

Exploring Factors Preventing the Popularization of Sorghum Grain for Human
Consumption in the United States

by

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ABSTRACT

Sorghum is a highly significant cereal crop that has been relied upon by cultures and populations for survival throughout recorded history and is still being utilized today. However, despite its potential health benefits and environmental advantages, human consumption of sorghum and sorghum-based products remains low in the US. This research aimed to shed light on the possible reasons behind this and to explore the ideas and attitudes that prevent the full utilization of this readily available resource.

The study found that most consumers had little knowledge of sorghum 43.2% ($n = 290$) or had never heard of it 43.2% ($n = 290$). However, when presented with information about sorghum's potential health benefits, consumers expressed interest in trying sorghum products. Factors such as taste, price, and convenience were important considerations for consumers when making grocery purchases.

The practical implications of this research suggest that increasing consumer awareness of sorghums' benefits and incorporating it into existing products could help to popularize its consumption in the US. The study also identified several areas for future research, including investigating consumer perceptions of sorghum and its taste, exploring the role of marketing in promoting sorghum consumption, and evaluating economic factors and how they affect consumer food purchasing habits.

Overall, this research highlights the need for greater awareness concerning the potential benefits of sorghum consumption, as well as the importance of incorporating sustainable and nutritious foods into our diets. By promoting the consumption of sorghum, we can not only improve our own health, but also help to reduce the environmental impact of food production and contribute to future food security. The

increased utilization and popularization of products made with sorghum would be a move toward a happier, healthier, and more sustainable future for society as a whole.

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CHAPTER I

INTRODUCTION

Background and Setting

The modern consumer is highly vigilant, exhibiting greater concern about the products they buy with respect toward quality, health benefits, and social responsibility (Sajdakowska, Gebiski, Gutkowska, & Zakowska-Biemans, 2018). Recognizing the significance of individual food choices is crucial for effecting meaningful change in our food system, with the goal of promoting human health and ensuring the long-term sustainability of the planet (Chen & Antonelli, 2020). Individual food choices are evolving in accordance to changes of natural environment, on a biological basis, due to physical need, lifestyle, and the development of technology (Montanari & Sonnenfeld, 2006). Ultimately the outcome of consumer food choice is based on interactions between both environmental and individual factors (Swinburn et al., 2011).

A 2016 Deloitte market research report suggests that there are different value drivers involved when consumers in the United States make their food purchasing decisions. There are traditional drivers that include price, taste, and convenience, but there is also what is identified as evolving value drivers (Renner & Ringquist, 2016). These evolving value drivers have not always been there, but they are having just as much influence as the traditional value drivers as time progresses. Evolving value drivers include things like health and wellness, safety, social impact, and experience (Renner & Ringquist, 2016).

Sustainable healthy diets refer to dietary patterns that consider not only the health and well-being of individuals, but also the impact of these diets on the environment, as

well as their affordability, accessibility, safety, and cultural acceptability (FAO, 2019). According to Willet et al. (2019), there is a pressing need for a societal shift towards healthy and environmentally sustainable diets, as well as increased utilization of underutilized plant species such as quinoa, millets, sorghum, and teff grains. These crops are considered highly resilient to climate change and contain beneficial nutritional content (Willet et al., 2019). Sorghum has traditionally served as a key source of energy and nutrition for humans in Asia, Africa, and other developing countries, particularly in arid and semi-arid regions (Rooney & Waniska, 2000). Unlike the US, most of the sorghum grain produced in these areas is utilized for human consumption (Ratnavathi & Patil, 2013). From a global perspective, the US is the largest producer of sorghum grain (Arendt & Zannini, 2013) although, as in most developed countries, sorghum is mainly grown for animal feed and ethanol production (Xiong, Zhang, Warner, & Fang, 2019). With the global population explosion, growing demand for animal products, and the depletion of fossil fuel reserves, there is growing interest in exploring the full potential of sorghum as a source of food, feed, fodder (dried feed), and fuel (Reddy & Reddy, 2019). The commercialization of products made from sorghum and its components among non-traditional consumers has been a challenge (Khoddami et al., 2021). In recent years there has been a growing interest in cultivating sorghum for human consumption due to the beneficial natural ingredients contained in the grain, which are useful for the development of healthy and functional foods (Rooney, Portillo, & Hayes, 2013). Considerable advances have been made in incorporating whole grain sorghum into functional foods, aimed at enhancing quality and functionality for non-traditional consumers in the Western world (Ratnavathi & Patil, 2013). Despite the progress made,

these efforts are still in the early stages and would benefit from further research (Khoddami et al., 2021). In order to raise awareness about sorghum and increase its utilization, it is essential to understand the limitations presented by supply chains, as well as the reasons for poor stakeholder collaborations (Stefoska-Needham & Tapsell, 2020).

Human Consumption of Sorghum

In regions where sorghum is commonly consumed, whole sorghum grain, as well as decorticated (milled) grain, and sorghum flour are used to produce a broad range of different foods (Arendt & Zannini, 2013). Some of the more popular foods include thin or thick porridge type dishes; boiled products similar to those we are familiar with being made with maize or rice; popped sorghum, similar to popcorn; flat breads including tortillas; and various types of deep-fried foods (Khoddami et al., 2021). In addition to utilization of the grain, sweet juices found in the stalks of the plant can be extracted to make syrup, vinegar, and other alimentary products (Pochiscanu et al., 2014).

Traditionally sorghum has also been used in the production of home-made alcoholic beverages (Xiong, Zhang, Warner, & Fang, 2019). Baijiu (in China) is the most prolific of spirits made from sorghum (Fan, Xu, & Huang, 2014). This colorless drink is the national liquor of China and has been for at least the last 2,000 years (Wu et al., 2022). There are many other non-food uses of the sorghum crop (Stroade, Boland, Huntrods, & Taylor, 2022), but for the purpose of this study we will adhere to discussing the human consumption properties of the crop.

Recent studies have shown that sorghum products contain nutritional properties that are significantly beneficial to the human body (Stefoska-Needham, Beck, Johnson, &

Tapsell, 2015). Sorghum is a rich source of various phytochemicals including tannins, phenolic acids, anthocyanin, phytosterols, and polycosanols. These phytochemicals all have the potential to improve human health (Punia et al., 2021). Sorghum contains high levels of these antioxidants, more so even than many fruits that we associate with being rich in antioxidants (Kamath et al., 2004). It has also been noted that consuming these grain products can potentially aid in the battle against common nutritional diseases such as cancer, cardiovascular disease, and obesity (Ye, Chacko, Chou, Kugizaki, & Liu, 2012). The most publicized health benefit of sorghum grain in the literature is the fact that the grain is gluten free, making it an alternative to wheat flour for people suffering from Celiac disease (CD) (Simnadis, Tapsell, & Beck, 2016).

The Sorghum Crop

While the origin of sorghum is believed to be in Africa, it is worth noting that more sorghum is consumed on that continent than anywhere else in the world (Smith & Fredricksen, 2000). This is due to the many environments that sorghum can be grown in. Sorghum has proven to outperform other cereals under different environmental stresses making it more economically feasible to produce (Awika & Rooney, 2004). The versatility of the crop, coupled with its climate-resistant and drought tolerant qualities is what gives sorghum an advantage over other comparable grains (Arendt & Zannini, 2013). Sorghum thrives with less rainfall than is needed for rice or corn and can be grown where no other major cereal can be cultivated (Venkateswaran, Elangovan, & Sivaraj, 2019) Inversely, not only is sorghum drought resistant, but it can also hold up to extended periods of water logging (Borghi et al., 2013). For millions of people living in developing countries, sorghum is the only viable food grain (ICRISAT, 2004).

The exceptional agronomic characteristics and potential health benefits of sorghum have sparked renewed interest in this crop, evident in the growing number of publications in academic journals and increased attention from the food and drug industry (Xiong, Zhang, Warner, & Fang, 2019). Given the rising demand for healthy and plant-based food choices among consumers, sorghum has emerged as a highly promising candidate for development into a diverse range of healthy foods, functional convenience foods, and food additives (Stefoska-Needham & Tapsell, 2020).

Due to the ongoing trend towards rising temperatures and aridity caused by climate change, sorghum has emerged as a crucial commodity and resource for ensuring food security on a global scale (Pochiscanu et al., 2014). Even so, in developed societies such as Europe, Australia, and the United States, sorghum is not traditionally consumed by humans (Ducksbury, Neale, & Stefoska-Needham, 2021). It is essential to promote the widespread use and adoption of successful sorghum technologies for diversification, particularly among the non-traditional urban population, in order to make sorghum a mainstream commodity (Ratnavathi & Patil, 2013). Reconsideration of sorghum as a widespread alimentary cereal crop in the US is essential (Pochiscanu et al., 2014).

