over short-term indulgence; hence, the purchase intent will increase (Carabante et al., 2018; Steinhauser, Janssen, & Hamm, 2019). Likewise, consumers must comprehend the information provided correctly and avoid misconceptions (Hipp et al., 2016). On the other hand, related to "guilty," previous research explains a cognitive association between guilt and pleasure; therefore, when guilt emotion is activated, it can automatically activate cognitions related to pleasure (Goldsmith, Cho, & Dhar, 2012).

3.5 Conclusions

Overall, it was observed that gluten-free mango-flavored muffins were successfully developed and highly acceptable to consumers. After removing artificial ingredients, instrumental color and texture on the Gluten-Free/Natural Clean label muffins (GF/NCL1) were significantly influenced. Regarding health benefit claims, gluten-free and gluten-free/clean-label claims may not necessarily improve the positive purchase intent of GF and GF/NCL2, respectively. However, a slight but significant increase in positive purchase intent was observed for GF/NCL1 after the claim was given to consumers. Positive emotion scores were not improved after the Gluten-Free/Natural Clean-Label claims were given to consumers. Consumers may not be willing to compromise sensory quality for a natural clean label. Based on the logistic regression

analysis (LRA), the incorporation of mango flesh positively impacted the purchase intent of Gluten-Free and Gluten-Free/Natural Clean-Label Mango-Flavored Muffins because the taste is one of the main drivers for consumers purchase decision. For future research, the texture of Gluten-Free/Natural Clean-Label products needs to be improved by adding natural hydrocolloid ingredients that mimic Xanthan Gum or baking soda.

CHAPTER 4. EFFECTS OF ADDED FIBER INTO GLUTEN-FREE/CLEAN-LABEL CHOCOLATE MUFFIN MIX ON CONSUMER PERCEPTION, EMOTIONS, LIKINGS AND PURCHASE INTENT

4.1. Introduction

Celiac disease (CD) is a well-known disorder that affects approximately 1% of the world's population at any age and continues to increase (A. B. do Nascimento, Fiates, Dos Anjos, & Teixeira, 2013). This disease affects individuals after gluten consumption, causing inflammation of the small-intestinal mucosa, leading to mal-absorption of nutrients (Capacci et al., 2018). Therefore, people with celiac disease need to follow a strict gluten-free diet including naturally gluten-free foods and gluten-free substitute foods in which wheat, barley, and rye grains have been replaced by gluten-free grains such as buckwheat, amaranth, rice, corn, and quinoa (do Nascimento et al., 2014).

Currently, the number of gluten-free bakery products available to consumers in the marketplace is increasing rapidly, not also due to the people who have celiac disease but also for those who are interested in consuming wheat-free foods (Nachay, 2010; do Nascimento et al., 2014). However, consumers' demand for gluten-free products with better sensory and nutritional characteristics represents the challenge of developing baked products with good quality (Sae-Eaw et al., 2007). To overcome these challenges, the manufacturers must find the right combination of alternative ingredients to improve the texture attributes and make them nutritionally acceptable (Matos et al., 2014). Among the most common cereals for the development of gluten-free baked goods is rice due to its hypoallergenic, nutritional, and bland taste properties. In this case, the addition of hydrocolloids such as Xanthan gum has been suggested from previous studies. Xanthan gum (XG) is produced by a fermentation of polysaccharides secreted by *Xanthomonas*

Campestris and this ingredient has widely used as a thickening agent in foods (Jatinder Pal Singh et al., 2015). This ingredient helps provide elasticity and viscosity to the dough (Matos et al., 2014; Jatinder Pal Singh et al., 2015).

Nevertheless, nutritional deficits have been associated with the use of rice due to its low level of Dietary Fiber (DF), protein, fat, sodium, and a higher level of rapidly digestible carbohydrates (Arslan et al., 2019). Hence, people eating this kind of product are consuming low-fiber diets. The addition of fiber in people diets plays an essential role in the human body in keeping the digestive system healthy and preventing diseases such as coronary heart disease, hypertension, and disorders of the gastrointestinal tract and obesity (Petruzziello, Iacopini, Bulajic, Shah, & Costamagna, 2006). Thus, most of the key players in the global gluten-free-products market are developing and formulating ingredients that are rich sources of dietary fibers so that in the end consumers do not experience lack of dietary fibers in their daily diets (MarketandMarkets, 2020a).

Previous research conducted by Arslan et al. 2019 reported that DF addition enhances nutritional value, improves techno-functional characteristics, and increases the sensory appeal. Lately, the addition of fiber also has been seen in products such as bakery premixes which has represented convenience to consumers, industrial-scale bakeries, and foodservice companies. The increasing spending trend to buy ready-to-use food products has led to an increase in demand for bakery products with unique textures and tastes. According to the Statista Research and Markets Report (2019), the baked goods market is expected to grow annually by 1.5% from 2020 to 2023. Therefore, with the popularity of baked goods, the interest of the targeted consumers, and the value-added and innovative product, the expected impact for the current of product is immense.

Nowadays, trends suggest that young generations are willing to purchase products containing dietary fiber; people are opting for healthier products containing fiber and are willing to spend more money on products with fiber content (Quagliani & Felt-Gunderson, 2017).

Therefore, the objectives of the present study were 1) to evaluate effects of added soluble fiber on product acceptability, consumer liking, and purchase intent before and after consumers were given health benefits information; 2) to evaluate consumer emotional/mood profile of Gluten-Free/Clean-Label Chocolate muffins before and after health benefits information; and 3) to evaluate convenience preparation of a pre-mix muffin and how this contributed to further acceptability, consumer liking and purchase intent based on Simulated Home-Use Test.

4.2. Materials and methods

The recipe included rice flour used as a base for the muffins, Pure cane sugar powder (Domino), Organic cocoa powder (Saco Conscious Kitchen), Corn Soluble Fiber DLQ (ADM; Fibersol Company) used as a fiber source; Xanthan Gum (Judee's Gluten Free; Walmart) used as a stabilizer, salt to provide salty taste and enhance flavor, unsalted butter and vanilla essence to add flavor and medium grade A eggs (average weight of 50 g per egg) use as a leavening agent (adding volume).

4.2.1 Experimental Design and Preparation of Gluten-Free chocolate muffins and Gluten-Free/Natural Clean Label formulations:

Chocolate Muffins were prepared following the method described in the previous study with some modifications. The recipe for rice-based gluten-free and the Gluten-Free/Natural Clean-label is given in Table 4.1. Rice flour, cocoa powder, fiber, sugar

powder, xanthan gum, and salt were stirred to mix all the ingredients, and were added gradually and mixed for 1 minute at a first speed and 1 minute at a second speed (In a Kitchen Aid®, Benton Harbor, MI, USA).

On the other side, ingredients including melted butter, vanilla, and egg were mixed manually in a container, and the dry ingredients were added gradually. Then, all the ingredients were mixed for about 2 minutes at a first speed and 30 seconds in a second speed. Then the dough was left 30 minutes at room temperature (25 ºC) and then were placed into a paper baking cup (1.25 in diameter 350 count Package WILTON-Mini Baking Cups; Great Value; Walmart), then baked in an electrical oven (ALTO-SHAAM Combitherm, USA) using the convection setting for 21 minutes at 375 ºF. Finally, the muffins were cooling at room temperature for 30 minutes and stored for further analysis (Figure 4.1).

Table 4.1. Experimental Design and Preparation of Chocolate Gluten-Free/Clean-Label Muffins

TREATMENTS*			**VARIABLES**
Control	GF/CL	0 g Fiber	No fiber
Trt. 1.	GF/CL/FC1	1.7 g Fiber	Fiber
Trt. 2.	GF/CL/FC2	3.8 g Fiber	Good source of fiber**

*GF/CL= Gluten Free/ Clean Label
*GF/CL/FC= Gluten Free/ Clean Label/Fiber-Content.
** According to US-FDA

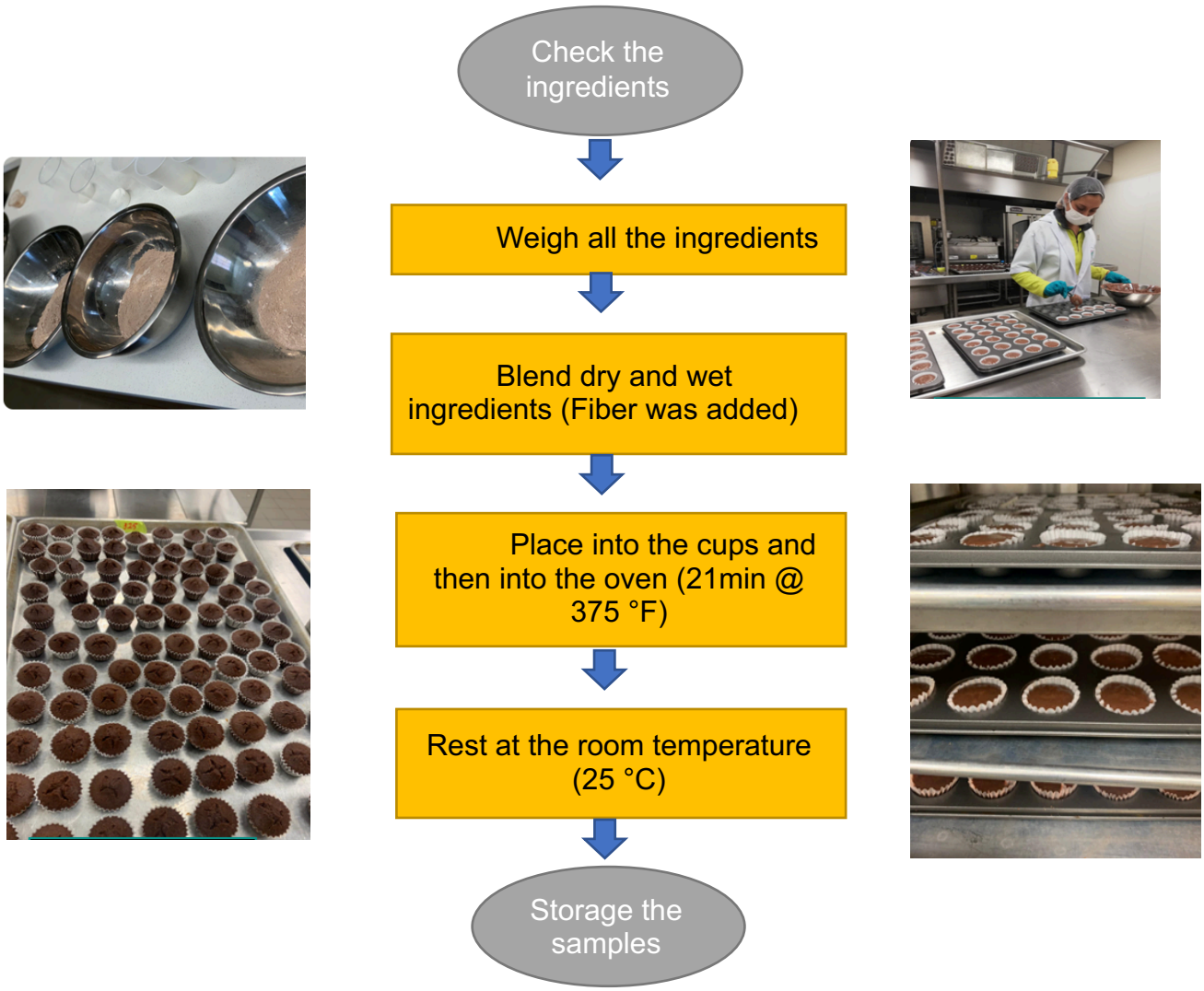


Figure 4.1. Steps for making Chocolate Muffins

4.3.2. Color and texture

The color was measured at the top and its center by using a portable Konica Minolta colorimeter (Model BC-10, Minolta camera Co. Ltd., Osaka, Japan); the results were reported as L* (0= black, 100= white), a*(+60 value = red, - 60 value = green) and b* (+ 60 value = yellow, - 60 value = blue). Three replicates of each sample from the crust and the inner part of muffins were performed. Texture for harness (N), cohesiveness, and springiness (%) were determined by using a Texture Analyzer (Texture Technologies, Hamilton, MA, USA) by using the texture profile analysis (TPA) using a compression test

according to the AACC standard 74-09 method (AACC, 2000). Cubes with 3x3x3 cm (L*W*H) were sliced using a sharp knife to avoid structural damage from the central part of each muffin. Ten replicates for each sample of treatment were done.

Figure 4.2. Texture and color analysis

4.2.3. Consumer study

Participants were recruited by using an online Qualtrics questionnaire and scheduled for participation. Consumer evaluation was conducted at the Sensory Analysis Laboratory in the Animal and Food Sciences Building, Louisiana State University, Baton Rouge, LA, USA. The evaluations were based on the earlier study (Wardy et al., 2018). Participants (N= 85 consumers) were limited due to the Covid-19 pandemic situation, from which 59% were female and 41% male, ages ≥ 18 years. In addition, consumers were aware of all ingredients to avoid allergic reactions. Consumers were presented with three different samples of GF/CL with (0 g, 1.7 g, and 3.8g of fiber/serving). A randomized complete block design method was used for this study to minimize psychological biases. Crackers and water at room temperature were provided to each

panelist to cleanse their palates between samples to avoid carry over effects. Consumers were seated in sensory booths and informed about the reason for the project. Panelists were asked to complete the demographic questionnaire, which included age, gender, and purchase of gluten-free products (yes/no). The acceptability, emotional response, and purchase intent of the muffins were evaluated after taste testing. All the precautions were taking due to the Covid-19 Pandemic situation.

Figure 4.3. Consumer's study taken place in the sensory laboratory.

4.2.4. Evaluation of consumers likings, emotions, and purchase intent.

To evaluate acceptability, the consumers were asked to evaluate eight sensory attributes (appearance, odor, taste, softness, moistness, stickiness, overall-flavor, and overall-liking (OL)) on a 9-hedonic scale (1= dislike immensely, 5= neither like nor dislike, 9= like extremely).

To perform Penalty analysis, the measurement of overall acceptability on a 9-point hedonic scale and JAR scale responses were collected from the same panelists. Then, for each of the selected attributes, the mean decrease in liking was calculated by subtracting the liking scores obtained from the hedonic scale of the consumers in the not-JAR category from those of the JAR category (mean decrease = JAR liking − not-JAR liking).

To evaluate product-elicited emotions, an emotion lexicon was derived from a mixture of existing literature on food-related emotions, based explicitly on a previous study conducted by Wardy et al. (2018). Emotions were evaluated by using a 5-point scale after a fiber-content/claim (FBCC) was given to consumers. The final list of emotions selected comprised 15 terms (adventurous, bored, calm, disgusted, enthusiastic, good, guilty, happy, interested, satisfied, pleased, unsafe, warm, worried, and wellness).

The PI (Purchase intent) was measured based on a (Yes/No) scale using a binomial method. This was conducted before and after the consumers were informed about the health benefits information (HBI) about the product "Gluten-Free/Clean-Label" and "Gluten-Free/ Clean-Label/Fiber-Content" muffins after tasting.