Problem Statement

Sorghum has been identified as one of the most important cereal crops that is grown in modern times (Ratnavathi & Patil, 2013). Cultures and populations have relied on this crop for their very survival throughout recorded history and continue to utilize it today (Smith & Fredricksen, 2000). In some parts of the world as much as half of the sorghum grown is utilized as a food staple for humans (Khoddami et al., 2021).

Today, the US is the leading producer of sorghum (Stroade, Boland, Huntrods, & Taylor, 2022), but in this country, we use it in a much different way than the rest of the world. The leading uses for sorghum in the US are for animal feed, for ethanol production, and as a product for export (Khoddami et al., 2021).

With human population on the rise, food security and the implementation of more sustainable agricultural practices are becoming more and more crucial (Coleman-Jensen, Rabbitt, & Singh, 2020). Also, due to rising population, widespread urbanization has become an alarming trend. As people move to a more urban lifestyle, there is a decrease in the quality of our diets (Hawkes, Harris, & Gillespie, 2017). Consumption of whole grains and fresh produce is being replaced by an increased intake of processed foods (Zobel, Hansen, Rossing, & Von Scholten, 2016). Consequently, we are experiencing an increase of food related health issues such as obesity and other dietary disorders (Kuddus, Tynan, & Mc Bride, 2020)

These challenges can be mitigated by integrating different foods into our diets (Hawkes, Harris, & Gillespie, 2017). Research has proven that sorghum is a food that can not only aid in human health (Ducksbury, Neale, & Stefoska-Needham, 2021), but can also aid in reducing human impact on the environment (Arendt & Zannini, 2013). Despite these facts, human consumption of sorghum and products made from sorghum have yet to be popularized in this country (Stefoska-Needham & Tapsell, 2020).

This research hopes to shed light on possible reasons as to why this is and to explore possible ideas and attitudes that are preventing the full utilization of this readily available resource.

Significance of the Study

The significance of this research study is deeply engrained in current societal issues. The first of these issues is the effects of our growing population on food security and available cropping areas used to produce the sustenance that is required to maintain a healthy and peaceful populous (Coleman-Jensen, Rabbitt, & Singh, 2020). Agricultural technology and innovation must continually evolve, not only maintain current production levels, but to also increase these levels to satisfy growing demand (Sayer & Cassman, 2013). In this case, the innovations presented in this research involve observing what has been done in the past and what practices are employed in other parts of the world. Additional challenges to innovation are presented as society strives to reduce human impacts on the environment (Willet et al., 2019). As factors such as pollution and climate change are becoming more and more apparent as being detrimental to the condition of the planet, it is becoming increasingly crucial that we employ all the resources that are available to us (Sayer & Cassman, 2013).

The significance of this study is also apparent in the lack of research that has been previously conducted that addresses the reasons why Western civilizations have yet to popularize human consumption of sorghum grain and other products derived from the sorghum crop (Stefoska-Needham & Tapsell, 2020). Being that sorghum is cultivated in all these developed countries, results in this resource being geographically available to consumers in the US (Stroade, Boland, Huntrods, & Taylor, 2022). As we see an increase in dietary disorders due to the declining quality of the average diet (Hawkes, Harris, & Gillespie, 2017), it is significant to explore how the health benefits of sorghum could be employed to curve this alarming human condition (Simnadis, Tapsell, & Beck, 2016).

Purpose Statement and Research Questions

This research study aimed to assess the relative knowledge level of US consumers concerning sorghum and its use as a food source. Additionally, the study aimed to explore potential stigmas and attitudes and their level of concern that US consumers have with sorghum and its consumption. Lastly, this research sought to get a better understanding of what consumers consider, when making their grocery purchasing selections. The findings of the study provide insights into the potential benefits and possible hindrances of consuming sorghum, which can inform efforts to increase its adoption as a food source in the US. The following, are the research questions which guided this study:

RQ1: What is the Level of Awareness and Knowledge Concerning Sorghum among US Consumers?

RQ2: At what Level of Importance do US Consumers hold for Common Perceived Benefits of Consuming Sorghum?

RQ3: What is the Pervasiveness of Stigmas to Consuming Sorghum for US Consumers?

RQ4: What Opportunities Exist for Increasing Food Grade Sorghum Consumption in the US and what Marketing Strategies can be Employed to Achieve this?

Limitations

The author identifies that the findings of this study must be seen in light of some limitations. First, the sample size was limited due to budgetary restraints and available

funding. While the researcher felt that the number of responses was sufficient in representing the target population, having more responses would result in a more robust data set. Also, in utilization of Qualtrics XM research services, a non-probability convenience sampling procedure was used (Qualtrics, 2023). While the sample was demographically diverse, this aspect could present challenges in generalizing the responses from the available sample to the larger target population.

Additionally, there is a limitation due to the lack of previous research specifically addressing barriers and stigmas to US consumers concerning the consumption of sorghum and sorghum products (Stefoska-Needham & Tapsell, 2020). While the author based this research on previous studies, there could be additional reasons as to why consumers would or would not be persuaded to adopt human consumption of sorghum that were not addressed during this research.

It is also identified that the timeline of the study presents a limitation to the research. For example, the data were collected in January 2023, factors such as changing inflation rates and other evolving economic factors which could have impacted participant responses were not addressed. Also, the research was conducted with time constraints due to academic deadlines.

Assumptions

Several assumptions were present in the execution of this research study. It was assumed that respondents answered the questions on the survey instrument thoughtfully, honestly, and free from cultural or personal bias. It was also assumed that participants would have experience and opinion towards grocery purchasing decisions.

It was also assumed that respondents were able to communicate effectively using the English language. The survey instrument was not offered in other languages to cater to non-English speaking participants.

Definition of Terms

The terms listed are important to understand while reviewing this study. For the purpose of this study, the following terms were operationally defined as listed below.

Alimentary - Relating to nourishment or sustenance.

Anthocyanins - Also called anthocyanins, are water-soluble vacuolar pigments that, depending on their pH, may appear red, purple, blue, or black.

Antinutrients - Are natural or synthetic compounds that interfere with the absorption of nutrients. Nutrition studies focus on antinutrients commonly found in food sources and beverages. Antinutrients may take the form of drugs, chemicals that naturally occur in food sources, proteins, or overconsumption of nutrients themselves.

Antioxidants - A substance such as vitamin C or E that removes potentially damaging oxidizing agents in a living organism.

Aridization - The gradual change of a region from a wetter to a drier climate.

Biomass - The total mass of organisms in a given area or volume.

C4 grass - Warm-season grasses are known as C4 Plants. This is because they use the four-carbon compound called PEP carboxylase in photosynthesis. In grasses PEP carboxylase is a photosynthetic enzyme that can “attract” CO₂ more efficiently than C3 plants and allows the stomates of the plant to be closed more often.

Decortication - The removal of the cortex, the enveloping membrane, or a fibrinous covering from an organ or structure.

Efficacy - The ability to produce a desired or intended result.

Evapotranspiration - The process by which water is transferred from the land to the atmosphere by evaporation from the soil and other surfaces and by transpiration from plants.

Fermentation - The chemical breakdown of a substance by bacteria, yeasts, or other microorganisms, typically involving effervescence and the giving off of heat.

Fodder - Food, especially dried hay or feed, for cattle and other livestock.

Genetically Modified Organism (GMO) - An organism whose genome has been engineered in the laboratory in order to favor the expression of desired physiological traits or the generation of desired biological products.

Gluten - A substance present in cereal grains, especially wheat, that is responsible for the elastic texture of dough. A mixture of two proteins, it causes illness in people with celiac disease.

Hectare - A metric unit of square measure, equal to 100 acres (2.471 acres or 10,000 square meters).

Hindrances - A thing that provides resistance, delay, or obstruction to something or someone.

Pasteurization - The partial sterilization of a product, such as milk or wine, to make it safe for consumption and improve its keeping quality.

Phenolic Acid - A phenolic acid is a type of phytochemical called polyphenol.

Phytochemicals - Any of various biologically active compounds found in plants.

Phytosterols - Are a family of molecules related to cholesterol. They're found naturally in a variety of plants. Like cholesterol, they're a key structural component of cell membranes.