4.2.5. Data Analysis

Data analyses were performed using R software version 4.0.3 (RStudio, Inc., Boston, MA, USA), and the Statistical Analysis Software (SAS) version 9.4 (Cary, NC, USA) with $\alpha = 0.05$ significance level. One-way Analysis of Variance (ANOVA) with an alpha level of 0.05 was used to compare formulations on instrumental color measurements (L*, a*, b*) and texture variables (Chewiness, Hardness and Springiness). A Randomized Block Design model of the Gluten-Fee/Clean-Label treatments (0g fiber); GF/CL1= (1.7g fiber); GF/CL2= (3.8g fiber), was used to evaluate if increasing fiber content significantly affected the liking scores of the tested attributes. A one-way ANOVA (a Glimmix procedure) followed by a post-hoc Tukey's honestly significantly different (HSD) test ($p \leq 0.05$) were used. Two-sided Cochran's Q test (asymptotic *p* value) based on the minimum required difference for multiple comparisons was used to investigate if

significant ($P \leq 0.05$) purchase intent (PI) differences exist among the formulations for each tasting condition; before and after the Health Benefit Information (HBI). McNemar tests (exact Pvalue) were performed to determine the significance of the HBI on each formulation PI (comparing the proportion of PI=Yes before and after the HBI for each formulation). Penalty analysis on the JAR ratings were performed to determine the effects of the sensory attributes on the liking of treatments. Finally, logistic regression models were used to predict the odds of PI = Yes based on hedonic responses and formulation (for the PI before HBI condition), and hedonic responses, formulations, and emotions (for the PI after HBI condition).

4.3. Results and discussion

4.3.1 Likings

The effects of fiber addition on gluten-free/clean-label muffins' sensory properties, overall liking scores, and percentages of purchase intent are presented in Table 4.2. All formulations were acceptable since they received scores higher than 5.0 on a 9-point hedonic scale; furthermore, the addition of DF at 1.7g and 3.8 g improved the acceptability scores for GF/CL/FC1&2. According to ANOVA results, the scores of GF/CL/FC1&2 were significantly higher ($p<0.05$) than GF/CL ranging from 6.27-7.27 and 6.27-7.45 in comparison with 5.91-7.18, correspondingly. Various studies have indicated that fiber has a positive effect on the final product. According to Tudoran, Olsen, and Dopico (2009), fiber is an essential driver of healthy food consumption, which leads to consumers rating a higher acceptance of muffins with fiber content than without fiber. Also, Sabanis et al. (2009) found that a gluten-free product with fiber content was well-accepted by panelists. According to Sciarini et al. (2017), dietary fiber provides a texturizing effect, which

improves all the sensory properties such as mouthfeel, flavor release, and texture perception during consumption of gluten-free formulation made with rice flour. Similar results were reported by Arslan et al. (2019), who revealed in his study that the ability of fiber to trap water keeps the crumb structure soft. Similar results were found from other researchers by Lebesi and Tzia (2009), in which reported that DF's presence slows the movement of water from cake crumb to crust, thus keeping the crumb structure softer than the control. In addition Mialon, Clark, Leppard, and Cox (2002) for example, in his evaluation "The effect of information about dietary fiber content on consumer perceptions of bread and English muffins," found that information strongly and positively affected the perceived healthiness, nutrition value, and sensory intensities of the bread and English muffins.

Therefore, as show in Table 4.2 the higher overall liking score (6.71-6.76) for GF/CL/FC1&2 was due to high liking scores for odor and appearance (7.27-7.20;7.07-7.45), while the lower OL scores (6.29) for GF/CL was due to taste and texture-related attributes such as moistness and stickiness. On the other hand, the acceptability scores of odor and stickiness were not significantly different, with mean scores ranging from 7.07 to 7.20 and 6.00 to 6.27 across the treatments. As rice has a bland taste that does not affect the end flavor of the product, it can mix well with cocoa powder to obtain a desirable aroma (Stantiall & Serventi, 2018). Regarding purchase intent (PI), "yes" before and after claims across treatments, significant differences were found among both GF/CL and GF/CL/FC1 vs GF/CL.FC2. However, significant increase was shown after claim was given to consumers for GF/CL/FC2 (58-69%). Corroborating the previous results, research conducted by Stelick, Sogari, Rodolfi, Dando, and Paciulli (2021) observed that

panelists increased purchase intent when they were provided with either nutrition (fiber content) or sustainability (use of upcycled ingredients) information. Also, research from Concha-Meyer et al. (2019) indicated that the nutrition message did have a significant and positive impact on the PI. A similar result was reported by Ginon et al. (2009), who said that labeling French baguettes as a "source of fiber" increased intent to purchase. According to Coleman, Miah, Morris, and Morris (2014), health claims may trigger an emotional response impacting purchase intent. Also, research from Jahn, Tsalis, and Lahteenmaki (2019), identified attitude towards health benefits as an essential driver of willingness to purchase and use foods that promise these benefits.

Table 4.2. Mean consumer acceptability scores and purchase intent (PI)[A] for Gluten-Free/Clean-label (GF/CL) chocolate muffins with fiber content (FC).

Attribute	**GF/CL**	**GF/CL/FC1**	**GF/CL/FC2**
Appereance	6.85±1.48 a	7.27±1.34 b	7.45±1.29 b
Odor[ND]	7.18±1.36 a	7.20±1.18 a	7.07±1.21 a
Taste[ND]	6.18±1.70 a	6.74±1.48 b	6.64±1.57 b
Softness	6.35±1.76 a	6.78±1.52 b	6.85±1.52 b
Moistness	5.91±1.84 a	6.42±1.61 b	6.75±1.57 b
Stickiness	6.00±1.58 a	6.27±1.51 a	6.27±1.47 a
Overall Flavor	6.23±1.77 a	6.55±1.50 ab	6.73±1.48 b
Overal Liking	6.29±1.63 a	6.71±1.46 b	6.76±1.48 b
PI (%)[C]			
Before	43 a	48 ab	58 b
After	52 a	58 ab	69 b*

[A]Mean ± SD values of liking row from N =85 consumers rated on a 9-point hedonic scale. Mean values in the same column followed by different lowercase letters are significantly different (P<0.05). PI was based on a yes/no scale.

[B]GF/CL= Gluten-Fee/Clean-Label (0g fiber); GF/CL1= (1.7g fiber); GF/CL2= (3.8g fiber).

[C]PI were obtained from before and after consumers had been given HBI related to GF/CL claim. *Significant differences of liking based on the dependent sample t-test, and of purchase intent (PI) based on the McNemar's test (P < 0.05), comparing before and after consumers had been given HBI.

4. 3.2. Emotions

Recently, some studies have focused on sensory, physiology, and psychology on emotions related to food (Gibson, 2006). Sensory attributes have been identified as one of the five potential sources of emotions in the food experience; however, previous studies have confirmed positive consumer attitudes and behaviors towards products enriched with fiber (Mialon et al., 2009; Tudoran et al., 2009). Table 4.3 shows results regarding emotional profile, which indicates that there were no significant differences between treatments; however, there is a slight but not significant increase in positive emotion (happy, interested, satisfied, pleased) for (GF/CL/FC2) with 3.8 g of fiber after giving health benefit claim. Previous studies have confirmed positive consumer attitudes and behaviors towards bread, yogurt, or english muffins enriched with fiber (Mialon et al., 2009; Tudoran et al., 2009). In addition, the chocolate flavor influences emotions because its consumption is associated with joy and pleasure, potentially being a stimulant, relaxant, euphoriant, or antidepressant; demonstrating that chocolate immediately affects negative mood but shows a low impact on neutral or positive moods and can suppress negatives emotions (Thamke et al.,2009).

4.3.3. Penalty Analyisis

A penalty analysis was carried out to understand which of the attributes under evaluation affected the acceptability of the product to a greater or a lesser extent. The penalizations indicate how much the global acceptability of a product drops when a particular attribute is seen as “much more” or “much less,” in such a way that the higher the values obtained, the more significant the impact of the acceptability.

Table 4.3. Mean consumer emotion scores[A] of gluten-free/clean-label (GF/CL) chocolate muffins made at different fiber content (FC).

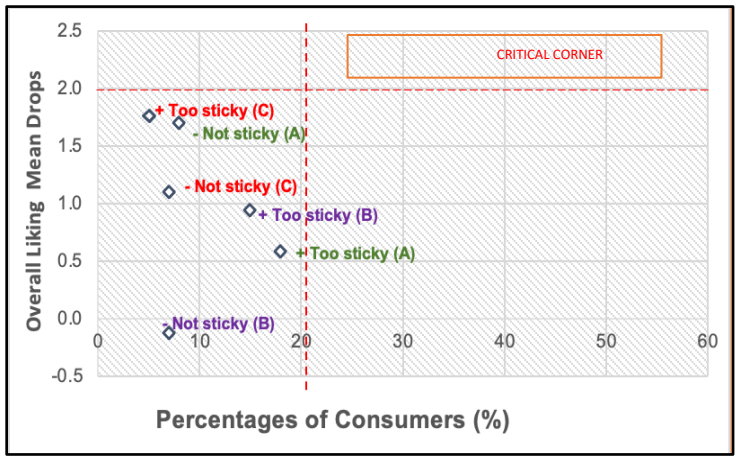
Emotion[C]	GF[B]				GF/CL/FC1[B]				GF/CL/FC2[B]			
Adventurous	1.88	±	1.16	NS	2.02	±	1.28	NS	2.08	±	1.25	NS
Bored	1.58	±	0.92	NS	1.49	±	0.71	NS	1.41	±	0.76	NS
Calm	2.43	±	1.21	NS	2.57	±	1.12	NS	2.52	±	1.10	NS
Disgusted	2.37	±	0.66	NS	1.14	±	0.44	NS	1.18	±	0.49	NS
Enthusiastic	2.82	±	1.24	NS	2.38	±	1.32	NS	2.42	±	1.29	NS
Good	2.82	±	1.24	NS	2.97	±	1.19	NS	3.02	±	1.17	NS
Guilty	1.24	±	0.70	NS	1.24	±	0.67	NS	1.32	±	0.77	NS
Happy	2.79	±	1.26	NS	2.79	±	1.29	NS	3.00	±	1.25	NS*
Interested	2.86	±	1.28	NS	2.92	±	1.23	NS	3.02	±	1.25	NS*
Satisfied	2.87	±	1.33	NS	2.86	±	1.24	NS	3.01	±	1.19	NS*
Pleased	2.83	±	1.26	NS	2.86	±	1.17	NS	3.04	±	1.21	NS*
Unsafe	1.15	±	0.54	NS	1.18	±	0.63	NS	1.13	±	0.45	NS
Warm	2.51	±	1.25	NS	2.48	±	1.23	NS	2.44	±	1.20	NS
Worried	1.16	±	0.53	NS	1.11	±	0.52	NS	1.10	±	0.36	NS
Wellness	2.80	±	1.36	NS	2.84	±	1.36	NS	2.88	±	1.44	NS

[A]Mean ±SD from 85 consumer responses based on a 5-point scale. NS= No significant differences. *Slightly but not significant increase.

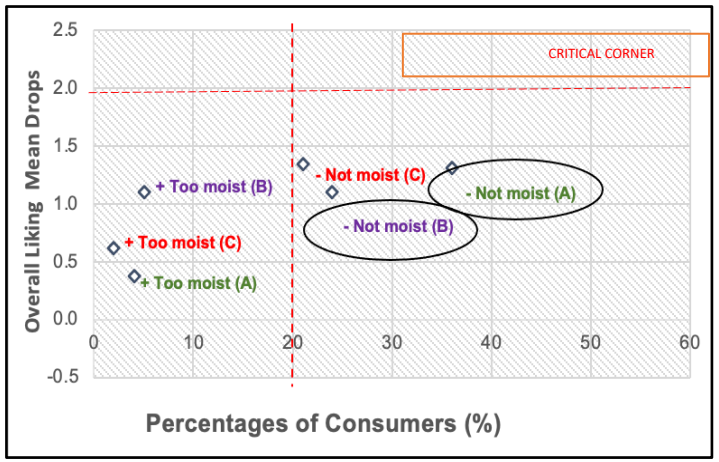
[B]GF/CL= Gluten-Fee/Clean-Label (0g fiber); GF/CL/FC1= (1.7g fiber); GF/CL/FC2= (3.8g fiber).

[C]Emotion scores were obtained after consumers had been given HBI related to GF/CL nature of the muffin. *Slightly but not significant increase

STICKINESS



MOISTNESS



SOFTNESS

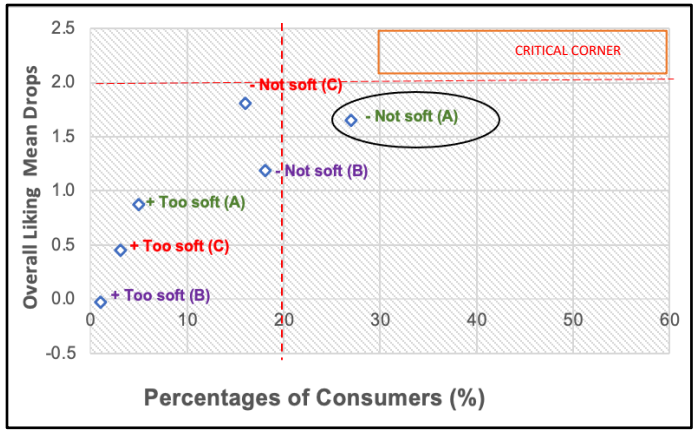


Figure 4.4. Penalty plots showing mean drops in liking as affected by “not enough” JAR attributes (stickiness, moistness, and softness) of gluten-free /clean-label chocolate muffins. GF/CL= (0g fiber); GF/CL/FC1= (1.7g fiber); GF/CL/FC2= (3.8g fiber).

Also, according to the American Society for Testing and Materials (ASTM), attributes impacting more than 20% of the participants and causing a drop of more than 2.0 units are included in the critical corner (ASTM, 2009). In this case, penalty analysis (Figure 4.4) showed that for the softness response represented as “not soft enough” 32% of consumers penalized the overall liking scores by dropping 1.7 units for GF/CL, and 21% of consumers dropped 1.2 units for GF/CL/FC1. However, as the units dropped are less than 2.0 units, these attributes are not of concern. Likewise, for the moistness attribute, 42 % of consumers penalized the overall liking by dropping 1.3 units for GF/CL, 28 % of consumers dropped 1 unit for GF/CL/FC1, and 24% of consumers dropped 1. 3 units for GF/CL/FC2 on a 9-point hedonic scale. As fiber content increases, the product is less penalized by the consumers (Figure 4.4).

3.3.4. Color and Texture

Table 4.4 shows the effects of fiber addition on the color and texture of gluten-free/clean-label muffins, in which the L* values were not significantly affected ($p<0.05$) by the concentration of fiber for the top and the center. This could be due to the original white color of the fiber. Then, for a* and b* values at the top, the high concentration of fiber (GF/CL/FC2 3.7 g) shows significant differences ($p<0.05$) in comparison with 0 g and 2.7 g of fiber added. On the other hand, at the center of the muffins significant difference ($p<0.05$) was observed between samples with and without fiber for b* value (Table 4.4). Similar results were obtained by Sabanis et al. (2009), who reported that the fiber added to a gluten-free bread formulation had no high impact on the product's color because of its light color.

Regarding with texture profile, fiber incorporation had a positive effect on hardness; significant differences ($p<0.05$) were observed between formula with and without fiber; the addition of 1.7 g and 3.8 g of fiber shows lower values from (13.34 - 13.67 N), respectively, in comparison with the sample with 0 g of fiber (17.46 N). Sciarini et al. (2017) reported that the crumb firming rate was slower when fibers were included in the formulation, which could have been related to a decrease in water loss during storage. These results were consistent with previous works by Pongjaruvat, Methacanon, Seetapan, Fuongfuchat, and Gamonpilas (2014) who reported that hardness decreased with the addition of hydrocolloids as its crosslinking reaction possibly allowed gases to expand more resulting in the increased porosity into the crumb.

Likewise, the percentage of springiness shows significant differences between samples; GF/CL/FC1&2 had higher values (25.78; 25.27) than the control GF/CL (23.49). Springiness is an attribute related to aeration and elasticity of the baked goods, and high values are expected, in this case, fiber addition improved springiness of gluten-free/clean-label muffins (Stantiall & Serventi, 2018). According to Arslan et al. (2019), the water-binding capacity of the GF products increases with the addition of DF, which explains the values of hardness and springiness. On the other hand, no significant differences ($p>0.05$) were found among the samples for chewiness.

Table 4.4. Color and texture properties[A] of gluten-free/clean-label (GF/CL) chocolate muffins made at different fiber content (FC).

Color	GF/CL[B]			GF/CL/FC1[B]			GF/CL/FC2[B]		
At top									
L	43.92	± 0.23	a	44.59	± 0.74	a	43.33	± 1.93	a
a*	4.75	± 0.17	a	4.89	± 0.27	a	5.75	± 0.82	b
b*	2.99	± 0.11	a	3.03	± 0.21	a	3.77	± 0.44	b
At the center									
L	43.11	± 0.62	a	43.06	± 0.62	a	42.58	± 0.60	a
a*	4.15	± 0.15	a	4.52	± 0.31	b	4.64	± 0.44	b
b*	2.84	± 0.09	a	3.36	± 0.24	b	3.41	± 0.46	b
Texture profiles									
Hardness (N)	17.46	± 2.34	a	13.34	± 2.45	b	13.67	± 1.12	b
Springiness (%)	23.49	± 0.71	a	25.78	± 0.57	b	25.27	± 0.61	b
Chewiness	90.07	± 13.39	a	86.5	± 11.42	a	84.39	± 7.85	a

[A]Mean ± SD from three independent replications for color and ten replications for texture. Mean values in the same row followed by different lowercase letters are significantly different ($P < 0.05$).
[B]GF/CL= Gluten-Free/Clean-Label (0g fiber); GF/CL/FC1= (1.7g fiber); GF/CL/FC2= (3.8g fiber).

4.3.5. Purchase intent

Results from LRA reported the Wald X^2 value at $p<0.05$, which identifies consumer sensory attributes and emotions influencing a purchase decision. Results (Table 4.5) indicated that all sensory attributes except odor and overall flavor were influential (Table 4.5). The odds ratio estimate of taste was 1.523, indicating the probability of the product being purchased is 1.523 times higher after HBI (than not being purchased, $p<0.05$) with every 1-unit increase of the taste score (based on a nine-point hedonic scale). The same happens with color, softness, moistness, and stickiness, and overall flavor which are significant PI predictors that would increase the probability of (being purchased $p<0.05$) by 1.29;1.46; 1.36 and 1.27 times higher (than not being purchased, for GF/CL/FC1&2)

respectively. These results are similar to earlier findings from Sae-Eaw et al. (2007), where the taste of rice butter cakes influenced purchase intent. As the addition of fiber increased the acceptability of the sensory attributes, they become the main predictors for purchase intent. In addition, since chocolate constitutes one of the most craved foods and its association with joy and pleasure, it helps influenced acceptance and purchase decision (Thamke, Dürrschmid, & Rohm, 2009).

Likewise, based on the odds ratio from emotions, results shows that purchase intent predictors were higher than those found in sensory attributes. For example, the highest odds ratio of happy was 11.19, indicating the probability of the product being purchased is 11.19 times higher (than not being purchased, $P<0.05$), followed by wellness (5.58) and enthusiastic (4.78). Similar results were found by Wardy et al. (2017), who reported emotions such as happiness and wellness as significant predictors when evaluating purchase intent after consumers being given HBI about sugar reduction.

As wellness is an emotion related to healthiness, these findings were consistent with the findings conducted by Hwang, Lee, and Lin (2016), who said that variables including healthiness perceptions were positively related to purchase intention.

Table 4.5. Combined odds ratio estimates[A] for predicting purchase intent of gluten-free/clean-label (GF/CL) chocolate muffins made at different fiber content (FC) before and after health benefit was given to consumers.

Variables		Purchase intent before		Purchase intent after	
		Odds ratio	Type 3 LRT	Odds ratio	Type 3 LRT
Sensory attributes	Color	1.297	0.0272*	–	–
	Odor	1.108	0.4022	–	–
	Taste	1.523	0.0021*	–	–
	Softness	1.455	0.0071*	–	–
	Moistness	1.364	0.0200*	–	–
	Stickiness	1.274	0.0401*	–	–
	Overall flavor	7.345	<.0001*	–	–
Emotions	Adventurous	–	–	0.778	0.5919
	Bored	–	–	0.609	0.4891
	Calm	–	–	0.609	0.5277
	Disgusted	–	–	0.502	0.4338
	Enthusiastic	–	–	4.789	0.0373*
	Good	–	–	0.515	0.4464
	Guilty	–	–	1.294	0.7935
	Happy	–	–	11.198	0.0113*
	Interested	–	–	0.386	0.1550
	Satisfied	–	–	0.689	0.6521
	pleased	–	–	1.101	0.9033
	unsafe	–	–	0.284	0.2271
	Warm	–	–	0.336	0.0936
	Worried	–	–	0.305	0.2473
	Wellness	–	–	5.588	0.0165*

[A]Based on logistic regression analysis, using seven sensory attributes and eleven emotions. Analysis of maximum-likelihood estimates was used to obtain parameter estimates.
*Significance of parameter estimates was based on the Wald chi-square value at $P< 0.05$.

A similar finding was found by Tudoran et al. (2009), who reported the positive effect of health information on consumer expectations, perceptions and consumers' purchasing high-quality products. Furthermore, previous studies established that people with higher nutrition understanding tended to concern themselves more with their health

(Hwang et al., 2016). Similarly, Sijtsema (2003) evaluated Dutch people's perceptions of healthy food based on several unstructured exploratory interviews, where natural, fresh, nutritious, unprocessed, vitamins and low fat were the primary health attributes reported by consumers. Studies have found that consumers' health perceptions of food are most often correlated with beliefs such as 'natural/no additives,' 'fresh,' 'low fat,' 'unprocessed,' 'nutritious,' 'vitamins and minerals content' (Sijtsema, Linnemann, Gaasbeek, Dagevos, & Jongen, 2002).

4.6 Conclusions

Consumer demand for gluten-free (GF), clean-label (CL) baked products continue to rise. This study demonstrated that GF/CL/FC2 with a "Good source of fiber" claim (3.8 g of fiber/serving) was successfully developed and acceptable to consumers. Therefore, compared to GF/CL, the addition of fiber improved the texture attributes in GF/CL/FC1 & GF/CL/FC2 with greater addition of fiber, higher liking scores were observed meaning that fiber was a desirable ingredient that improved the sensory attributes and provided nutritional value to the final product. In addition, positive emotion scores were slightly (not significant) improved for happy, interested, satisfied, and pleased after the addition of fiber in Gluten-Free/Clean-Label chocolate muffins. It was shown that providing consumers with product benefit information positively impacted hedonic scores, consumer emotional profiles, and purchase intent.

Gluten-free products with added fiber are becoming more attractive not only for people with celiac disease but also for those who are opting for healthier products containing fiber. Also, health-conscious consumers who purchase these products may develop the nutritional problems that have been linked with gluten-free diets that lack

micronutrients, proteins, and fiber (J. P. Singh et al., 2016). Consequently, there is a need for a product that is a good source of fiber that certainly could help people who have celiac disease or prefer gluten-free products. Therefore GF/CL/FC2, which is a good source of fiber (3.8 g fiber/serving), was successfully developed and acceptable to consumers. As time-crunched consumers prefer convenient products, a prototype ready-to-bake GF/CL/FC2 premix was developed in the Sensory laboratory for possible further commercialization.

4.7. Preparation of Pre-Mix

The pre-mix was prepared as follows. Rice flour was ground from the commercial rice into flour by using a grinder (CGGOLDENWALL CE 110 V; USA). The resulting flour was sieved through a 0.0165 inches sieve, collected, packed in polyethylene bags, and stored at room temperature (approximately 25 °C) before further use. Ingredients such as: salt, xanthan gum, cocoa powder, sugar powder and fiber were weighed, and the rice flour was added to the Mix and combined all together. The Mix was placed into a Ziploc bag and the baking instructions were added to the package.

4.7.1. Consumer test of the pre-mix

For the simulated baking process the testing of pre-mix took place in similar conditions as in a common kitchen to have accurate results from consumers evaluation. The pre-mixes were presented to (N=15) participants between 18 to 60 years old that included 73% males and 27 % females' students, and faculty from LSU, who participated voluntarily in this study. All the participants met the following criteria: they were at least 18 years old, they did not present any visual impairment or color blindness, they had availability of 60 to 90 minutes to participate in a simulated baking experience; and they

were asked to complete Qualtrics questionnaire. The baking experience was conducted at the LSU AgCenter Sensory Laboratory/ commercial test kitchen (Baton Rouge LA, USA), where they were provided a ready-to-use chocolate muffins mix with all the instructions included to prepare the muffins, ingredients such as (milk, butter, vanilla, eggs) and all the utensils needed. After muffins had been baked and cooled enough at room temperature (25 °C), participants accessed and complete a Qualtrics questionnaire by using a QR code provided (Figure 4.5).

This survey asked questions about the baking experience and final products to obtain quantitative and qualitative results. Consumers were asked to complete the demographic questionnaire, including age, gender, consumption of gluten-free and clean label products, and baking frequency by using a dry-mix. Then, questions were asked based on the evaluation of the ingredients, processing, simplicity, timing, and satisfaction during the mixing and baking process, such as overall experience, handling process of the batter, the stickiness of the batter, satisfaction with the baking process, baking process convenience, easy to follow the instructions, and easy to remove the muffins from the pan. Finally, the data were analyzed by using Excel.

Figure 4.5. Simulated Baking Experience Process

4.7.3. Baking Experience Results

There were 15 participants in the simulated baking experience ranging between 18 to 35 years of age among males and females. The answer to gluten-free/clean-label consumption is summarized in Figure 4.6 showing that 67% of participants consumed gluten-free products, and the same results were obtained for clean-label products. The results obtained in the present study could be explained by the results obtained by the

IFIC-Food-and-Health-Survey-2020, which reported that clean eating was the second common diet followed by Americans in 2020 (FoodInsight, 2020b).

Mai and Hoffmann (2015) pointed out that consumers' health consciousness is increasing in most industrialized countries.

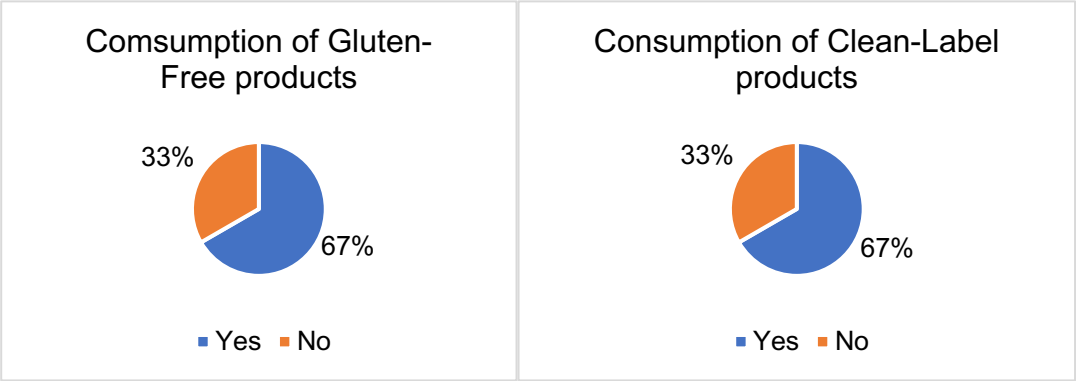


Figure 4.6. Consumption of Gluten-free/Clean-Label products

Table 4.7 shows the result about the frequency and use of the pre-mix. The participants who evaluated the baking experience included nine people who reported baking once a month or less, five every two weeks, and one person more than once a week. Previous studies revealed that the baking process is an essential factor that will affect the quality of the final product. Therefore, baking process conditions such as oven temperature, baking time, and oven humidity strongly influence the development of all quality attributes (Ureta, Olivera, & Salvadori, 2013). Hence, people who bake more frequently will have some skill that help to easily follow the recipe. For example, Wayne Gisslen, in his book called "*Professional baking*," said that some people can make a judgment based on their previous knowledge.

However, any change in the procedure can produce a significant change in baking. Most of the participants in this study reported little experience with baking (Gisslen, 2017).

Table 4.6. Frequency of baking

How often do you bake?	
More than one a week	1
Once a week	0
Every two weeks	5
Once a month or less	9
Total	15

In Figure 4.6, the results show that 9 of 15 people had used a muffin pre-mix. The remaining 6 people could have prepared muffins from scratch or were not familiar with pre-mixes. Following the next question, all participants were satisfied with the baking process and process convenience.

Figure 4.7. Simulated Baking experience after making muffins from consumer responses (N = 15). Statements with 15 frequency count are shown.

Likewise, positive results were obtained for easy-to-follow instructions. Also, for removing the product from the pan, 11 participants agreed that it was easy to remove from the pan. As it was previously mentioned in study II, the addition of fiber, making a

product a “good source of fiber,” improved the texture attributes, making it easy to handle and remove from the pan (Figure 4.7).

Table 4.7. Survey results after a simulated baking process (N= 15)

General Questions	Liking scores
Overall Experience	8.60±0.51
Handling process of the batter during mixing.	8.27±0.80
Appearance	7.93±1.44
Odor	8.20±1.26
Texture	8.20±1.15
Softness	8.40±0.74
Moistness	8.40±0.63
Stickiness	8.13±1.06
Overall Flavor	7.67±1.35

[A]Mean ± SD from 15 consumers responses based on a 9-point hedonic scale.

Table 4.7 shows the questions asked to the consumers who participated in the baking test. The results show that consumers perceived this baking simulation as a positive experience. As shown in Table 4.7, they rated the liking of the experience with a mean of 8.60 on a 9-hedonic scale, which means that the participants highly liked the experience. Likewise, the handling process of the batter during mixing was rated with a mean of 8.27, which could be due to the addition of fiber which helped during mixing. All the texture attributes obtained scores ranging from 8.13 to 8.40 units; this corroborates those reported by Aprudu and Banu (2015), who said that a good combination of ingredients such as rice flour with hydrocolloids and a good combination of fiber helps improve the texture of gluten-free products. Also, scores for overall flavor were well-accepted as participants scored 7.67 on a 9-hedonic scale. Similar results were found by Arslan et al. (2019), who said that fiber improves all the sensory parameters of GF bread

compared to the control due to the texturizing effect of fiber and fat mimetic, which affect texture perception, mouthfeel, and flavor release during consumption.

Table 4.8. Penalty analysis* of the pre-mix “good source of fiber”

Attribute	Level	N	% Consumers	Overall Liking	Penalty
	Not enough	0	0.00	0	
	JAR	13	86.67	7.85	
Softness	Too much	2	13.33	8	0.15
	Not enough	0	0.00	0	
	JAR	12	80.00	7.83	
Moistness	Too much	3	20.00	8	0.17
	Not enough	0	0.00	0	
	JAR	14	93.33	7.79	
Stickiness	Too much	1	6.67	9	1.21

*N=15 responses

The results obtained for the JAR scales are shown in Table 4.8, in which all texture attributes such as softness, moistness, and stickiness were mainly scored in “JAR,” ranging from 80% (moistness) to 93% (stickiness). Furthermore, they also indicated high scores for overall liking, higher than 7.0 units on a 9-hedonic scale, which have the lowest penalty values. These results follow results obtained from likings scores above (Table 4.7), meaning that participants were able to make their muffins and were satisfied with most aspects.

Figure 4.8 shows the final product from each participant, all of them had high quality in terms of color, texture, and flavor.