Polycosanols - A mixture of primary aliphatic alcohols derived chiefly from the waxy coating of sugarcane that is used especially as a dietary supplement to lower cholesterol levels though of uncertain effectiveness.

Porridge - A dish consisting of oatmeal, or another meal or cereal boiled in water or milk.

Stigmas - A mark of disgrace associated with a particular circumstance, quality, or person.

Sustainability - Avoidance of the depletion of natural resources in order to maintain an ecological balance.

Tannins - A yellowish or brownish bitter-tasting organic substance present in some galls, barks, and other plant tissues, consisting of derivatives of gallic acid, used in leather production and ink manufacture.

Urbanization - The process of making an area more urban.

CHAPTER II

REVIEW OF LITERATURE

Introduction

Sorghum is a major cereal grain crop which is also known as “milo” in some regions of the United States (Stroade, Boland, Huntrods, & Taylor, 2022). The major global sorghum growing regions include the US, India, Argentina, Mexico, Africa, China, and Australia (Arendt & Zannini, 2013). It is noted that sorghum is the fifth most important cereal crop in the world behind wheat, rice, corn, and barley (Awika & Rooney, 2004). Sorghum is a useful crop being that it has multiple and diversified end uses as food, feed, fodder, fiber, and fuel (Venkateswaran, Elangovan, & Sivaraj, 2019). Much like rice and maize, sorghum is a C4 (warm season) cereal grass and belongs to the family *Gramineae*, subfamily *Panicoideae* and the tribe *Andropogoneae* (Smith & Fredricksen, 2000). There are three different species of sorghum: *S. Halapense*, *S. propinquum* and *S. bicolor*. *S.bicolor* Is further divided into three subspecies; *S. bicolor bicolor*, *S. bicolor drummondii* and *S. bicolor verticilliflorum*. All cultivated sorghums are of the sub species *S. bicolor* (Smith & Fredricksen, 2000).

Humans have domesticated sorghum, leading to its diversification for various purposes, such as a source of sugar, a building material, a raw material for household items, and an industrial raw material (Smith & Fredricksen, 2000). The different cultivars of sorghum grain that are cultivated in modern times reflect this and are very diverse in their appearance. These crops vary in color and height, and they have multiple and diversified end uses (Norton et al., 2007). Sorghum cultivated for its grain tends to be shorter and have a larger panicle (Smith & Fredricksen, 2000). These characteristics aid

in maximizing yield as well as convenience of mechanical harvest. Forage sorghums are taller and have more leaves, this is advantageous in maximizing the amount of biomass for feed production (Norton et al., 2007). There are also sweet sorghums with large stems that are harvested and the fructose containing sweet juices are extracted for the manufacture of syrups, vinegar, molasses, and other alimentary products (Khoddami et al., 2021).

Sorghum is thought to have its origins in Africa some 3,000-5,000 years ago. (Arendt & Zannini, 2013). It is agreed that *S. bicolor* was originated and cultivated in the Sub-Saharan region of Africa and subsequently spread to India and China (Henzell & Jordan, 2009). The spread and distribution of sorghum has followed the historical movement of people as well as changing global weather patterns (Smith & Fredricksen, 2000). Sorghum has been carried by humans to more than 100 countries in a variety of habitats and environments and today continues to serve as a staple food crop in many parts of the world (Venkateswaran, Elangovan, & Sivaraj, 2019). Nowhere is sorghum more crucial for food security as in the semi-arid tropics, which represent home for billions of people (ICRISAT, 2021).

United States Sorghum Production

Currently there are approximately 700 million hectares of land on the planet where cereal crops are grown. Of that area, 42 million hectares are in sorghum production, 65% of which are in developing countries (Arendt & Zannini, 2013). The US is the number one global sorghum producer, harvesting 8.7 million tons in 2010 (FAO, 2019) This is due to intensive breeding programs, the availability and application of fertilizers, and the advancement of cultivation practices including pest control and seed

bed preparation that have allowed for growers in the US to maximize the attainable yield (Venkateswaran, Elangovan, & Sivaraj, 2019). India and Mexico follow as the next highest sorghum producing countries producing 6.9 million tons each in 2010 (FAO, 2019).

Sorghum may have been initially introduced to the US by Benjamin Franklin, who reportedly grew the crop before the year 1800 (McGinnis & Painter, 2020). Franklin's writings from the year 1757 confirm that he grew broomcorn type sorghum and mentioned its application in the construction of brooms for household use (Venkateswaran, Elangovan, & Sivaraj, 2019). The first sorghum that was grown for agronomic reasons in the US was reported in 1853, this was a sweet sorghum called 'Chinese Amber' which was introduced from France (Venkateswaran, Elangovan, & Sivaraj, 2019). The next sorghum plants grown in the US, were a series of sweet and forage sorghums from China, Africa, and Australia (Smith & Fredricksen, 2000). It wasn't until the slave ships carried the plant over from the West Indies that grain sorghum was introduced into this country (Smith & Fredricksen, 2000). These early grain sorghums had names like "Rural Branching Durra" and "White Milo Maize" but were better recognized by their slang term "Guinea Corn" (Ajeigbe et al., 2020). Unfortunately, sorghum failed to gain a foothold in American agriculture during its early days, leading to its eventual disappearance from production (Smith & Fredricksen, 2000).

Grain sorghum reappeared in California around 1874 (Smith & Fredricksen, 2000). Advances in agricultural technologies and knowledge resulted in sorghum being recognized as a viable and efficient drought-tolerant crop that would outperform corn and other grains in arid regions of the country (Assefa et al., 2014). Scientists with the USDA

and the Texas Agricultural Experiment Station began selecting cultivars to be grown in dry and harsh environments found in the southern Great Plains (Smith & Fredricksen, 2000).

Today sorghum is grown in more than 30 states with the top producer being Kansas, followed by Texas, Oklahoma, Colorado, and South Dakota (Venkateswaran, Elangovan, & Sivaraj, 2019). Approximately one-third to half of all sorghum produced in the US is exported to other countries. The remainder is used as animal feed, in the production of fuel (ethanol), and as a raw ingredient in industrial products (Nanjundaswamy, Praveen, Vadlani, & Prasad, 2011).

Global Human Consumption of Sorghum

Although sorghum has yet to be popularized in the US for human consumption, it has been and continues to be utilized in many other regions of the globe (Awika & Rooney, 2004). Possibly owing to its African origins, sorghum products are consumed more in Africa than any other region in the world (Awika & Rooney, 2004). Instant beer powder, cracked or coarsely ground malt, shelf stable opaque beer, and a variety of meals, rice-like products, and sorghum flour are all available commercially in southern Africa (Rooney & Waniska, 2000).

Porridges are a popular food that is made with sorghum, and different versions make up traditional fare across Africa (Khoddami et al., 2021). There are thick porridges that are consumed with a sauce containing tomato, okra or chilies, cow pea leaves, cow peas, and Amaranthus (Ratnavathi & Patil, 2013). Then there are thin porridges that are made from sorghum and served for breakfast or to lactating mothers and young children (Arendt & Zannini, 2013). Vita-Malt in Nigeria, and Maltabella in South Africa are

commercial, ready-to-cook breakfast foods made from malted sorghum (Smith & Fredricksen, 2000). In researching the sorghum porridges of Africa, we found many different names for basically the same dish. There is ogi, jowar, upma, ugali, sima, vhuswa, bogobe, fufu, gauli, gima, isitshwala, kimnyet, kuon, mieliepap, ngima, hshima obokima, and ovuchima just to name a few (ICRISAT, 2004).

Another popular use of sorghum in Africa is as an ingredient in many region-specific opaque beers (Ratnavathi & Patil, 2013). The sorghum-based beers are produced using malted sorghum and unmalted maize, and they differ significantly from the typical clear lager beers (Khoddami et al., 2021). In contrast to European-style beer, the opaque sorghum beers lack hops, are usually unpasteurized, and are consumed while still actively fermenting (Donini, 2003). Much like porridge, we find many different names for essentially the same beverage. Some of these would include ioala (South Sotho-Lesotho), bjwala (Pedi-South Africa), oruramba (Uganda) (Taylor & Duodu, 2019). Other names for these sorghum beers, include marisa, busaa, merrisa, urwaga, mwenge, munkoyo, bantu beer, kaffir beer, utshwala, utywala, and ikigage (ICRISAT, 2004).