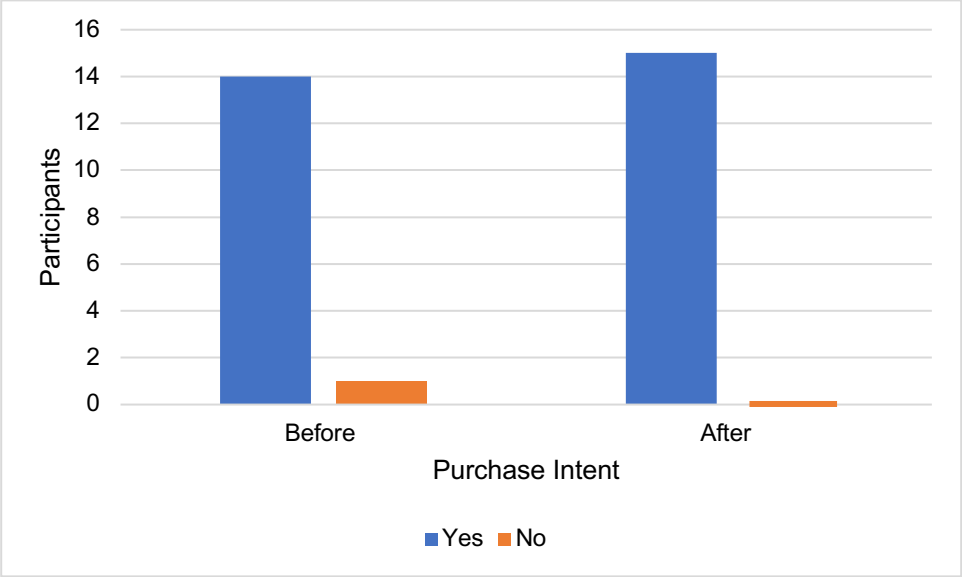


Figure 4.9. Purchase Intent before/after Health Benefit Information (HBI).

Previous studies indicate that “free-from” products have been gaining popularity because consumers prefer naturalness, which leads to an increased willingness to pay a premium price for products labeled free-from (Hartmann et al., 2018). In this study, as the pre-mix was labeled with a health benefit information “gluten-free/clean-label” “good source of fiber”, participants perceived it as a healthy product, and were willing to purchase. Based on Figure 4.9, the purchase intent values before and after shows no differences. All the participants indicated that they would purchase the pre-mix. In addition, the higher purchase intent could be due to convenience. For example, since 2003, according to Informa Markets, “there is a strong drive toward further convenience, healthier products, improved functionality for shelf-life improvement, and overall quality improvement in future dry-mix development,” “the health segment has taken off and driven all these-dry mix categories.” The International Food Information Council

Foundation's 2019 Food and Health Survey found that more than 80% of respondents said they considered fiber to be healthy (FoodInsight, 2020b).

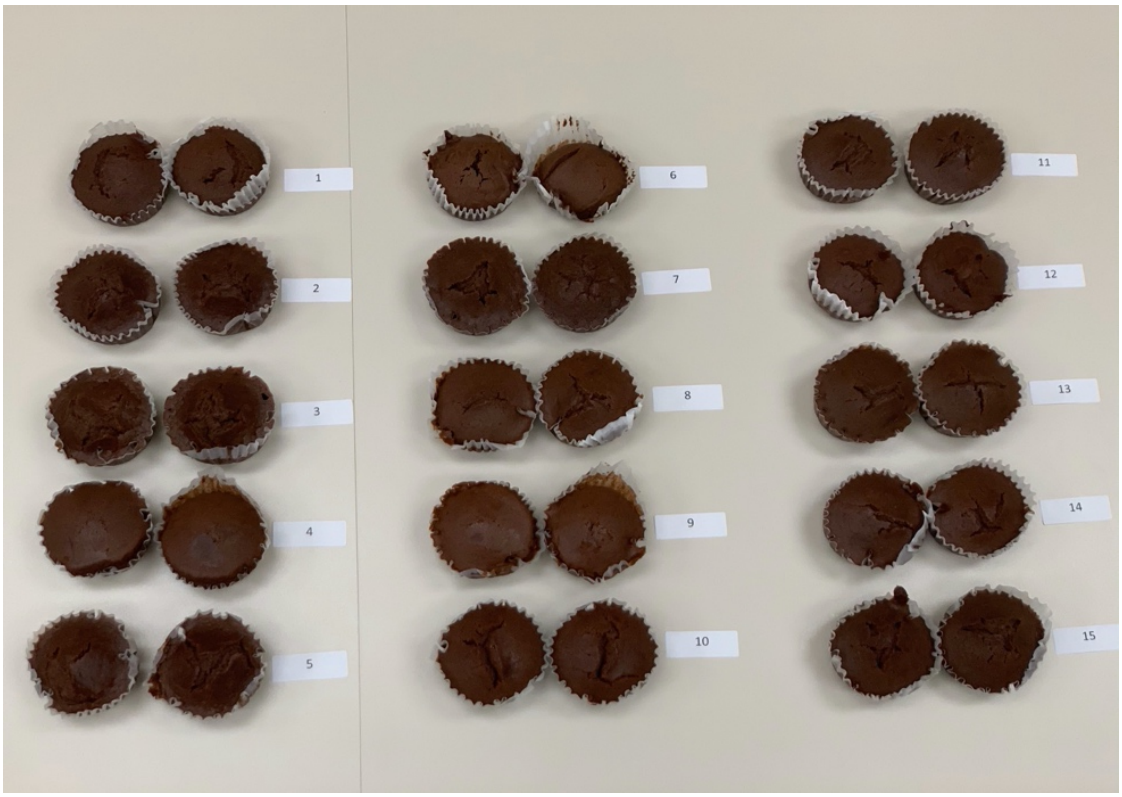


Figure 4.8. Final products from the Simulated Baking Test.

4.7.4. Conclusions and Future Directions

Overall, the simulated baking test was successfully conducted by the participants. Even though they did not have much baking experience, they were satisfied with the Chocolate Muffins Dry-Mix, due to its convenience, easy to use, and quick preparation time. The product had liking scores higher than 8.0 on a 9-point hedonic scale, meaning that it's a high-quality product. This finding was corroborated by the high percentages of consumers who indicated high JAR (Just About Right) scores; therefore, the texture attributes such as softness, stickiness and moistness were well-accepted by participants. Regarding purchase intent before and after being provided with health benefit claim, they were no significant differences; participant showed high willingness to purchase. The

addition of fiber to chocolate gluten-free/clean label muffins certainly played an important role by improving the sensory attributes as shown in the previous study. This dry-mix can provide a product that contributes variety and nutritional value to gluten-free product consumers. Further study could focus on improving the protein content of this product to obtain a better nutritive product.

CHAPTER 5. CONCLUSIONS

After having conducted the study to evaluate consumers perception of gluten-free/clean-label muffins with added fiber content, we can conclude that mango-flavored muffins were accepted by consumers, and based on the likings after removing artificial ingredients, color, and texture on the Gluten-Free/Natural Clean label muffins (GF/NCL1) were negatively influenced; however, mango flavor helped the product to be accepted. Regarding health benefit claims, gluten-free and clean-label claims slightly improved positive purchase intent for GF/NCL1.

There were no increases in emotion scores after the Gluten-Free/Natural Clean-Label claims were given to consumers. The consumers were not willing to compromise sensory quality for a natural clean label. Finally, the incorporation of mango flesh may increase the purchase intent of Gluten-Free and Gluten-Free/Natural Clean-Label Muffins because the taste improved, and it is one of the main drivers for consumers purchase decision. Related with the second study, we can conclude that the addition of fiber positively influenced the texture attributes of GF/CL/FC1 & GF/CL/FC2. The addition of fiber improved the sensory attributes and delivered additional nutritional value to the final product. Regarding positive emotions, no significant differences were observed but happy, interested, satisfied, and pleased were slightly improved after the addition of fiber in Gluten-Free/Clean-Label chocolate muffins.

Consumers cared about a product with health benefit information and hedonic scores were impacted as well as consumer emotional profiles, and purchase intent. Convenient pre-mix with a gluten-free/clean-label stating “good source of fiber” health benefit was well accepted. As consumers wants easier to make products but also pay

attention to what they are eating, this kind of product becomes a great option to overcome nutritional deficits and provide tasty products to those who wants gluten-free products.

APPENDIX A. SUPPLEMENTARY MATERIAL FOR CHAPTER 3

A.1. Questionnaire

CONSUMER RESEARCH QUESTIONNAIRE MANGO MUFFINS 2019

SCREENER:

(1) Consume muffins or similar products,
(2) Not allergic to muffin ingredients
(3) Over 18 years old

PART 1: DEMOGRAPHICS

Gender: ( ) Female ( ) Male

Age (years): ( ) 18-30 ( ) 31-40 ( ) 41-50 ( ) 51-60 ( ) >60

Race: ( ) African American ( ) Caucasian American ( ) Asian ( ) Hispanic ( ) Other

Do you normally purchase or consume Gluten Free (Wheat free) Products?

Yes ( ) No ( )

Do you normally purchase or consume Clean Label (Simple, no chemical added) Products?

Yes ( ) No ( )

PART 2: SAMPLE TESTING

Instructions:

- Please have unsalted crackers and water to cleanse your palate between each sample.
- Please taste at least half of Sample XXX.

1. How would you rate the COLOR of this product?

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]

2. How would you rate the ODOR of this product?

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]

3. How would you rate the TASTE of this product?

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]

4. How would you rate the MANGO FLAVOR of this product?

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]

5. How would you rate the SOFTNESS of this product?

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]

Please rate how you perceive the SOFTNESS intensity of this product.

[ ] Not soft enough [ ] Just about right [ ] Too soft much

6. How would you rate the MOISTNESS of this product?

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]

Please rate how you perceive the MOISTNESS of this product.
[ ] Not moist enough [ ] Just about right [ ] Too moist

7. How would you rate the STICKINESS of this product?

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]

Please rate how you perceive the STICKINESS of this product?
[ ] Not sticky enough [ ] Just about right [ ] Too sticky

8. How would you rate your OVERALL LIKING of this product?

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]

9. Are you willing to purchase this product?

YES ☐ NO ☐

PART 2: SAMPLE TESTING

12. How would you rate the COLOR of this product?

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]

13. How would you rate the ODOR of this product?

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]

14. How would you rate the TASTE of this product?

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]

15. How would you rate the MANGO FLAVOR of this product?

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]

16. How would you rate the SOFTNESS of this product?

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]

Please rate how you perceive the SOFTNESS intensity of this product.

[ ] Not soft enough [ ] Just about right [ ] Too soft much

17. How would you rate the MOISTNESS of this product?

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]

Please rate how you perceive the MOISTNESS of this product.

[ ] Not moist enough [ ] Just about right [ ] Too moist

18. How would you rate the STICKINESS of this product?

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]

Please rate how you perceive the STICKINESS of this product?

[ ] Not sticky enough [ ] Just about right [ ] Too sticky

19. How would you rate your OVERALL LIKING of this product?

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]

20. Are you willing to purchase this product?

YES ☐ NO ☐

Sample XXX= This product is gluten free (wheat free) mango fresh muffins, Clean Label (No chemicals added)

21. How does this product make you FEEL?

Feeling	Not at all [1]	Slightly [2]	Moderately [3]	Very much [4]	Extremely [5]
Calm	❑	❑	❑	❑	❑
Good	❑	❑	❑	❑	❑
Guilty	❑	❑	❑	❑	❑
Happy	❑	❑	❑	❑	❑
Healthy	❑	❑	❑	❑	❑
Pleasant	❑	❑	❑	❑	❑
Pleased	❑	❑	❑	❑	❑
Satisfied	❑	❑	❑	❑	❑
Unsafe (regarding nutrition facts)	❑	❑	❑	❑	❑
Wellness (healthy lifestyle)	❑	❑	❑	❑	❑
Worried	❑	❑	❑	❑	❑

22. Are you willing to purchase this product?

YES ☐ NO ☐

PART 2: SAMPLE TESTING

23. How would you rate the COLOR of this product?

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]

24. How would you rate the ODOR of this product?

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]

25. How would you rate the TASTE of this product?

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]

26. How would you rate the MANGO FLAVOR of this product?

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]

27. How would you rate the SOFTNESS of this product?

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]

Please rate how you perceive the SOFTNESS intensity of this product.

[ ] Not soft enough [ ] Just about right [ ] Too soft much

28. How would you rate the MOISTNESS of this product?

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]

Please rate how you perceive the MOISTNESS of this product.

[ ] Not moist enough [ ] Just about right [ ] Too moist

29. How would you rate the STICKINESS of this product?

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]

Please rate how you perceive the STICKINESS of this product?

[ ] Not sticky enough [ ] Just about right [ ] Too sticky

30. How would you rate your OVERALL LIKING of this product?

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]

31. Are you willing to purchase this product?

YES ☐ NO ☐

Sample XXX= This product is gluten free (wheat free) mango fresh muffins, Clean Label (No chemicals added)

32. How does this product make you FEEL?

Feeling	Not at all [1]	Slightly [2]	Moderately [3]	Very much [4]	Extremely [5]
Calm	❑	❑	❑	❑	❑
Good	❑	❑	❑	❑	❑
Guilty	❑	❑	❑	❑	❑
Happy	❑	❑	❑	❑	❑
Healthy	❑	❑	❑	❑	❑
Pleasant	❑	❑	❑	❑	❑
Pleased	❑	❑	❑	❑	❑
Satisfied	❑	❑	❑	❑	❑
Unsafe (regarding nutrition facts)	❑	❑	❑	❑	❑
Wellness (healthy lifestyle)	❑	❑	❑	❑	❑
Worried	❑	❑	❑	❑	❑

33. Are you willing to purchase this product?

YES ☐ NO ☐

A.2. SAS Code

A.2.1 Physicochemical Analysis

```
dm 'log;clear';
options date pageno=1;
ods pdf;
title1 'muffins color and texture';
data muffins;
input sample Rep L_CRUST a_CRUST b_CRUST L_INNER a_INNER
      b_INNER Hardness adhesiveness resilence cohesion
      springiness gumminess Chewiness;
datalines;

;
proc
print;
title2 'raw
data';
run;
proc sort data=muffins; by
sample;
run;
proc means data=muffins n mean stddev min
max;
class
sample;
var L_CRUST a_CRUST b_CRUST L_INNER a_INNER b_INNER
      Hardness adhesiveness resilence cohesion springiness
      gumminess Chewiness;
run;
proc
glm;
title2 'anova results using
glm';
class
sample;
model L_CRUST a_CRUST b_CRUST L_INNER a_INNER b_INNER
      Hardness adhesiveness resilence cohesion springiness
      gumminess Chewiness= sample/ss3;
means sample/
tukey;
run;
ods pdf close;
```

A.2.2 Likings

```
dm 'log; clear; output; clear';
options nodate nocenter pageno=1 ls=132 ps=512 formchar="|----|+|---+=|-/\<>*";
ods listing; ods graphics
on;
ods html style=minimal body='vanessa.html';
ods pdf;
data mixed;
input panelist sample color odor taste softness moistness stickiness mango_f ol;
datalines;
;
proc
print;
title2 'raw
data';
run;
proc sort data=mixed; by
sample;
run;
proc means data=mixed n mean stddev min
max;
class
sample;
var color odor taste softness moistness stickiness mango_f ol;
run;

proc glimmix data=mixed;
class panelist sample;
model color= sample;
random panelist;
lsmeans sample/lines adjust=tukey;
run;

proc glimmix data=mixed;
class panelist sample;
model odor= sample;
random panelist;
lsmeans sample/lines adjust=tukey;
run;

proc glimmix data=mixed;
class panelist sample;
model taste= sample;
random panelist;
lsmeans sample/lines adjust=tukey;
```

```
run;

proc glimmix data=mixed;
class panelist sample;
model softness= sample;
random panelist;
lsmeans sample/lines adjust=tukey;
run;

proc glimmix data=mixed;
class panelist sample;
model moistness= sample;
random panelist;
lsmeans sample/lines adjust=tukey;
run;

proc glimmix data=mixed;
class panelist sample;
model stickiness= sample;
random panelist;
lsmeans sample/lines adjust=tukey;
run;
```