Sorghum products are not only utilized in Africa, two similar products which are popular outside of Africa are unfermented flat breads including roti (India), and tortillas (Mexico) (Ratnavathi & Patil, 2013). With proper preparation, sorghum can partially or entirely replace yellow maize in the production of tortillas (Arendt & Zannini, 2013). In North Africa, sorghum flour is used in popular fermented breads such as injera in Ethiopia, and kisra in Sudan (Ratnavathi & Patil, 2013). Kisra constitutes the staple diet of the Sudanese population (Arendt & Zannini, 2013). Sorghum and wheat flour blends have been used to produce many baked products, including yeast leavened pan, hearth

and flat breads, cakes, muffins, cookies, biscuits, flour tortillas, and others (Xiong, Zhang, Warner, & Fang, 2019).

Sorghum has been used in the preparation of Chinese egg noodles and in Southeast Asia, it is used in making traditional noodles and related products (Ratnavathi & Patil, 2013). In China and Taiwan, sorghum wine, (Moutai or Maotai) are produced from fermented sorghum grain (Xiong, Zhang, Warner, & Fang, 2019) Due to the high value of alcohol distilled from sorghum, it is not uncommon to find sorghum-based alcohol used in the production of gin, whiskey, vodka, and other distilled beverages in these areas (Smith & Fredricksen, 2000). The most prolific of spirits made from sorghum is baijiu (Fan, Xu, & Huang, 2014). This colorless drink is the national liquor of China and has been for at least the last 2,000 years (Wu et al., 2022) At production exceeding 12 million metric tons per year (Zheng & Han, 2016), baijiu is a culturally essential beverage that is frequently consumed at festivals and social gatherings (Wu et al., 2022). For the people of China, baijiu holds significant emotional value, as it is not only a food item, but also a cultural heritage (Zheng & Han, 2016). To put this into perspective, the average person in China consumes 9.43 liters per year of the spirit (Fan, Xu, & Huang, 2014). In comparison, the average drinking volume of all alcoholic spirits by consumers in the US is 8.2 liters per year (Statista, 2023).

Sorghum Consumption Human Health Benefits

The literature identifies several different qualities of the sorghum grain that have the potential to be beneficial to the human body. First, sorghum has a high nutritional value, one serving of sorghum (one cup) contains 22 grams of protein, this is 43% of the daily recommended intake. A serving also contains 47% of the recommended level of

iron, 55% of phosphorous, and 30% of niacin and thiamin which are B-vitamins that help the body to metabolize and properly absorb carbohydrates and nutrients (Ratnavathi & Patil, 2013).

Sorghum is also a gluten free grain, the lack of gluten is an advantage in a niche marketing strategy, targeting people who are gluten intolerant (Stroade, Boland, Huntrods, & Taylor, 2022). This makes it an ideal alternative food for individuals suffering from Celiac disease (CD) (Pontieri et al., 2013). CD, an autoimmune disorder of the small intestine, and is activated in individuals with genetic susceptibility upon consumption of gluten, a protein present in wheat, rye, and barley (Green & Cellier, 2007; Freeman et al., 2011). For individuals with CD, failing to observe a strict gluten-free diet may lead to disease complications and even death (Viljamaa et al., 2006). Research has shown that many people who should follow a diet free from gluten often do not (Butterworth et al., 2004). It is reported by patients (Verrill et al., 2013) that it is not easy to avoid gluten, which is found in many packaged processed foods, as well as in some medicines and dietary supplements. In a study by (Roma et al., 2010), 58% of respondents report that lack of gluten free options in the grocery store contributes to non-adherence to prescribed diets. Most gluten is found in products that are produced with wheat (Xiong, Zhang, Warner, & Fang, 2019). This has become such an issue that the Food and Drug Administration (FDA) requires foods containing wheat to be labeled as such. This is in adherence to the Food Labeling and Consumer Protection Act (FALCPA) of 2004. FALCPA identifies wheat as a ‘major food allergen’ but the other grains that contain gluten do not require labeling.

High levels of antioxidants (phytochemicals) are found in the bran layer of the sorghum kernel, more so than fruits that we associate with being high in antioxidants such as blueberries, strawberries, and plums (Xiong, Zhang, Warner, & Fang, 2019). Antioxidants are beneficial to the human body because they are known to slow down aging, they also lower the risk of heart disease, cancer, type 2 diabetes, and neurological disorders (Punia et al., 2021).

Sorghum is also very high in fiber; this helps to improve digestive health. (Stefoska-Needham, Beck, Johnson, & Tapsell, 2015). These antinutritional factors such as polyphenolic compounds, are concentrated in the pigmented testa layer of the sorghum kernel (Khoddami et al., 2021). These compounds are able to bind dietary proteins, digestive enzymes, minerals, and vitamins (Xiong, Zhang, Warner, & Fang, 2019), thus rendering them unavailable for mammalian assimilation in the gut. Much of the sorghum grain that is produced for human consumption internationally is used to aid digestion and relieve human constipation (Awika & Rooney, 2004).

Environmental Benefits of Sorghum

Sorghum production has environmental benefits, mainly due to its climate-resilience and drought-tolerant qualities (Venkateswaran, Elangovan, & Sivaraj, 2019). These traits give sorghum the ability to be cultivated in places where other grains would struggle (Arendt & Zannini, 2013). While this research is concerned with the human consumption aspects of sorghum, the evolving value drivers in the food value equation show us that environmental and sustainability features of products are becoming increasingly important to the average US consumer (Renner & Ringquist, 2016).

Corn and sorghum are two very different crops, and the comparisons made between the two are due to them having similar end uses. Despite appearing to compete for summer cropping area, corn and sorghum utilize different parts of the season and should therefore be viewed as alternative crops to maximize the use of diverse environmental conditions (Assefa et al., 2014).

Crop resource use efficiency is defined as the ratio of crop output to resource input (Assefa et al., 2014). The resources that are referred to include land, water, fertilizer, and pesticides. EPA.gov defines drought as a prolonged period of dry weather caused by a lack of precipitation that results in a serious water shortage for some activity, population, or ecological system. As of July 2022, 44.98% of US land area is experiencing drought conditions (NIDIS, 2023). Drought has become a serious issue that US producers have been battling in recent years. Between the years of 2000-2020 some 20%-70% of US land area has experienced conditions that were at least abnormally dry at any given time (NIDIS, 2023). Because sorghum is less sensitive to environmental variation, it has an advantage over corn for US farmers (Hamman, Luther, Kansas, & Boland, 2023).

Specifically comparing sorghum to corn, and looking at land use efficiency, research has concluded that under the same conditions if expected grain yield is above six Mg/ha-1 then corn is more efficient than sorghum. If yields are below the above cutoff point, then planting sorghum is a better use of the land (Assefa et al., 2014). When comparing sorghum and corn in terms of water use efficiency we look at evapotranspiration (ET) rates to make the comparison. ET is defined as the process by which water is transferred from the land to the atmosphere by evaporation from the soil

and other surfaces and by transpiration by plants (Oxford). The research has determined that the cutoff between sorghum and corn is 533mm of ET (Assefa et al., 2014), meaning that corn is the more efficient crop as long as the ET rates are below 533mm, and anything above that, sorghum outperforms corn. In terms of rainfall use efficiency, the cutoff is 432mm of total seasonal rainfall (Assefa et al., 2014). This means that in areas that experience at least 432mm of seasonal rainfall, corn yields more grain than sorghum. In areas that do not get that much precipitation, planting sorghum will result in a higher grain yield at harvest. Fertilizer is also a consideration when discussing crop resource use efficiency (Hamman, Luther, Kansas, & Boland, 2023). Corn and sorghum are very similar in reference to fertilizer requirements and research has shown that corn actually responds better than sorghum to fertilizer nutrient amendments under ideal conditions (Assefa et al., 2014).

Consumer Food Choices

Understanding consumer food choices in today's society tends to be complicated and must consider multiple aspects to achieve a comprehensive view (Chen & Antonelli, 2020). The choices that consumers make have changed over time and continue to evolve (Renner & Ringquist, 2016). The Deloitte report identifies the changing factors as "evolving value drivers" and when combined with "traditional value drivers" it makes up the 'food value equation' (Renner & Ringquist, 2016). Food environments also influence consumer choices. Food environments are defined as a collective physical, economic, policy, and sociocultural surroundings that influence food choice and nutritional status (Swinburn et al., 2013).

In modern times, the average US consumer is more concerned about living a healthy lifestyle, and the relationship between a healthy existence and food choices is becoming increasingly significant (Steinhauser & Hamm, 2018). These changes are more visible in Western society, as there are still 690 million people worldwide who struggle with hunger, most of which are in developing countries (Global Nutrition Report, 2020). To complicate this global issue, it is predicted that food insecurity is expected to worsen due to the COVID-19 pandemic (Chen & Antonelli, 2020). Even though most people who experience hunger live outside the US, this country still has 34 million people, nine million of which are children that are classified by the USDA as “food insecure” (Coleman-Jensen, Rabbit, Gregory, & Singh, 2022).

Predominantly in the developed world, we are also experiencing the issue of obesity (Global Nutrition Report, 2020). Currently there are approximately 677.6 million people, which is approximately 13.1% of the world population, who are classified as “obese”. This phenomenon is largely due to unhealthy diets (Global Nutrition Report, 2020). The increase in unhealthy diets has been attributed to the worldwide increase in urbanization (Chen & Antonelli, 2020). Consumers are increasingly consuming animal proteins and processed foods while reducing their intake of minimally processed foods such as whole grains, legumes, and other high-fiber foods (McMichael, Powles, Butler, & Uauy, 2007). Additionally, research has identified that eating patterns and food choices tend to change in accordance with global food systems (Jacka, Sacks, Berk, & Allender, 2014) and food supply (Zobel, 2016).

The consumer of today is concerned with environmental issues more than ever before, as we are seeing the effects of our booming population on the earth (Grunert,

2011). Food production accounts for 37% of greenhouse gases emitted into the atmosphere, this release of pollution can be mitigated in part by the consumer and the foods they choose to consume (Shukla et al., 2019). Further emphasizing this point, reduced consumption of discretionary products such as oils and sugars would reduce land use, emissions, and freshwater withdrawals (Poore & Nemecek, 2018). Recent research has suggested the importance of individual food choices in decreasing these nutritional and environmental crises (Joyce, Dixon & Comfort, 2012; Lartey et al., 2016; Willet et al., 2019).

Individual food choices most often change when one's personal circumstances change. These changes often include things like a change in the natural environment, change based on a biological basis, change due to physical need, a lifestyle change, or the introduction of new technology (Montanari & Sonnenfeld, 2006). The literature identified five different factors that influence consumer food choices (Chen & Antonelli, 2020).

1. Food Internal Factors- sensory and perceptual
2. Food External Factors- information, social environment, and physical environment
3. Personal State Factors- biological features, physical needs, and psychological components including habit and experience.
4. Cognitive Factors- knowledge, skills, attitude, preference, anticipated consequences, and personal identity
5. Sociocultural Factors- culture, economic variables, and political elements

Food internal factors refer to the characteristics of food that are intrinsic to the food itself, such as sensory and perceptual attributes (Chen & Antonelli, 2020). These factors play a crucial role in shaping food choices, they affect preferences by influencing the way food is perceived by the individual.

Sensory factors refer to the physical attributes of food, such as taste, texture, and smell. For example, sweetness, bitterness, and sourness are sensory attributes that can influence food preferences. The perceptual factors refer to how food is perceived by the individual in terms of its appearance, shape, size, and color (Chen & Antonelli, 2020).

Food external factors refer to the external influences that shape food choices and preferences, such as information, social environment, and physical environment. These factors play a crucial role in shaping food choices by affecting the way food is perceived, evaluated, and ultimately selected by the individual (Chen & Antonelli, 2020).

These factors can impact food choices by shaping individual preferences, attitudes, and beliefs about food (Chen & Antonelli, 2020). For example, changes in the natural environment, such as a shift in local food availability, can affect food choices by making certain food products more or less accessible (Sobal & Bisogni, 2009). Similarly, lifestyle changes, such as a change in diet for health reasons, can also impact food choices (Steinhauser & Hamm, 2018).

Overall, changes in personal circumstances can play a significant role in shaping individual food choices (Montanari & Sonnenfeld, 2006). By understanding the various factors that influence food choices, researchers and policy makers can better understand

and address the factors that drive food choice decisions and develop strategies to promote healthy and sustainable food choices (Bisogni, Falk, & Madore, 2006)

Theoretical Framework

This research is an attempt to better understand why consumers in the US have yet to popularize a consumable resource that is currently and commonly utilized in other parts of the world. Researchers in a variety of disciplines including social and behavioral sciences have tried to explain why humans react and behave the way they do (Bosnjak, Ajzen, & Schmidt, 2020).

This study is theoretically guided by the Theory of Planned Behavior (TPB). This theoretical framework is a psychological theory that helps to explain how a person's beliefs shape their behavior (Clough & Casey, 2011). TPB has evolved from earlier works by researchers who wanted to predict human behavior (Shaw, 2016). TPB has been utilized for research to predict health behaviors such as diet (White et al., 2010), child immunization rates (Tickner, Leman, & Woodcock, 2010), and smoking behaviors (Nehl et al., 2009). TPB has been used to guide previous research studies in agriculture and agricultural education related studies (Hansson et al., 2013). Most notably in research concerning the adoption of conservation practices (Chaudhary, Gosavi, & Durve, 2017), and agriculture innovation technologies (Senger, Borges, & Machado, 2017; Dessart, Barreiro-Hurlé, & Van Bavel, 2019). The accuracy and efficacy of TPB has been evaluated and supported by empirical studies (Armitage & Talibudeen, 2010) and a meta-analysis (Armitage & Conner, 2001).

In 1971, Norman Anderson introduced the Information Integration Theory. Anderson's theory described how a mixture of new information combined with existing

thoughts and cognitions results in a change in a person's beliefs and attitudes (Luenendonk, 2019). Anderson presented that humans have positive or negative attitudes toward a certain subject, but these viewpoints can change when presented with new information (Hagger, 2019). This change takes place by the individual being presented with new information, which they compare and combine with their existing knowledge (Kan & Fabrigar, 2017). This integration of information has the power to completely erase the current attitude and pave the way for a new viewpoint (Ajzen & Fishbein, 2005).

In 1980, social psychologists Martin Fishbein and Icek Ajzen introduced the TPB which built on and enhanced Anderson's Information Integration Theory by including the concepts of "perceived behavioral control" and "behavioral intent" (Hagger, 2019). This adds to the concept by explaining that behavior is affected and influenced not only by perceptions and attitudes but also by the individual's expectation or expected outcomes (Clough & Casey, 2011). This theory has greatly contributed to such fields as advertising, public relations, healthcare, sports management, and sustainability (Zhang, 2018). Ajzen initially introduced the TBP in his book chapter titled "From Intention to Actions: A Theory of Planned Behavior" which was published in 1985 (Luenendonk, 2019).

TPB consists of three key variables: behavioral beliefs, normative beliefs, and control beliefs (Phelps et al, 2020). There are both internal and external factors involved in the establishment of these beliefs (Brookes, 2021). These three aspects are considered by an individual and then an intention is created. It is this intention that leads to the actual behavior or change in behavior (Shaw, 2016).

Behavioral Beliefs

Behavioral beliefs are described as an individual's personal perception of a subject, action, or behavior (Kan & Fabrigar, 2017). Basically, it solicits the realization of "what do I think about this" (Brookes, 2021). There are multiple sources of influence that can potentially steer a person's normative beliefs. These can include, but are not limited to, an individual's values and morals, which are commonly instilled by parents, guardians, or other influential characters during one's upbringing (Kan & Fabrigar, 2017). Influence also comes from education, religious ideals, as well as environmental sources (Ajzen & Fishbein, 2005). Behavioral beliefs have a direct influence on a person's attitude toward a behavior (Bosnjak, Ajzen, & Schmidt, 2020). Considering the end outcome is a positive and favorable one, the likelihood of actual performance is increased (Hagger, 2019).

Normative Beliefs

Normative beliefs are established when the individual considers the beliefs and opinions of the people around them, and/or the persons or groups that influence them (Bosnjak, Ajzen, & Schmidt, 2020). It can be thought of as one asking themselves "what do others think about this" (Luenendonk, 2019). There are many influences that are at play here and are considered during the establishment of this belief (Kan & Fabrigar, 2017). The perception, stance, or point of view of people, or groups of people that a person identifies with are used to establish normative beliefs (Brookes, 2021). These can include political groups, friends or peers and other social groups. If the individual determines that others find an idea favorable or beneficial then they are more likely to adopt the idea (Hagger, 2019).