A.2.3. Emotions

```
dm 'log; clear; output; clear';
options nodate nocenter pageno=1 ls=132 ps=512 formchar="|----|+|---+=|-/\<>*";
ods listing; ods graphics
on;
ods html style=minimal body='vanessa.html';
ods pdf;
data emotions;
input panelist sample CALM       GOOD       GUILTY     HAPPY      HEALTHY
        PLEASANT  PLEASED    SATISFIED  UNSAFE     WELLNESS  WORRIED;
datalines;

;
proc
print;
title2 'raw
data';
run;
proc sort data= emotions; by
sample;
run;
```

```
proc means data=emotions n mean stddev min
max;
class
sample;
var CALM     GOOD         GUILTY       HAPPY        HEALTHY     PLEASANT
        PLEASED     SATISFIED   UNSAFE       WELLNESS  WORRIED;
run;

proc glimmix data=emotions;
class panelist sample;
model CALM= sample;
random panelist;
lsmeans sample/lines adjust=tukey;
run;

proc glimmix data=emotions;
class panelist sample;
model GOOD= sample;
random panelist;
lsmeans sample/lines adjust=tukey;
run;

proc glimmix data=emotions;
class panelist sample;
model GUILTY= sample;
random panelist;
lsmeans sample/lines adjust=tukey;
run;

proc glimmix data=emotions;
class panelist sample;
model HAPPY= sample;
random panelist;
lsmeans sample/lines adjust=tukey;
run;

proc glimmix data=emotions;
class panelist sample;
model HEALTHY= sample;
random panelist;
lsmeans sample/lines adjust=tukey;
run;
```

A.2.4. Logistic Regression

PI before

```
dm 'log; clear; output; clear';
options nodate nocenter pageno = 1 ls=78
ps=53; title1 'LOGIT PI BEFORE';
ods pdf;
Title2 'Logistic regression PI hedonics NO OL';
data MUFFIN;
input PANELIST SAMPLE $ COLOR     ODOR        TASTE       SOFTNESS
      MOISTNESS STICKINESS MANGO_FLAVOR  OL     PI $;
datalines;
;
proc print data= MUFFIN;run;
proc sort data= MUFFIN; by panelist; run;
proc logistic descending;
class PANELIST SAMPLE PI;
model PI= SAMPLE COLOR      ODOR        TASTE       SOFTNESS  MOISTNESS
      STICKINESS MANGO_FLAVOR/aggregate;
run;
ods pdf close;
```

PI after

```
dm 'log; clear; output; clear';
options nodate nocenter pageno = 1 ls=78
ps=53; title1 'LOGIT PI AFTER';
ods pdf;
Title2 'Logistic regression PIafter emotions';
data MUFFIN;
input PANELIST SAMPLE $ PIB $ CALM       GOOD        GUILTY      HAPPY
      HEALTHY    PLEASANT  PLEASED    SATISFIED  UNSAFE      WELLNESS
      WORRIED    PIA $;
datalines;

;
proc print data= MUFFIN;run;
proc sort data= MUFFIN; by panelist; run;
proc logistic descending;
class PANELIST SAMPLE PIB PIA;
model PIA= SAMPLE PIB CALM  GOOD        GUILTY      HAPPY       HEALTHY
      PLEASANT  PLEASED    SATISFIED  UNSAFE      WELLNESS
      WORRIED/aggregate;
run;
ods pdf close;
```

A.2.5. Penalty Analysis

GF/CL

XLSTAT 2019.3.2.61685 - Penalty analysis - Start time: 10/9/2019 at 4:10:59 PM / End time: 10/9/2019 at 4:11:00 PM
Liking scores: Workbook = demoPenalty.xlsm / Sheet = 145 OL PENALTY / Range = '145 OL PENALTY'!$A:$A / 112 rows and 1 column
Just about right data: Workbook = demoPenalty.xlsm / Sheet = 145 OL PENALTY / Range = '145 OL PENALTY'!$B:$D / 112 rows and 3 columns
Labels of the 3 JAR levels: Workbook = demoPenalty.xlsm / Sheet = 145 OL PENALTY / Range = '145 OL PENALTY'!$G$1:$I$4 / 3 rows and 3 columns
Scale: 1 -> 3
Threshold for population size (%): 20
Significance level (%): 5
Multiple comparisons: Tukey (HSD)

Mean drops vs %:			
Variable	Level	%	Mean drops
Softness JAR scores	Not soft enough	35.714	0.614
	Too soft	0.893	0.014
Moistness JAR score	Not moist enough	33.036	0.704
	Too moist	4.464	0.029
Stickiness JAR scores	Not sticky enough	8.929	0.592
	Too sticky	8.036	0.559

GF/CL1

XLSTAT 2019.3.2.61685 - Penalty analysis - Start time: 10/9/2019 at 4:17:58 PM / End time: 10/9/2019 at 4:17:59 PM
Liking scores: Workbook = demoPenalty.xlsm / Sheet = 428 OL PENALTY / Range = '428 OL PENALTY'!$A:$A / 112 rows and 1 column
Just about right data: Workbook = demoPenalty.xlsm / Sheet = 428 OL PENALTY / Range = '428 OL PENALTY'!$B:$D / 112 rows and 3 columns
Labels of the 3 JAR levels: Workbook = demoPenalty.xlsm / Sheet = 428 OL PENALTY / Range = '428 OL PENALTY'!$G$1:$I$4 / 3 rows and 3 columns
Scale: 1 -> 3
Threshold for population size (%): 20
Significance level (%): 5

Mean drops vs %:			
Variable	Level	%	Mean drops
Softness JAR scores	Not soft enough	50.893	1.476
	Too soft	1.786	2.028
Moistness JAR score	Not moist enough	49.107	1.909
	Too moist	1.786	1.709
Stickiness JAR scores	Not sticky enough	25.000	1.117
	Too sticky	8.929	0.681

GF/CL2

XLSTAT 2019.3.2.61685 - Penalty analysis - Start time: 10/9/2019 at 4:21:59 PM / End time: 10/9/2019 at 4:22:00 PM
Liking scores: Workbook = demoPenalty.xlsm / Sheet = 796 OL PENALTY / Range = '796 OL PENALTY'!$A:$A / 112 rows and 1 column
Just about right data: Workbook = demoPenalty.xlsm / Sheet = 796 OL PENALTY / Range = '796 OL PENALTY'!$B:$D / 112 rows and 3 columns
Labels of the 3 JAR levels: Workbook = demoPenalty.xlsm / Sheet = 796 OL PENALTY / Range = '796 OL PENALTY'!$G$1:$I$4 / 3 rows and 3 columns
Scale: 1 -> 3
Threshold for population size (%): 20
Significance level (%): 5
Multiple comparisons: Tukey (HSD)

XLSTAT-Student 2019.3.2.61685 - McNemar test - Start time: 10/8/2019 at 6:33:50 PM / End time: 10/8/2019 at 6:33:51 PM
Subjects/Treatments table: Workbook = VANESA SURVEY CRISTY 10-08-19.xltm / Sheet = MCNEMAR BEFORE VS AFTER PI / Range = 'MCNEMAR BEFORE VS AFTER PI'!$C$3:$D$115 / 112 rows and 2 columns
Significance level (%): 5
p-value: Exact p-value
Positive response code: 1

Summary statistics (Qualitative data):

Variable	Categories	Counts	Frequencies	%
PIB	0	36	36	32.143
	1	76	76	67.857
PI AFTER	0	32	32	28.571
	1	80	80	71.429

Mean drops vs %:			
Variable	Level	%	Mean drops
Softness JAR scores	Not soft enough	51.786	1.445
	Too soft	2.679	0.118
Moistness JAR score	Not moist enough	42.857	1.115
	Too moist	5.357	1.948
Stickiness JAR scores	Not sticky enough	20.536	1.862
	Too sticky	23.214	1.426

A.2.6 Mc Nemar test (before vs after)

GF

Contingency table:

	PI AFTER|1	PI AFTER|0
PIB|1	76	0
PIB|0	4	32

McNemar test (Exact p-value) / Lower-tailed test:

Q	4
z	-2.000
p-value (one-tailed)	0.063
alpha	0.05

Test interpretation:
H0: The treatments are identical.
Ha: Positive responses are less likely with treatment PIB than with treatment PI AFTER.
As the computed p-value is greater than the significance level alpha=0.05, one cannot reject the null hypothesis H0.

GF/CL1

XLSTAT-Student 2019.3.2.61685 - McNemar test - Start time: 10/8/2019 at 6:37:49 PM / End time: 1
Subjects/Treatments table: Workbook = VANESA SURVEY CRISTY 10-08-19.xltm / Sheet = MCNEM
rows and 2 columns
Significance level (%): 5
p-value: Exact p-value
Positive response code: 1
Summary statistics (Qualitative data):

Variable	Categories	Counts	Frequencies	%
PB	0	68	68	60.714
	1	44	44	39.286
PI AFTER	0	60	60	53.571
	1	52	52	46.429

Contingency table:

	PI AFTER|1	PI AFTER|0
PB|1	44	0
PB|0	8	60

McNemar test (Exact p-value) / Lower-tailed test:

Q	8
z	-2.828
p-value (one-tailed)	0.004
alpha	0.05

Test interpretation:
H0: The treatments are identical.
Ha: Positive responses are less likely with treatment PB than with treatment PI AFTER.

As the computed p-value is lower than the significance level alpha=0.05, one should reject the null hypothesis H0, and accept the alternative hypothesis Ha.

GF/CL2

XLSTAT-Student 2019.3.2.61685 - McNemar test - Start time: 10/8/2019 at 6:21:46 PM / End time: 1
Subjects/Treatments table: Workbook = VANESA SURVEY CRISTY 10-08-19.xltm / Sheet = MCNEM
rows and 2 columns
Significance level (%): 5
p-value: Exact p-value
Positive response code: 1

Summary statistics (Qualitative data):

Variable	Categories	Counts	Frequencies	%
PB	0	72	72	64.286
	1	40	40	35.714
PI AFTER	0	71	71	63.393
	1	41	41	36.607

Contingency table:

	PI AFTER|1	PI AFTER|0
PB|1	39	1
PB|0	2	70

McNemar test (Exact p-value) / Lower-tailed test:

Q	0.333
z	-0.577
p-value (one-tailed)	0.500
alpha	0.05

Test interpretation:
H0: The treatments are identical.
Ha: Positive responses are less likely with treatment PB than with treatment PI AFTER.
As the computed p-value is greater than the significance level alpha=0.05, one cannot reject the null hypothesis H0.

A.2.7 Cochran-Q test across-trt by using XLSTAT

(PI BEFORE)

XLSTAT-Student 2019.3.2.61685 - Cochran's Q test - Start time: 10/8/2019 at 7:37:22 PM / End time
Subjects/Treatments table: Workbook = VANESA SURVEY CRISTY 21 / Sheet = PI across samples
rows and 3 columns
Significance level (%): 5
p-value: Asymptotic p-value
Continuity correction: Yes

Summary statistics (Qualitative data):

Variable	Categories	Counts	Frequencies	%
PIB145	NO	36	36	32.143
	YES	76	76	67.857
PIB428	NO	68	68	60.714
	YES	44	44	39.286
PIB796	NO	72	72	64.286
	YES	40	40	35.714

Cochran's Q test (Asymptotic p-value):

Q (Observed value)	30.737
Q (Critical value)	5.991
DF	2
p-value (one-tailed)	< 0.0001
alpha	0.05

An approximation has been used to compute the p-value.
The continuity correction has been applied.

Test interpretation:
H0: The treatments are identical.
Ha: The treatments are different.
As the computed p-value is lower than the significance level alpha=0.05, one should reject the null hypothesis H0, and accept the alternative hypothesis Ha.

Variable	Categories	Counts	Frequencies	%
PIA145	NO	32	32	28.571
	YES	80	80	71.429
PIA428	NO	60	60	53.571
	YES	52	52	46.429
PIA796	NO	71	71	63.393
	YES	41	41	36.607

Multiple pairwise comparisons using the Critical difference (Sheskin) procedure:

Sample	Relative frequency	Groups	
PIB796	0.357	A	
PIB428	0.393	A	
PIB145	0.679		B

Table of pairwise differences:

	PIB145	PIB428	PIB796
PIB145	0	**0.286**	**0.321**
PIB428	**-0.286**	0	0.036
PIB796	**-0.321**	-0.036	0

XLSTAT-Student 2019.3.2.61685 - Cochran's Q test - Start time: 10/8/2019 at 7:38:16 PM / End time: 10/8/2019 at 7:38:16 PM / Microsoft Excel 16.011328
Subjects/Treatments table: Workbook = VANESA SURVEY CRISTY 21 / Sheet = PI across samples / Range = 'PI across samples '!$J$2:$L$114 / 112 rows and 3 columns
Significance level (%): 5
p-value: Asymptotic p-value
Continuity correction: Yes
Summary statistics (Qualitative data):

(PI AFTER)

Cochran's Q test (Asymptotic p-value):

Q (Observed value)	32.784
Q (Critical value)	5.991
DF	2
p-value (one-tailed)	< 0.0001
alpha	0.05

An approximation has been used to compute the p-value.
The continuity correction has been applied.

Test interpretation:
H0: The treatments are identical.
Ha: The treatments are different.
As the computed p-value is lower than the significance level alpha=0.05, one should reject the null hypothesis H0, and accept the alternative hypothesis Ha.

Multiple pairwise comparisons using the Critical difference (Sheskin) procedure:

Sample	Relative frequency	Groups	
PIA796	0.366	A	
PIA428	0.464	A	
PIA145	0.714		B

Table of pairwise differences:

	PIA145	PIA428	PIA796
PIA145	0	**0.250**	**0.348**
PIA428	**-0.250**	0	0.098
PIA796	**-0.348**	-0.098	0

Critical difference: 0.1501

Significant differences:

	PIA145	PIA428	PIA796
PIA145	No	**Yes**	**Yes**
PIA428	**Yes**	No	No
PIA796	**Yes**	No	No

APPENDIX B. SUPPLEMENTARY MATERIAL FOR CHAPTER 4

B.1 Questionnaire for recruiting consumers

CHOCOLATE MUFFINS – VANESA CHICAIZA

Researchers are seeking undergraduate and graduate student participants for a study on Gluten-Free Chocolate Muffins sensory evaluation.
Participants will come to the Animal and Food Sciences Laboratory Building (Next to Turead Hall) and spend 10 to 15 minutes taking some samples and trying them to evaluate different sensory attributes and completing a survey. If interested, please contact at vchica1@lsu.edu

What is your name?

First Name

Last Name

Would you be interested in participating in this study?
Yes. I'm interested
No. I'm not interested

Would you be able to come to the Animal and Food science Laboratory building to do the sensory study or pick the samples and do it at home if you have experience?
Sensory Laboratory
At home

What is your email address to contact you for further instructions?

Email Address

Please leave any additional information that you would like us to know in the space provided below or any questions. We will provide a safe place to do the sensory test, following all the preventives measures.