Control Beliefs

Control beliefs involve the consideration by the individual concerning the procedural actions or feasibility of the action or behavior (Bosnjak, Ajzen, & Schmidt, 2020). Simply put, control beliefs involve the individual considering if an action can be carried out, and perceived behavioral control is the consideration of how difficult it is to carry out (Venkatesh, Morris, Davis, & Davis, 2003). This is the person considering their self-efficacy or asking themselves “can I do this” or “how hard will this be” (Luenendonk, 2019). Control beliefs have control factors that are considered, and impact how the behavior or action will ultimately turn out (Armitage & Christian, 2003). These control factors can include things like policy or laws that can affect the action or the result of the action or behavior (Zhang, 2018). What is considered during this stage is if the action is against the law, a policy, or otherwise prohibited for any reason. This is different from normative beliefs, or what other people think because it is established that this action will come with actual negative consequences and not just the disapproval of others (Zhang, 2018). Other control factors can include such concepts as self-efficacy, and if the action or behavior has been successfully executed by others (Venkatesh, Morris, Davis, & Davis, 2003). Control factors also solicit the question if the idea or behavior is available to the individual or not (Luenendonk, 2019).

Application of Theoretical Framework

Adhering to the concepts presented in TPB, this research study was able to explore the thought process that is potentially being applied by consumers when they are considering if sorghum product consumption is a behavior they should adopt or not. In applying these concepts to the study, it was the three belief categories that shaped the

development of the questions in the survey instrument (Bosnjak, Ajzen, & Schmidt, 2020). In order to avoid asking random questions related to sorghum consumption and grocery buying behavior, the questions were categorized by the corresponding TPB concepts (Senger, Borges, & Machado, 2017). This was crucial in that the study sought to gain a comprehensive understanding of the factors present that are contributing to the reasons and barriers preventing the popularization of consumption of sorghum and sorghum products by consumers in the US.

In respect to behavioral beliefs, questions solicited responses that required respondents to consider what they specifically thought about human sorghum consumption (Kan & Fabrigar, 2017). These would include concepts such as the health benefits of sorghum and how this practice could address their pre-existing dietary requirements and those of whom they are responsible for providing for.

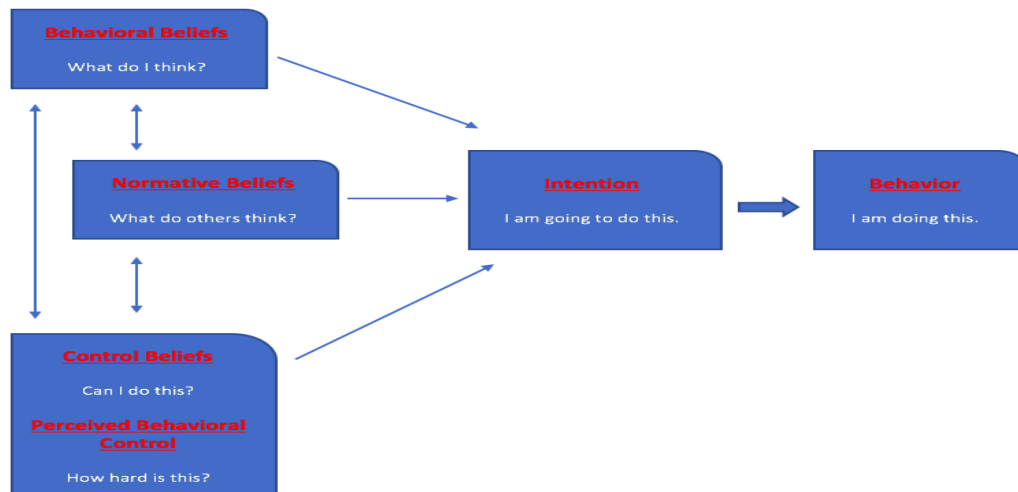
Also applied were concepts related to normative beliefs, as humans are social animals, what others think is engrained into our thought and decision-making processes (Luenendonk, 2019). In addition to considering what is best for us, we also consider what is beneficial to others and society. This is important to consider that modern consumers have added new considerations in their consumption and grocery buying behaviors (Renner & Ringquist, 2016). While the environmental and sustainability benefits could be argued as being able to be classified as pertaining to either behavioral beliefs or normative beliefs, the researcher classified the environmental beliefs as normative. This was done in the idea that consumers want to contribute to a healthy environment for the benefit of not only themselves but for society as a whole and for future generations. The consumer is not only considering what is good for themselves, they are also taking into

account the opinions and well-being of those around them. The factors considered when inquiring about the respondents’ normative beliefs, were the environmental and sustainability benefits of sorghum as well as the general familiarity and knowledge of others consuming this resource.

Questions included in the survey instrument which could be categorized as pertaining to control beliefs were those inquiring about the aspects of sorghum consumption regarding the availability of sorghum products at local retailers and the price/ value of those items. These are important, because if consumers cannot find these products for sale especially at a price point that is acceptable to them, then all the behavioral and normative beliefs become irrelevant (Brookes, 2021).

Overall, the TPB framework was useful in guiding the study's research questions and survey design, as well as in analyzing the results. The study was able to identify key factors influencing consumers' attitudes and intentions towards sorghum consumption, which could inform future efforts to promote and popularize sorghum as a sustainable and nutritious food source in the US.

Figure 2.1. *Theory of Planned Behavior Flow Chart*



CHAPTER III

METHODOLOGY

Overview

Although several studies were reviewed that involved the assessment of sorghum consumption behavior, (Kane-Potaka et al., 2021; Nambiar & Patwardhan, 2014), limited research was found to assess these behaviors among consumers in the United States. Further, the researcher experienced a lack of research specifically identifying the specific stigmas or reasons that US consumers have yet to popularize this behavior.

Based on the TPB, individuals consider multiple aspects or beliefs in relation to an idea before they develop an intention to adopt or deny the implementation of said action (Luenendonk, 2019). These include behavioral beliefs (what do I think), normative beliefs (what do others think), and control beliefs (is this possible for me to do) (Bosnjak, Ajzen, & Schmidt, 2020). This framework was utilized to create the survey instrument and overall guidance of this research.

Following this theoretical framework, we conducted an observational study to examine the level of consumer knowledge toward sorghum, and sorghum consumption, as well as if certain pre-conceived ideas would hinder consumers from consuming sorghum, and sorghum-based products. We also examined which benefits of sorghum consumption were thought to be most important to consumers. Further questions were asked to determine dietary challenges that are faced in the households of respondents.

This chapter of the dissertation explains the procedures taken during the implementation of this research study. The chapter will focus on the guiding research questions, the research design used in the study, as well as the identification of the study

sample, instrumentation, data collection procedures, and data analysis. This project was supported by the Department of Agricultural Education and Communications at Texas Tech University. This research was submitted to and approved by the Institutional Review Board at Texas Tech University. Documentation of IRB approval is provided in (Appendix A).

Research Design

To answer the research questions presented in this study, a survey instrument was constructed to measure levels of knowledge, attitudes, and opinions on sorghum grain consumption behavior among the target population. The target population was grocery buyers over the age of 25, within the US.

In this study three categories of sorghum consumption benefits were presented, these include perceived health benefits, environmental benefits, and benefits regarding the availability of sorghum grain in the US (Stefoska-Needham & Tapsell, 2020). Additionally, six commonly assumed negative aspects of sorghum consumption were presented to measure their level of impact among consumers (Kane-Potaka et al., 2021). These negatives consisted of the idea that consumers did not know that sorghum was suitable to eat, sorghum is mainly consumed by people in developing countries, sorghum is commonly consumed by livestock in the US, sorghum competes with corn, sorghum is used in the manufacture of fuels, and the fact that there is a lack of products made with sorghum available to purchase in grocery stores (Kane-Potaka et al., 2021).

Population and Sample

Non-probability convenience sampling (Jager et al., 2017), was employed by Qualtrics XM Research Service staff to identify participants which met the target

demographics of the study (Qualtrics, 2023). Convenience sampling is a method of selecting participants for research studies based on how easily accessible or available they are (Jager et al., 2017). The researcher chooses participants who are convenient for them to reach, instead of selecting a sample that is representative or randomly selected from the population. Respondents were selected based upon their self-identification and adherence to the selection criteria, as well as accessibility and availability (Qualtrics, 2023). The target population for this research was consumers over the age of 25, that are responsible for making grocery buying decisions, and that live within the US. Upon confirmation of eligibility, participants were able to locate and complete the survey instrument online. Participants were provided with a standard script and informational introduction sheet that was approved by the Institutional Review Board at Texas Tech University (Appendix A).