B. 2 Questionnaire (sensory study)

Research Consent Form

I, _____, agree to participate in the research entitled Consumer perception of Gluten-Free/Clean-Label Chocolate Muffins" which is being conducted by Witoon Prinyawiwatkul of the School of Nutrition and Food Sciences at Louisiana State University Agricultural Center, (225) 578-5188.
I understand that participation is entirely voluntary and whether or not I participate will not affect how I am treated on my job. I can withdraw my consent at any time without penalty or loss of benefits to which I am otherwise entitled and have the results of the participation returned to me, removed from the experimental records, or destroyed. One hundred consumers will participate in this research. For this particular research, about 5-10 minutes participation will be required for each consumer.
The following points have been explained to me:
1. In any case, it is my responsibility to report prior to participation to the investigator any food allergies I may have.
2. The reason for the research is to gather information on consumer perception and acceptability of Gluten-Free/Clean-Label Chocolate Muffins with addition of fiber. The benefit that I may expect from it is a satisfaction that I have contributed to solution and evaluation of problems related to such examination.
3. The procedures are as follows: three coded samples will be placed in front of me, and I will evaluate them by normal standard methods and indicate my evaluation on score sheets. All procedures are standard methods as published by the American Society for Testing and Materials and the Sensory Evaluation Division of the Institute of Food Technologists.
4. Participation entails minimal risk: The only risk may be an allergic reaction to rice, soluble fiber (corn), xanthan gum, eggs, salt, organic chocolate, organic vanilla, and sugar. However, because it is known to me beforehand that all those foods and ingredients are to be tested, the situation can normally be avoided.
5. The results of this study will not be released in any individual identifiable form without my prior consent unless required by law.
6. The investigator will answer any further questions about the research, either now or during the course of the project.
The study has been discussed with me, and all of my questions have been answered. I understand that additional questions regarding the study should be directed to the investigator listed above. In addition, I understand the research at Louisiana State University AgCenter that involves human participation is carried out under the oversight of the Institutional Review Board. Questions or problems regarding these activities should be addressed to Dr. Michael Keenan of LSU AgCenter at 578-1708. I agree with the terms above.

Name:

Demographics6 Questions
Block Options
Sample 201
Block Options
Q96
Instructions:

Please have unsalted crackers and water to cleanse your palate between samples.
Q213
PLEASE CLOSELY OBSERVE SAMPLE 201.

Please answer the following questions **BY VISUAL EVALUATION ONLY (DO NOT TASTE THE SAMPLE YET):**
Q214
Please rate your liking of the **APPEARANCE** of Sample 201

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither like nor dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely

Page Break

SMELL
PLEASE SMELL SAMPLE 201, AND ANSWER THE FOLLOWING QUESTION
Q110
Please rate your liking of the **ODOR** of Sample 201

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither like nor dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely

Page Break
Q222
PLEASE TASTE SAMPLE 201, AND ANSWER THE FOLLOWING QUESTIONS:
Q111
Please rate your liking of the **TEXTURE** of Sample 201

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither like nor dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely

Q113
Please rate your liking of the **SOFTNESS** of Sample 201

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither like nor dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely

Q224
Based on your preference, please rate the **SOFTNESS** of Sample 201

Not soft enough	Just about right	Too soft

Q114
Please rate your liking of the **MOISTNESS** of Sample 201

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither like nor dislike	Like slightly	Like Moderately	Like Very Much	Like Extremely

Q225
Based on your preference, please rate the **MOISTNESS** of Sample 201

Not moist enough	Just about right	Too moist

Q115
Please rate your liking of the **STICKINESS** of Sample 201

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither like nor dislike	Dislike slightly	Like Moderately	Like Very Much	Like extremely

Q116
Based on your preference, please rate the **STICKINESS** of Sample 201

Not sticky enough	Just about right	Too sticky

Q112
Please rate your liking of the **OVERALL FLAVOR** of Sample 201

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither like nor dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely

Q227
Please rate your **OVERALL LIKING** of Sample 201

Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither like nor dislike	Like Slightly	Like Moderately	Like Very much	Like Extremely

Q119
Will you purchase this product?

Yes No

Q90

Sample 201= This is a Gluten (Wheat) Free and Clean Label simple and no chemical ingredients product.

Q75

How does this product make you FEEL?

	Not at all	Slightly	Moderately	Very much	Extremely
Adventurous					
Bored					
Calm					
Disgusted					
Enthusiastic					
Good					
Guilty					
Happy					
Interested					
Joyful					
Pleased					
Satisfied					
Unsafe (related to health)					
Warm					
Worried					

Q228

Will you purchase this product?

Yes No

Sample 352

Block Options

Q349

Instructions:

Please have unsalted crackers and water to cleanse your palate between samples.

Q350

PLEASE CLOSELY OBSERVE SAMPLE 352.

Please answer the following questions **BY VISUAL EVALUATION ONLY (DO NOT TASTE THE SAMPLE YET):**

Q351

Please rate your liking of the **APPEARANCE** of Sample 352

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither like nor dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely

Page Break

Q352

PLEASE SMELL SAMPLE 352, AND ANSWER THE FOLLOWING QUESTION

Q353

Please rate your liking of the **ODOR** of Sample 352

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither like nor dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely

Page Break

Q354

PLEASE TASTE SAMPLE 352, AND ANSWER THE FOLLOWING QUESTIONS:

Q355

Please rate your liking of the **TEXTURE** of Sample 352

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither like nor dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely

Q356

Please rate your liking of the **SOFTNESS** of Sample 352

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither like nor dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely

Q357

Based on your preference, please rate the **SOFTNESS** of Sample 352

Not soft enough Just about right Too soft

Q358

Please rate your liking of the **MOISTNESS** of Sample 352

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither like nor dislike	Like slightly	Like Moderately	Like Very Much	Like Extremely

Q359

Based on your preference, please rate the **MOISTNESS** of Sample 352

Not moist enough	Just about right	Too moist

Q360

Please rate your liking of the **STICKINESS** of Sample 352

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither like nor dislike	Dislike slightly	Like Moderately	Like Very Much	Like extremely

Q361

Based on your preference, please rate the **STICKINESS** of Sample 352

Not sticky enough	Just about right	Too sticky

Q362

Please rate your liking of the **OVERALL FLAVOR** of Sample 352

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither like nor dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely

Q363

Please rate your **OVERALL LIKING** of Sample 352

Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither like nor dislike	Like Slightly	Like Moderately	Like Very much	Like Extremely

Q364

Will you purchase this product?

Yes	No

Q365

Sample 352= This is a Gluten (Wheat) Free and Clean Label simple and no chemical ingredients product. According to the FDA, a product containing 2.5 grams of fiber is considered a good source of fiber. This product contains 1.7 grams of fiber per serving.

Q366

How does this product make you FEEL?

	Not at all	Slightly	Moderately	Very much	Extremely
Adventurous					
Bored					
Calm					

	Not at all	Slightly	Moderately	Very much	Extremely
Disgusted					
Enthusiastic					
Good					
Guilty					
Happy					
Interested					
Joyful					
Pleased					
Satisfied					
Unsafe (related to health)					
Warm					
Worried					

Q367
Will you purchase this product?
Yes No

Q368
Instructions:

Please have unsalted crackers and water to cleanse your palate between samples.
Q369
PLEASE CLOSELY OBSERVE SAMPLE 502.

Please answer the following questions **BY VISUAL EVALUATION ONLY (DO NOT TASTE THE SAMPLE YET):**
Q370
Please rate your liking of the **APPEARANCE** of Sample 502

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither like nor dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely

Page Break
Q371
PLEASE SMELL SAMPLE 502, AND ANSWER THE FOLLOWING QUESTION
Q372
Please rate your liking of the **ODOR** of Sample 502

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither like nor dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely

Page Break

Q373

PLEASE TASTE SAMPLE 502, AND ANSWER THE FOLLOWING QUESTIONS:

Q374

Please rate your liking of the **TEXTURE** of Sample 502

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither like nor dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely

Q375

Please rate your liking of the **SOFTNESS** of Sample 502

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither like nor dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely

Q376

Based on your preference, please rate the **SOFTNESS** of Sample 502

Not soft enough	Just about right	Too soft

Q377

Please rate your liking of the **MOISTNESS** of Sample 502

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither like nor dislike	Like slightly	Like Moderately	Like Very Much	Like Extremely

Q378

Based on your preference, please rate the **MOISTNESS** of Sample 502

Not moist enough	Just about right	Too moist

Q379

Please rate your liking of the **STICKINESS** of Sample 502

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither like nor dislike	Dislike slightly	Like Moderately	Like Very Much	Like extremely

Q380

Based on your preference, please rate the **STICKINESS** of Sample 502

Not sticky enough	Just about right	Too sticky

Q381

Please rate your liking of the **OVERALL FLAVOR** of Sample 502

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither like nor dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely

Q382

Please rate your **OVERALL LIKING** of Sample 502

Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither like nor dislike	Like Slightly	Like Moderately	Like Very much	Like Extremely

Q383

Will you purchase this product?

Yes No

Q384

Sample 502= This is a Gluten (Wheat) Free and Clean Label simple and no chemical ingredients product. According to the FDA, a product containing 2.5 grams of fiber is considered a good source of fiber. This product contains 3.8 grams of fiber per serving.

Q385

How does this product make you FEEL?

	Not at all	Slightly	Moderately	Very much	Extremely
Adventurous					
Bored					
Calm					
Disgusted					
Enthusiastic					
Good					
Guilty					
Happy					
Interested					
Joyful					
Pleased					
Satisfied					
Unsafe (related to health)					
Warm					
Worried					

Q386

Will you purchase this product?

Yes No

B.2 SAS code & R code

B.2.1 Physicochemical Analysis (R CODE)

COLOR

````
---
title: "color"
author: "VANESA CHICAIZA"
date: "7/15/2021"
output: html_document
---
```{r}
COLOR <- read.csv("COLORC.csv", header=TRUE, sep=",")
```

```{r}
ipak <- function(pkg){
   new.pkg <- pkg[!(pkg %in% installed.packages()[, "Package"])]
   if (length(new.pkg))
      install.packages(new.pkg, dependencies = TRUE)
   sapply(pkg, require, character.only = TRUE)
}

# usage
packages <- c("lsr", "psych", "car", "agricolae", "tidyverse", "knitr", "kableExtra", "ggplot2")
ipak(packages)
```
```{r}
library(psych)
```

```{r}
describeBy(COLOR$L_crust, group = COLOR$Treatment, mat = TRUE, digits = 2)
```
```{r}
describeBy(COLOR$a_crust, group = COLOR$Treatment, mat = TRUE, digits = 2)
```
```{r}
describeBy(COLOR$b_crust, group = COLOR$Treatment, mat = TRUE, digits = 2)
```
```{r}
describeBy(COLOR$L_inner, group = COLOR$Treatment, mat = TRUE, digits = 2)
```
````

```{r}
describeBy(COLOR$a_inner, group = COLOR$Treatment, mat = TRUE, digits = 2)
```

```{r}
describeBy(COLOR$b_inner, group = COLOR$Treatment, mat = TRUE, digits = 2)
```

```{r}
Model1<-lm(L_crust~Treatment, data = COLOR)
ANOVA <-aov(Model1)
summary(ANOVA)

```

```{r}
TUKEY2<-HSD.test(Model1, "Treatment", group = TRUE)
TUKEY2
```
```{r}
Model1<-lm(a_crust~Treatment, data = COLOR)
ANOVA <-aov(Model1)
summary(ANOVA)
```
```{r}
TUKEY3<-HSD.test(Model1, "Treatment", group = TRUE)
TUKEY3
```
```{r}
Model1<-lm(b_crust~Treatment, data = COLOR)
ANOVA <-aov(Model1)
summary(ANOVA)
```
```{r}
TUKEY4<-HSD.test(Model1, "Treatment", group = TRUE)
TUKEY4
```
```{r}
Model1<-lm(L_inner~Treatment, data = COLOR)
ANOVA <-aov(Model1)
summary(ANOVA)
```
```{r}
TUKEY5<-HSD.test(Model1, "Treatment", group = TRUE)
```

TUKEY5
```
```{r}
Model1<-lm(a_inner~Treatment, data = COLOR)
ANOVA <-aov(Model1)
summary(ANOVA)
```
```{r}
TUKEY6<-HSD.test(Model1, "Treatment", group = TRUE)
TUKEY6
```
```{r}
Model1<-lm(b_inner~Treatment, data = COLOR)
ANOVA <-aov(Model1)
summary(ANOVA)
```

```{r}
TUKEY7<-HSD.test(Model1, "Treatment", group = TRUE)
TUKEY7
```

Texture

title: "choco"
author: "VANESA CHICAIZA"
date: "5/27/2021"
output: word_document

```{r}
TEXTURE <- read.csv("CHOCO1.csv", header=TRUE, sep=",")
```

```{r}
ipak <- function(pkg){
   new.pkg <- pkg[!(pkg %in% installed.packages()[, "Package"])]
   if (length(new.pkg))
      install.packages(new.pkg, dependencies = TRUE)
   sapply(pkg, require, character.only = TRUE)
}

# usage
packages <- c("lsr", "psych", "car", "agricolae", "tidyverse", "knitr", "kableExtra", "ggplot2")
ipak(packages)

```
```{r}
library(psych)
```

```{r}
boxplot(TEXTURE$Hardness~TEXTURE$Treatment,
      main="Boxplot comparing Springiness",
      col= rainbow(5),
      vertical = TRUE)
```
```{r}
boxplot(TEXTURE$Springiness~TEXTURE$Treatment,
      main="Boxplot comparing Springiness",
      col= rainbow(5),
      vertical = TRUE)
```
```{r}
boxplot(TEXTURE$Chewiness~TEXTURE$Treatment,
      main="Boxplot comparing Chewiness",
      col= rainbow(5),
      vertical = TRUE)

```
```{r}
describeBy(TEXTURE$Hardness, group = TEXTURE$Treatment, mat = TRUE, digits = 2)
```
```{r}
describeBy(TEXTURE$Springiness, group = TEXTURE$Treatment, mat = TRUE, digits = 2)
```
```{r}
describeBy(TEXTURE$Chewiness, group = TEXTURE$Treatment, mat = TRUE, digits = 2)
```
```{r}
Model1<-lm(Hardness~Treatment, data = TEXTURE)
ANOVA <-aov(Model1)
summary(ANOVA)

```
```{r}
```



```{r}

```
TUKEY2<-HSD.test(Model1, "Treatment", group = TRUE)
TUKEY2
```

```{r}
```

```{r}
Model2<-lm(Springiness~Treatment, data = TEXTURE)
ANOVA <-aov(Model2)
summary(ANOVA)
```

```{r}
TUKEY2<-HSD.test(Model2, "Treatment", group = TRUE)
TUKEY2
```

```{r}
Model3<-lm(Chewiness~Treatment, data = TEXTURE)
ANOVA <-aov(Model3)
summary(ANOVA)
```

```{r}
TUKEY2<-HSD.test(Model3, "Treatment", group = TRUE)
TUKEY2
```

B.2.2. Likings

```
dm 'log; clear; output; clear';
options nodate nocenter pageno=1 ls=132 ps=512 formchar="|----|+|---+=|-/\<>*";
ods listing; ods graphics on;
ods html style=minimal body='vanessa.html';
ods pdf;
data mixed;
input panelist sample color odor taste softness moistness stickiness overall_f ol;
datalines;

;
proc print;
title2 'raw data';
run;
proc sort data=mixed; by sample;
run;
```

```
proc means data=mixed n mean stddev min max;
class sample;
var color odor taste softness moistness stickiness mango_f ol;
run;

proc glimmix data=mixed;
class panelist sample;
model color= sample;
random panelist;
lsmeans sample/lines adjust=tukey;
run;

proc glimmix data=mixed;
class panelist sample;
model odor= sample;
random panelist;
lsmeans sample/lines adjust=tukey;
run;

proc glimmix data=mixed;
class panelist sample;
model taste= sample;
random panelist;
lsmeans sample/lines adjust=tukey;
run;

proc glimmix data=mixed;
class panelist sample;
model softness= sample;
random panelist;
lsmeans sample/lines adjust=tukey;
run;

proc glimmix data=mixed;
class panelist sample;
model moistness= sample;
random panelist;
lsmeans sample/lines adjust=tukey;
run;

proc glimmix data=mixed;
class panelist sample;
model stickiness= sample;
random panelist;
lsmeans sample/lines adjust=tukey;
run;
```

```
proc glimmix data=mixed;
class panelist sample;
model overall_f= sample;
random panelist;
lsmeans sample/lines adjust=tukey;
run;

proc glimmix data=mixed;
class panelist sample;
model ol= sample;
random panelist;
lsmeans sample/lines adjust=tukey;
run;

ods graphics off;
ods pdf close;
```

B.2.3. Emotions

```
dm 'log; clear; output; clear';
options nodate nocenter pageno=1 ls=132 ps=512 formchar="|----|+|---+=|-/\<>*";
ods listing; ods graphics
on;
ods html style=minimal body='vanessa.html';
ods pdf;
data emotions;
input panelist sample Adventurous Bored Calm Disgusted Enthusiastic Good Guilty
Happy Interested     Satisfied Pleased     Unsafe Warm          Worried Wellness;
datalines;
;
proc
print;
title2 'raw
data';
run;
proc sort data= emotions; by
sample;
run;
proc means data=emotions n mean stddev min
max;
class
sample;
var Adventurous Bored Calm Disgusted Enthusiastic Good Guilty Happy    Interested
        Satisfied Pleased Unsafe Warm WorriedWellness;
```

```
run;

proc glimmix data=emotions;
class panelist sample;
model Adventurous= sample;
random panelist;
lsmeans sample/lines adjust=tukey;
run;

proc glimmix data=emotions;
class panelist sample;
model Bored= sample;
random panelist;
lsmeans sample/lines adjust=tukey;
run;

proc glimmix data=emotions;
class panelist sample;
model Calm= sample;
random panelist;
lsmeans sample/lines adjust=tukey;
run;

proc glimmix data=emotions;
class panelist sample;
model Disgusted= sample;
random panelist;
lsmeans sample/lines adjust=tukey;
run;

proc glimmix data=emotions;
class panelist sample;
model Enthusiastic= sample;
random panelist;
lsmeans sample/lines adjust=tukey;
run;

proc glimmix data=emotions;
class panelist sample;
model Good= sample;
random panelist;
lsmeans sample/lines adjust=tukey;
run;

proc glimmix data=emotions;
class panelist sample;
```

```
model Guilty= sample;
random panelist;
lsmeans sample/lines adjust=tukey;
run;

proc glimmix data=emotions;
class panelist sample;
model Happy= sample;
random panelist;
lsmeans sample/lines adjust=tukey;
run;

proc glimmix data=emotions;
class panelist sample;
model Interested= sample;
random panelist;
lsmeans sample/lines adjust=tukey;
run;

proc glimmix data=emotions;
class panelist sample;
model Satisfied= sample;
random panelist;
lsmeans sample/lines adjust=tukey;
run;

proc glimmix data=emotions;
class panelist sample;
model Pleased= sample;
random panelist;
lsmeans sample/lines adjust=tukey;
run;

proc glimmix data=emotions;
class panelist sample;
model Unsafe = sample;
random panelist;
lsmeans sample/lines adjust=tukey;
run;

proc glimmix data=emotions;
class panelist sample;
model Warm= sample;
random panelist;
lsmeans sample/lines adjust=tukey;
run;
```

```
proc glimmix data=emotions;
class panelist sample;
model Worried= sample;
random panelist;
lsmeans sample/lines adjust=tukey;
run;

ods graphics off;
ods pdf close;
```

B.2.4. Logistic Regression

PI BEFORE

```
dm 'log; clear; output; clear';
options nodate nocenter pageno = 1 ls=78
ps=53; title1 'LOGIT PI BEFORE';
ods pdf;
Title2 'Logistic regression PI hedonics NO OL';
data MUFFIN;
input PANELIST SAMPLE $ color odor taste softness moistness stickiness overall_f ol
        PI $;
datalines;
;
proc print data= MUFFIN;run;
proc sort data= MUFFIN; by panelist; run;
proc logistic descending;
class PANELIST SAMPLE PI;
model PI= SAMPLE color odor taste softness moistness stickiness overall_f
ol/aggregate;
run;
ods pdf close;
```

PI AFTER

```
dm 'log; clear; output; clear';
options nodate nocenter pageno = 1 ls=78
ps=53; title1 'LOGIT PI AFTER';
ods pdf;
Title2 'Logistic regression Plafter emotions';
data MUFFIN;
input PANELIST SAMPLE $ PIB $ Adventurous Bored Calm Disgusted Enthusiastic
Good Guilty Happy Interested     Satisfied Pleased    Unsafe Warm         Worried
Wellness      PIA $;
```

```
datalines;
 ;
proc print data= MUFFIN;run;
proc sort data= MUFFIN; by panelist; run;
proc logistic descending;
class PANELIST SAMPLE PIB PIA;
model PIA= SAMPLE PIB Adventurous Bored Calm Disgusted Enthusiastic Good Guilty
Happy Interested     Satisfied Pleased     Unsafe Warm          Worried
Wellness/aggregate;
run;
ods pdf close;
```

B.2.5. Penalty Analysis

OVERALL LIKING – JAR SCORE

Overall liking- softness 201

	Not enough	JAR	Too much
Panelist	27	53	5
Aveg Liking	5.22	6.87	6
% CONSUMERS	31.8	62.4	5.9
Penalty	1.65		0.87

Overall liking -softness 352

	Not enough	JAR	Too much
Panelist	18	66	1
Aveg Liking	5.78	6.97	7
% CONSUMERS	21.2	77.6	1.2
Penalty	1.19		-0.03

Overall liking -softness 503

	Not enough	JAR	Too much
Panelist	16	66	3
Aveg Liking	5.31	7.12	6.67
% CONSUMERS	18.8	77.6	3.5
Penalty	1.81		0.45

OVERALL LIKING- JAR

Overall liking moistness 201

	Not enough	JAR	Too much
Panelist	36	45	4
Aveg Liking	5.56	6.87	6.5
% CONSUMERS	42.4	52.9	4.7
Penalty	1.31		0.37

Overall liking moistness 352

	Not enough	JAR	Too much
Panelist	24	56	5
Aveg Liking	6	7.089	6
% CONSUMERS	28.2	65.9	5.9
Penalty	1.089		1.089

Overall liking -moistness 503

	Not enough	JAR	Too much
Panelist	21	62	2
Aveg Liking	5.77	7.11	6.5
% CONSUMERS	24.7	72.9	2.4
Penalty	1.34		0.61

Overall liking stickiness 201

	Not enough	JAR	Too much
Panelist	8	59	18
Aveg Liking	4.88	6.58	6
% CONSUMERS	9.4	69.4	21.2
Penalty	1.7		0.58

Overall liking -stickiness 352

	Not enough	JAR	Too much
Panelist	7	63	15
Aveg Liking	7	6.87	5.93
% CONSUMERS	8.2	74.1	17.6
Penalty	-0.13		0.94

Overall liking -stickiness 503

	Not enough	JAR	Too much
Panelist	7	72	5
Aveg Liking	5.86	6.96	5.2
% CONSUMERS	8.2	84.7	5.9
Penalty	1.1		1.76

B.2.6. COCHRAN'S Q TEST AND MC NEMAR TEST BY USING R SOFWARE

R CODES

```
#McNemar Test

ComparePI201 <-
  matrix(c(44, 41, 43, 42),
         nrow = 2,
         dimnames = list("PIa" = c("Yes", "No"),
                         "PIb" = c("Yes", "No")))
ComparePI201
mcnemar.test(ComparePI201)

ComparePI352 <-
  matrix(c(49, 36, 48, 37),
         nrow = 2,
         dimnames = list("PIa" = c("Yes", "No"),
                         "PIb" = c("Yes", "No")))
ComparePI352
mcnemar.test(ComparePI352)

ComparePI503 <-
  matrix(c(59, 26, 58, 27),
         nrow = 2,
         dimnames = list("PIa" = c("Yes", "No"),
```

```
                    "PIb" = c("Yes", "No")))
ComparePI503
mcnemar.test(ComparePI503)

#Cochran's Q test#

install.packages("nonpar")
library(nonpar)

#PIA
Input = ("
")
Data= read.table(textConnection(Input),header=TRUE)
Data$Compare=factor(Data$Compare,
                    levels=unique(Data$Compare))
Data$Response=factor(Data$Response,
                     levels=c("YES","NO"))

library(psych)

headTail(Data)

str(Data)

summary(Data)

rm(Input)


Data$Response.n=as.numeric(Data$Response)-1
Table=xtabs(Response.n~Compare, data=Data)
Table

xtabs(~Compare+Response,data=Data)

Table=xtabs(~Response+Compare, data=Data)
Table

barplot(Table,
        beside = TRUE,
        legend = TRUE,
        ylim = c(0, 65),
        cex.names = 0.8,
        cex.axis = 0.8,
        args.legend = list(x   = "topleft",
                           cex = 0.8,
```

```
                    bty = "n"))
library(RVAideMemoire)

cochran.qtest(Response ~ Compare | PANELIST,
              data = Data)

#pairwise MCNemar test
Data$Compare=factor(Data$Compare,
                    levels=c("PIA201","PIA352","PIA503"))
library(rcompanion)
PT <- pairwiseMcnemar(Response~Compare | PANELIST,
                      data=Data,
                      test="permutation",
                      method = "fdr",
                      digits = 3)
PT


PT=PT$Pairwise
library(rcompanion)
cldList(p.adjust~Comparison,
        data=PT,
        threshold = 0.05)

#PIB
Input2 = ("
")
Data2= read.table(textConnection(Input2),header=TRUE)
Data2$Compare=factor(Data2$Compare,
                     levels=unique(Data2$Compare))
Data2$Response=factor(Data2$Response,
                      levels=c("YES","NO"))

library(psych)

headTail(Data2)

str(Data2)

summary(Data2)

rm(Input2)


Data2$Response.n=as.numeric(Data2$Response)-1
Table2=xtabs(Response.n~Compare, data=Data2)
```

```
Table2

xtabs(~Compare+Response,data=Data2)

Table2=xtabs(~Response+Compare, data=Data2)
Table2

barplot(Table2,
        beside = TRUE,
        legend = TRUE,
        ylim = c(0, 65),
        cex.names = 0.8,
        cex.axis = 0.8,
        args.legend = list(x   = "topleft",
                           cex = 0.8,
                           bty = "n"))
library(RVAideMemoire)

cochran.qtest(Response ~ Compare | PANELIST,
              data = Data2)

#pairwise MCNemar test
Data2$Compare=factor(Data2$Compare,
                     levels=c("PIB201","PIB352","PIB503"))
library(rcompanion)
PT2 <- pairwiseMcnemar(Response~Compare | PANELIST,
                       data=Data2,
                       test="permutation",
                       method = "fdr",
                       digits = 3)
PT2


PT2=PT2$Pairwise
library(rcompanion)
cldList(p.adjust~Comparison,
        data=PT2,
        threshold = 0.05)
```

RESULTS

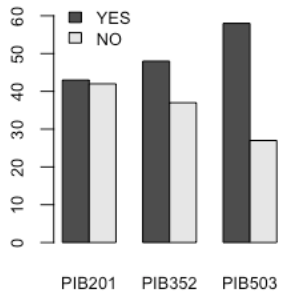
data: ComparePI201
McNemar's chi-squared = 0.011905, df = 1, p-value = 0.9131

data: ComparePI352
McNemar's chi-squared = 1.4405, df = 1, p-value = 0.2301

data: ComparePI503
McNemar's chi-squared = 11.44, df = 1, p-value = 0.0007186

PIB:

Response	PIB201	PIB352	PIB503
YES	43	48	58
NO	42	37	27



data: Response by PIB, block = PANELIST

Q = 8.9744, df = 2, p-value = 0.01125

alternative hypothesis: true difference in probabilities is not equal to 0

sample estimates:

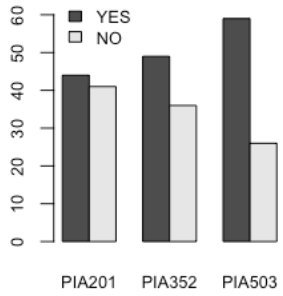
proba in group PIB201	proba in group PIB352	proba in group PIB503
0.4941176	0.4352941	0.3176471

Pairwise comparisons

Group	Letter
PIB201	a
PIB352	ab
PIB503	b

PIA:

Response	PIA201	PIA352	PIA503
YES	44	49	59
NO	41	36	26



Cochran's Q test

data: Response by PIA, block = PANELIST

Q = 8.3333, df = 2, p-value = 0.0155

alternative hypothesis: true difference in probabilities is not equal to 0

sample estimates:

proba in group PIA201	proba in group PIA352	proba in group PIA503
0.4823529	0.4235294	0.3058824

Pairwise comparisons

Group	Letter
PIA201	a
PIA352	ab
PIA503	b

B 3. Simulated baking test

B 3.1. Questionnaire

Research Consent Form

I, _____, agree to participate in the research entitled "Consumer perception, emotions, likings and purchase intent of Gluten-Free/Clean-Label chocolate Muffin Mix after health benefits information" which is being conducted by Witoon Prinyawiwatkul of the School of Nutrition and Food Sciences at Louisiana State University Agricultural Center, (225) 578-5188. I understand that participation is entirely voluntary and whether or not I participate will not affect how I am treated on my job. I can withdraw my consent at any time without penalty or loss of benefits to which I am otherwise entitled and have the results of the participation returned to me, removed from the experimental records, or destroyed. One hundred consumers will participate in this research. For this particular research, at least 1 hour of participation will be required for each consumer. The following points have been explained to me: 1. In any case, it is my responsibility to report prior to participation to the investigator any food allergies I may have. 2. The reason for the research is to gather information on consumer perception and acceptability of Gluten-Free/Clean-Label Chocolate Muffins Pre-Mix. The benefit that I may expect from it is a satisfaction that I have contributed to the solution and evaluation of problems related to such examination. 3. The procedures are as follows: I will evaluate samples prepared by myself by normal standard methods and indicate my evaluation on score sheets. All procedures are standard methods as published by the American Society for Testing and Materials and the Sensory Evaluation Division of the Institute of Food Technologists. 4. Participation entails minimal risk: The only risk may be an allergic reaction to rice, soluble fiber (corn), xanthan gum, eggs, salt, organic chocolate, organic vanilla, and sugar. However, because it is known to me beforehand that all those foods and ingredients are to be tested, the situation can normally be avoided. 5. The results of this study will not be released in any individually identifiable form without my prior consent unless required by law. 6. The investigator will answer any further questions about the research, either now or during the course of the project. The study has been discussed with me, and all of my questions have been answered. I understand that additional questions regarding the study should be directed to the investigator listed above. In addition, I understand the research at Louisiana State University AgCenter that involves human participation is carried out under the oversight of the Institutional Review Board. Questions or problems regarding these activities should be addressed to Dr. Michael Keenan of LSU AgCenter at 578-1708. I agree with the terms above. Name:

_____

End of Block: Block 4

Start of Block: Demographics

Q1 Gender

Male (1)

Female (2)

Q2 Age
18-25 (1)
26-35 (2)
36-45 (3)
46+ (4)

End of Block: Demographics

Start of Block: Cooking experiencce

Q26 Do you consume Gluten-Free products?
Yes (1)
No (2)

Q27 Do you consume Clean-Label (Natural ingredients/No artificial) products?
Yes (1)
No (2)