Respondents were compensated monetarily, at a rate determined by Qualtrics XM Research Service policy and procedure (Qualtrics, 2023). A total of 1,936 responses were gathered; post data scrubbing found 670 usable responses for analysis in the study. Incomplete responses were removed from the sample.

Qualtrics XM is an online survey and research platform that collects data by recruitment and compensation of participants for purposes of data collection. It is widely used in various industries for conducting surveys and market research studies (Qualtrics, 2023). Qualtrics XM provides an efficient and reliable way to collect data from a large number of participants and provides researchers with a wealth of information to analyze and draw insights from (Qualtrics, 2023).

Instrumentation

Data collection was achieved by conducting a survey questionnaire to record existing knowledge, possible inhibitions to adoption, and purchasing habits of consumers (Appendix C). Questionnaires that measure beliefs, reasons, and barriers regarding purchasing and consumption behaviors are commonly used in food choice research (Roche et al., 2012; Irianto, 2017). The survey instrument was created using Qualtrics XM survey builder software (Qualtrics, 2023). The survey included 24 questions, all of which were created by the researcher. The instrument was initially pilot tested by distributing it to approximately 20 graduate students at Texas Tech University. Pilot testing was done to validate and identify problems concerning the content, as well as comprehensiveness of the questions (Kane-Potaka et al., 2021). No visual aids were used in the survey instrument.

In order to obtain an accurate representation of the participants' attitudes and beliefs, questions were carefully chosen to reflect the key components of the TPB (Bosnjak, Ajzen, & Schmidt, 2020). Questions solicited responses which spanned normative beliefs, subjective beliefs, and control beliefs (Luenendonk, 2019). The survey instrument was designed to be user-friendly and easy to understand, with an average completion time of six minutes and 13 seconds. This was to ensure that the respondents were able to provide meaningful and accurate responses without feeling overwhelmed or frustrated.

Respondent participation in the survey was voluntary and anonymous. This ensured that the respondents felt comfortable providing honest and accurate responses, without any fear of consequences or judgment (Qualtrics, 2023). The anonymous nature

of the survey also prevented any potential biases from affecting the results. Participants were given a brief explanation of the purpose of the study, as well as a general definition of what sorghum grain is. The use of the data was explained to participants, to be solely used for statistical analysis, further guaranteeing confidentiality.

The initial questions of the instrument measured the demographic characteristics of the respondents. The specific demographics which were of concern were age, ethnicity, gender, marital and parental status, income level, and political stance. Also included in the demographics segment were questions designed to get an idea of the regional and housing characteristics of participants. These questions asked respondents to identify the region of the US that they reside in, and more specifically, which US state they were in. Due to the mention of urbanization, the researcher also asked a question to determine the relative housing setting of participants. The three available responses for the housing question included “city/ urban,” “suburban,” and “rural.”

The following questions were designed to measure the level of sorghum knowledge that each respondent had prior to taking this survey. The first question was meant to measure knowledge and awareness and asked, “Prior to taking this survey, had you ever heard of sorghum?” This initial question offered an idea of the broad level of knowledge and awareness that participants had coming into the responding of this instrument. It was expected that the knowledge level would be low, the responses confirmed this and offered a specific representation of how low these levels were reported by participants.

Questions were then asked to measure existing sorghum consumption utilization knowledge and identification of the sorghum crop. The researcher determined that these

questions would offer an insight into the relative knowledge of how sorghum is used by humans both domestically and internationally. This was a series of three questions that solicited a yes or no response. The first question asked, “Have you ever seen sorghum/milo growing in the field?” Followed by “Do you know what sorghum grain is used for in the United States?” The last question included in this series asked, “Do you know what sorghum grain is used for in other parts of the world?”

To further our measurement of existing knowledge and awareness of sorghum grain consumption the next question asked if participants had actually ever consumed sorghum and listed responses which also indicated how often the individual had eaten sorghum if they in fact ever had. The question asked, “Have you ever consumed sorghum as a food ingredient?” This question offered response options that also gave a relative idea of the frequency of the consumption habits if it was indicated that they had consumed sorghum.

Respondents were presented with positive aspects of sorghum and asked to rank which aspects had the most/least impact concerning their grocery buying decisions. This question was included to measure the potential of sorghum grain in US markets and to give a brief outline of what marketing strategies could be employed to appeal to consumers. Additionally, the survey offered respondents a chance to identify what their major motivations would be to consume sorghum grain as a food item in their household. Potential motivations were asked with the intention of building upon the previous question in that we wanted to explore the potential reasoning that consumers would have towards a hypothetical initial change in grocery purchase and consumption behavior.

Respondents were then presented with common stigmas/negative ideas regarding human consumption of sorghum (Kane-Potaka et al., 2021). They were asked to identify which aspects were most/least likely to influence their decisions by ranking them on a Likert-type scale. In understanding the current state of sorghum consumption behavior, it is significant to identify these possible barriers and to measure the level of influence that each had. Many of the stigmas presented could be of concern due to misinformation their influence could be curbed by clarification through education and outreach efforts.

The next question included in the survey questionnaire identified seven statements which could possibly be included in advertising and labeling of sorghum products. The statements included in the provided responses all represented aspects of sorghum grain that consumers might find attractive when shopping for these products. Respondents were prompted to report on a Likert scale the likelihood of each statement toward a grocery purchasing selection.

The following question was a rank order question designed to solicit a response from respondents concerning what they are considering when they are comparing similar products to make a decision as to which product would ultimately be purchased. The responses listed included, price/ value, health benefits, the same product you always get (familiarity), you saw it advertised, and environmentally friendly. Participants were asked to report the importance of each aspect in relation to the others by ranking them from most important to least important.

A question was included that asked participants to identify the types of things they specifically avoid when shopping for groceries. Six possible responses were offered, and each response was included because it directly related to aspects of sorghum grain

products. The six items that would potentially be avoided were listed and respondents were prompted to check all that apply. The responses to this question gave insight into what aspects would be advantageous or detrimental if they were added or removed from production practices and marketing efforts.

Procedures

Demographic information collected at the beginning of the instrument was analyzed using descriptive statistics. The results of the demographic information of respondents were displayed in the form of tables with the exception of the political characteristics. Political characteristics were displayed using a pie chart to better visually represent the spread of the respective beliefs. To increase the readability of demographic data the information was broken up into four separate tables including general demographic characteristics, regional characteristics, family characteristics, and region by US state.

Being that the operational questions asked within the survey questionnaire were of differing format, the summary and analysis of each question was considered independently from the others. Questions solicited responses in the form of multiple choice, rank order, Likert-type, check all that apply, and a binary yes or no format.

Questions soliciting a multiple-choice response were analyzed by calculating the percentage of respondents who reported each of the listed responses. This data was displayed using a simple column graph format. Each of the provided responses was listed and represented within these graphs. To provide the specific numerical percentages of these responses the graphs included a data label which was displayed above each of the representative columns.

For the rank order questions a stacked column graph representation was utilized to best display the collected data. Each response to these questions was analyzed and the data was presented by visualizing the percentage of respondents who ranked each response respectively. To alleviate confusion each percentage value for the corresponding response was labeled on the graph and different colors and fill patterns were utilized to differentiate between the stacked responses.

In reference to the Likert type response questions a table format was utilized to display the data. This was done by constructing tables which listed all of the responses and reported the percentage of each response that was reported in relation to the likelihood of each influencing participants. In addition, to further describe this data the mean and standard deviation was calculated and included on each table.

The questions asking respondents to identify what they avoided when making their grocery purchasing decisions, this was measured by a “check all that apply” format. For the purpose of summarization, the data was analyzed by reporting which response choice was indicated in the highest frequency by respondents. A visualization of this data was provided in the form of a bar graph. The bar graph included labels identifying the percentage of respondents who reported that they avoided each of the listed items.

The three questions that measured the ability of respondents to identify if they were knowledgeable concerning the uses of sorghum as well as if they could identify sorghum growing in the field utilized a yes or no response format. To report the findings from these questions the three questions were grouped into a descriptive table and the percentages of both the yes and no responses were reported.

The questions included in the instrument were meant to answer each of the research questions guiding the study. The survey instrument questions utilized to answer the corresponding research questions are displayed in Table 3.1.