Q56 How often do you bake?
More than once a week (1)
Once a week (5)
Every 2 weeks (2)
Once a month or less (3)

Q5 Have you ever baked using Muffin Pre-Mix?
Yes (1)
No (2)

End of Block: Cooking experiencce

Start of Block: Baking process

Q28 BASED ON THE SIMULATED BAKING TEST, ANSWER THE FOLLOWING QUESTIONS

Q7 How would you describe the overall experience of this Simulated Baking Test?
Dislike extremely (1)
Dislike very much (2)
Dislike moderetaly (3)
Dislike slightly (4)
Neither like nor dislike (5)
Like slightly (6)
Like moderately (7)
Like very much (8)

Like extremely (9)

Q29 How would you describe your liking of the handling process of the batter during mixing.
Dislike extremely (1)
Dislike very much (2)
Dislike moderetaly (3)
Dislike slightly (4)
Neither like nor dislike (5)
Like slightly (6)
Like moderately (7)
Like very much (8)
Like extremely (9)

Q13 Based on your preference, please rate the STICKINESS of the batter.
Not easy to mix (1)
Easy to mix (2)

Q10 Are you satisfied with the baking process (mixing and baking) in terms of time?
Yes (1)
No (2)

Q33 Is the baking process convenient?
Yes (1)
No (2)

Q34 Is the baking instructions easy to follow?
Yes (1)
No (2)

End of Block: Baking process

Start of Block: FINAL PRODUCT

Q36 Instructions: Please wait till the muffin is cool down before tasting

Q71 Was it difficult to remove the final product from the baking pan?
Yes (1)
No (2)

Q38 Please answer the following questions BY VISUAL EVALUATION ONLY (DO NOT TASTE THE SAMPLE YET):

Q40 Please rate your liking of the APPEARANCE of the final product

Dislike Extremely (60)
Dislike Very Much (61)
Dislike Moderately (62)
Dislike Slightly (63)
Neither like nor dislike (64)
Like Slightly (65)
Like Moderately (66)
Like Very Much (69)
Like Extremely (67)

Q42 PLEASE SMELL THE FINAL PRODUCT, AND ANSWER THE FOLLOWING QUESTION

Q44 Please rate your liking of the ODOR of the final product
Dislike Extremely (60)
Dislike Very Much (61)
Dislike Moderately (62)
Dislike Slightly (63)
Neither like nor dislike (64)
Like Slightly (65)
Like Moderately (66)
Like Very Much (69)
Like Extremely (67)

Q46 PLEASE TASTE THE FINAL PRODUCT, AND ANSWER THE FOLLOWING QUESTIONS:

Q48 Please rate your liking of the TEXTURE of the final product
Dislike Extremely (60)
Dislike Very Much (61)
Dislike Moderately (62)
Dislike Slightly (63)
Neither like nor dislike (64)
Like Slightly (65)
Like Moderately (66)
Like Very Much (69)
Like Extremely (67)

Q50 Please rate your liking of the SOFTNESS of the final product
Dislike Extremely (60)
Dislike Very Much (61)
Dislike Moderately (62)
Dislike Slightly (63)
Neither like nor dislike (64)
Like Slightly (65)
Like Moderately (66)

Like Very Much (69)
Like Extremely (67)

Q52 Based on your preference, please rate the SOFTNESS of the final product
Not soft enough (1)
Just about right (2)
Too soft (3)

Q54 Please rate your liking of the MOISTNESS of the final product
Dislike Extremely (60)
Dislike Very Much (61)
Dislike Moderately (62)
Dislike Slightly (63)
Neither like nor dislike (64)
Like Slightly (65)
Like Moderately (66)
Like Very Much (69)
Like Extremely (67)

Q56 Based on your preference, please rate the MOISTNESS of the final product
Not moist enough (60)
Just about right (61)
Too moist (62)

Q58 Please rate your liking of the STICKINESS of the final product
Dislike Extremely (60)
Dislike Very Much (61)
Dislike Moderately (62)
Dislike Slightly (63)
Neither like nor dislike (64)
Like Slightly (65)
Like Moderately (66)
Like Very Much (69)
Like Extremely (67)

Q60 Based on your preference, please rate the STICKINESS of the final product
Not sticky enough (60)
Just about right (61)
Too sticky (62)

Q62 Please rate your liking of the OVERALL FLAVOR of the final product
Dislike Extremely (60)
Dislike Very Much (61)
Dislike Moderately (62)
Dislike Slightly (63)
Neither like nor dislike (64)

Like Slightly (65)
Like Moderately (66)
Like Very Much (69)
Like Extremely (67)

Q64 Please rate your OVERALL LIKING of the final product
Dislike Extremely (60)
Dislike Very Much (61)
Dislike Moderately (62)
Dislike Slightly (63)
Neither like nor dislike (64)
Like Slightly (65)
Like Moderately (66)
Like Very Much (69)
Like Extremely (67)

Q66 Will you purchase this Pre-Mix to bake?
Yes (70)
No (71)

Q68 This is a Gluten (Wheat) Free and Clean Label (Simple, NO artificial ingredients/ All Natural, Organic) product. According to the FDA, a product containing 2.5 grams of fiber is considered a good source of fiber. This product contains 3.8 grams of fiber per serving.

Q70 Will you purchase this Pre-Mix to bake?
Yes (70)
No (71)

End of Block: FINAL PRODUCT

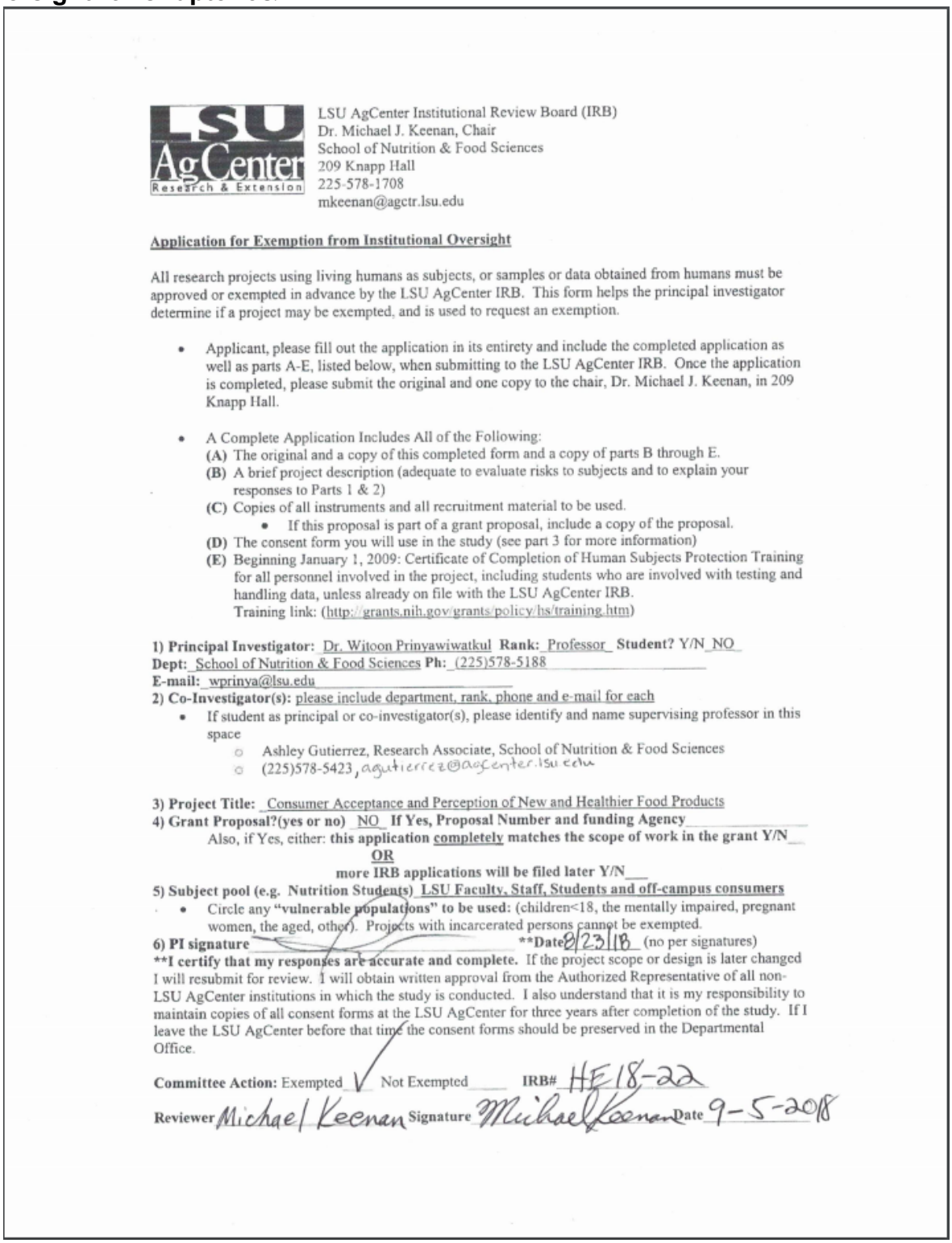
Start of Block: Block 3

Q17 Thank you for your participation

End of Block: Block 3

APPENDIX C. APROVAL FOR USE OF HUMAN SUBJECTS

C.1. LSU AgCenter Institutional Review Board (IRB) Exemption from Institutional Oversight for Chapter 3&4



LSU AgCenter Institutional Review Board (IRB)
Dr. Michael J. Keenan, Chair
School of Nutrition & Food Sciences
209 Knapp Hall
225-578-1708
mkeenan@agctr.lsu.edu

Application for Exemption from Institutional Oversight

All research projects using living humans as subjects, or samples or data obtained from humans must be approved or exempted in advance by the LSU AgCenter IRB. This form helps the principal investigator determine if a project may be exempted, and is used to request an exemption.

- Applicant, please fill out the application in its entirety and include the completed application as well as parts A-E, listed below, when submitting to the LSU AgCenter IRB. Once the application is completed, please submit the original and one copy to the chair, Dr. Michael J. Keenan, in 209 Knapp Hall.

- A Complete Application Includes All of the Following:
  - **(A)** The original and a copy of this completed form and a copy of parts B through E.
  - **(B)** A brief project description (adequate to evaluate risks to subjects and to explain your responses to Parts 1 & 2)
  - **(C)** Copies of all instruments and all recruitment material to be used.
    - If this proposal is part of a grant proposal, include a copy of the proposal.
  - **(D)** The consent form you will use in the study (see part 3 for more information)
  - **(E)** Beginning January 1, 2009: Certificate of Completion of Human Subjects Protection Training for all personnel involved in the project, including students who are involved with testing and handling data, unless already on file with the LSU AgCenter IRB.
    Training link: (http://grants.nih.gov/grants/policy/hs/training.htm)

1) Principal Investigator: Dr. Witoon Prinyawiwatkul **Rank:** Professor **Student?** Y/N NO
Dept: School of Nutrition & Food Sciences **Ph:** (225)578-5188
E-mail: wprinya@lsu.edu
2) Co-Investigator(s): please include department, rank, phone and e-mail for each

- If student as principal or co-investigator(s), please identify and name supervising professor in this space
  - Ashley Gutierrez, Research Associate, School of Nutrition & Food Sciences
  - (225)578-5423, agutierrez@agcenter.lsu.edu

3) Project Title: Consumer Acceptance and Perception of New and Healthier Food Products
4) Grant Proposal?(yes or no) NO **If Yes, Proposal Number and funding Agency**
Also, if Yes, either: **this application completely matches the scope of work in the grant Y/N**
OR
more IRB applications will be filed later Y/N
5) Subject pool (e.g. Nutrition Students) LSU Faculty, Staff, Students and off-campus consumers

- Circle any **"vulnerable populations" to be used:** (children<18, the mentally impaired, pregnant women, the aged, other). Projects with incarcerated persons cannot be exempted.

6) PI signature ****Date** 8/23/18 (no per signatures)
****I certify that my responses are accurate and complete.** If the project scope or design is later changed I will resubmit for review. I will obtain written approval from the Authorized Representative of all non-LSU AgCenter institutions in which the study is conducted. I also understand that it is my responsibility to maintain copies of all consent forms at the LSU AgCenter for three years after completion of the study. If I leave the LSU AgCenter before that time the consent forms should be preserved in the Departmental Office.

Committee Action: Exempted ✓ Not Exempted ____ **IRB#** HE18-22
Reviewer Michael Keenan **Signature** Michael Keenan **Date** 9-5-2018

C. 2.1. Research Consent Form for Chapter 3&4

APPROVED BY
LSU AG CENTER
IRB AS HE18-22
ON 9-5-2018

Research Consent Form (EXAMPLE)

I, _____, agree to participate in the research entitled "Consumer Acceptance and Perception of New and Healthier Food Products" which is being conducted by Dr. Witoon Prinyawiwatkul, Professor of the School of Nutrition and Food Sciences at Louisiana State University, Agricultural Center, phone number (225) 578-5188.

I understand that participation is entirely voluntary and whether or not I participate will not affect how I am treated on my job. I can withdraw my consent at any time without penalty or loss of benefits to which I am otherwise entitled and have the results of the participation returned to me, removed from the experimental records, or destroyed. Up to 300 consumers will participate in this research. For this particular research, about 15-20 minutes participation will be required for each consumer.

The following points have been explained to me:

1. In any case, it is my responsibility to report prior to participation to the investigator any food allergies I may have.

2. The reason for the research is to gather information on sensory acceptability, emotion and purchase intent of new and healthier food products. The benefit that I may expect from it is a satisfaction that I have contributed to quality improvement of these products.

3. The procedures are as follows: 3-5 coded samples will be placed in front of me, and I will evaluate them by normal standard methods and indicate my evaluation on score sheets. All procedures are standard methods as published by the American Society for Testing and Materials and the Sensory Evaluation Division of the Institute of Food Technologists.

4. Participation entails minimal risk: The only risk which can be envisioned is that of an allergic reaction toward common food ingredients [red beans, bell pepper, onion, garlic, celery, thyme, cayenne pepper, bay leaf, pork products, rice and rice products, milk and dairy products, yogurt or fermented milk products, peanuts, mayonnaise products, wheat flour, tapioca flour, eggs, table sugar, vanilla, soy products, sweet potato, salt (sodium chloride) and salt substitute (potassium chloride and common amino acids such as glycine and lysine), and plain unsalted crackers]. However, because it is known to me beforehand that the food to be tested contains common food ingredients, the situation can normally be avoided.

5. The results of this study will not be released in any individual identifiable form without my prior consent unless required by law.

6. The investigator will answer any further questions about the research, either now or during the course of the project.

The study has been discussed with me, and all of my questions have been answered. I understand that additional questions regarding the study should be directed to the investigator listed above. In addition, I understand the research at Louisiana State University, Agricultural Center, which involves human participation, is carried out under the oversight of the Institutional Review Board. Questions or problems regarding these activities should be addressed to Dr. Michael Keenan, Chair of LSU AgCenter IRB, (225) 578-1708. I agree with the terms above and acknowledge.

_____ _____
Signature of Investigator Signature of Participant

Witness: _____ Date: _____

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VITA

Vanesa Gisela Chicaiza was born in Ecuador. She obtained her bachelor's degree in Food Science and Technology at Zamorano (Honduras). After she graduated, she worked in the food industry as a Quality Control Assistant for about two years. Then, in 2019 she started doing an internship in the product development and sensory department, focusing on evaluating consumers' perception of Gluten-Free/Clean-Label muffins. Afterward, she is pursuing her second year of her master's in Food Science In the same laboratory under Dr. Witoon Prinyawiwatkul, where she expects to graduate with her master's degree in December 2021. Finally, she plans to pursue a career as an R&D/ Sensory Scientist.