Table 3.1 *Survey Instrument Question Utilized to Answer Research Questions*

Research Question	Survey Instrument Question
Research Question #1	<p>Prior to taking this survey, had you ever heard of sorghum?</p> <p>Have you consumed sorghum as a food ingredient?</p> <p>Do you know what sorghum grain is used for in the United States?</p> <p>Do you know what sorghum grain is used for in other parts of the world?</p> <p>Have you ever seen sorghum/ milo growing in the field?</p>
Research Question #2	<p>The following are benefits of eating sorghum grain that have been identified by others. Please rank (drag and drop) these potential benefits of consuming sorghum grain products by what is most important to you.</p>
Research Question #3	<p>Would any of these aspects about sorghum be likely to deter you from purchasing a product made with sorghum?</p>
Research Question #4	<p>What motivates you to use products made with sorghum?</p> <p>Do you avoid any of the following in your diet?</p> <p>Which of these statements are likely to influence your grocery purchasing selections?</p> <p>When you are selecting groceries, which of these criteria are most important/ least important to you?</p>

Data Analysis

Data were cleaned by Qualtrics XM research staff prior to acceptance by the researcher. Data cleaning is an essential step in the research process and is crucial for ensuring the quality and accuracy of research findings (Deshmukh & Wangikar, 2011). In the present study, the Qualtrics XM research staff was responsible for cleaning the data prior to acceptance by the researcher. The initial data collection resulted in 1,963 responses, but some of these responses were incomplete or did not meet the demographic criteria of the study. As a result, the data were scrubbed and only 670 responses were retained for inclusion in the analysis.

The reason for retaining only 670 responses was because of budgetary constraints, and this number of responses was guaranteed by Qualtrics XM Research Services. The number of responses was determined to be the maximum amount available with respect to available funding. This number of responses provided a substantial dataset for the researcher to analyze, and the findings of the study would be representative of the target population. Once the data was scrubbed and organized, it was coded and analyzed using IBM SPSS version 27, which was provided by Texas Tech University. SPSS is a software widely utilized in social sciences for data analysis, offering an array of tools and features to arrange, code, and evaluate data (Kpolovie, 2017).

The researcher utilized descriptive statistics, such as frequency, mean, median and standard deviation to determine the practices and knowledge of the participants. Descriptive statistics are commonly used in social science research to provide an overview of the data, and they provide a summary of the main characteristics of the data, such as the distribution of responses as well as the central tendency of the data (Yellapu,

2018). The survey instrument was approved by the Institutional Review Board at Texas Tech University. Documentation of IRB approval is provided in (Appendix A).

Validity and Reliability

The consistency of measurement is referred to as reliability (Ary et al., 2010). The process of developing a research instrument is a crucial aspect of any study. The validity of the instrument can have a significant impact on the accuracy and reliability of the study's findings (Ary et al., 2010). The researcher recognized this and took steps to ensure that the instrument used in their study was valid and reliable. The survey presented three distinct categories of benefits associated with consuming sorghum and six common negative assumptions about sorghum consumption to assess their impact on consumers. This approach helps to ensure that the survey is measuring the relevant constructs related to sorghum consumption behavior. The study also used a specific target group, individuals in the US who were over the age of 25 and responsible for grocery purchases, to ensure that the survey responses are representative of the relevant population.

To establish validity, the researcher presented the instrument to expert faculty members to evaluate the instrument's content and face validity. The expert review was essential in ensuring that the instrument's questions were relevant, clear, and accurately represented the study's intended population. The expert review helps to guarantee that the instrument comprises an adequate quantity of the content or objectives to be assessed (Ary et al., 2010). Once the instrument passed the expert review, it was tested on graduate students enrolled in the department. This pilot test helped to identify any

potential issues with the instrument, allowing the researchers to make any necessary changes before using it in the actual study.

In order to further ensure the reliability of the survey instrument, IBM SPSS version 27 was used to calculate the Cronbach's Alpha coefficient for questions that were of similar scale and direction. Cronbach's alpha is a measure of reliability that focuses on the internal consistency of a test or scale and is commonly used in the construction and interpretation of psychological tests (Johnson, 2013). A test is considered to have internal consistency when its items are connected to each other and assess the same underlying construct. The purpose of Cronbach's alpha is to determine the degree to which the test items are related to one another and therefore measure the same construct (Johnson, 2013). The analysis produced a Cronbach's Alpha coefficient of 0.852 (sorghum stigmas) and 0.794 (sorghum benefits). Both of the Cronbach's alpha coefficients were greater than 0.75.

To further ensure the validity and reliability of the study, the individuals who participated in the review or pilot test were excluded from taking part in the actual study. This helped to minimize any potential biases that could have arisen from their involvement in the instrument's development.

The investigator's committee also provided feedback on the demographic section of the instrument and how to word the questions to ensure inclusivity, clarity, and relevance to the target population under investigation. This attention to detail in the instrument's development and testing process helped to ensure the study's findings were accurate and reliable.

Description of Participants

The demographic characteristics of the study participants are illustrated in Table 3.2. There were 1,936 individuals that started responding to the online instrument. Incomplete responses were scrubbed, as well as responses from individuals who did not meet the demographic criteria. Post data scrubbing, there was a total of 670 responses which were retained for inclusion in the analysis. Due to budgetary constraints, 670 responses were the number of responses guaranteed by Qualtrics XM Research Services.

Of the 670 responses included in the study 323 (48.1%) were male, while 338 (50.4%) were female. In addition, there were seven (1.0%) respondents that reported their gender as non-binary, and one (0.1%) respondent reported their gender as other. Most respondents were between the ages of 25-40, this age group consisted of 267 (39.8%) participants. The next highest age demographic was 41-55 with 181 (27%) participants. Included were 108 (16.1%) responses from people between the ages of 56-65 and 114 (17.0%) who were older than 66. The race distribution of respondents included 502 (74.8%) who reported as white, 66 (9.8%) who reported as Black/African American, 39 (5.8%) identified as Hispanic, and 23 (3.4%) reported as being of two or more races. There were six (0.9%) who were of American Indian or Alaska Native decent, three (0.4%) reported to be Native Hawaiian or Pacific Islander, three (0.4%) individuals who did not respond to the race question, and two (0.3%) who listed themselves as other.

Participants were then asked to report their income range, the three lower income ranges were distributed relatively evenly among participants with 23.7% ($n = 159$) reporting income of \$30,000 or less per year. Then 23.4% ($n = 157$) made up the income bracket between \$31,000-\$50,000 dollars per year and 25.9% ($n = 174$) were between

\$51,000 and \$80,000. As income increased to \$81,000-\$100,000 there were less, with 9.2% ($n=62$), the next bracket spanned from \$101,000-\$150,000 and was reported by 11.5% ($n = 77$) of respondents. There were also 6.1% ($n = 41$) who made \$151,000 or over. The demographic characteristics of the study participants are provided in Table 3.2.

Table 3.2 *Demographic Characteristics of Participants (n = 670)*

Characteristic	Frequency (n)	Frequency Percent (%)
Gender		
Male	323	48.1
Female	338	50.4
Non-binary	7	1.0
Other	1	0.1
Age		
25-40	267	39.8
41-55	181	27.0
56-65	108	16.1
66+	114	17.0
Ethnicity or Race		
White	502	74.8
Black/ African American	66	9.8
Hispanic	39	5.8
Native Hawaiian or Pacific Islander	3	0.4
American Indian or Alaska Native	6	0.9
Two or more races	23	3.4
Other	2	0.3
Prefer not to respond	3	0.4
Income Level		
Less than \$30,000	159	23.7
\$31,000- \$50,000	157	23.4
\$51,000- \$80,000	174	25.9
\$81,000- \$100,000	62	9.2
\$101,000- \$150,000	77	11.5
\$151,000+	41	6.1

Family Characteristics

A visual representation of the study respondent's family characteristics is provided in Table 3.3. Overall, the table provides a comprehensive overview of the respondents' family characteristics, including their marital status, as well as if they have children. More than half of the respondents reported to be parents 57.8% ($n = 388$), while 42% ($n = 282$) identified as not having children. Marital status was recorded as 47.5% ($n = 388$) reporting to be married, while 34.7% ($n = 233$) identified as single. In addition, there was 11.2% ($n = 75$) participants who said they were divorced, 5.4% ($n = 36$) were widowed and there was 1.0% ($n = 7$) who reported to be separated.

Table 3.3 *Family Characteristics of Participants (n = 670)*

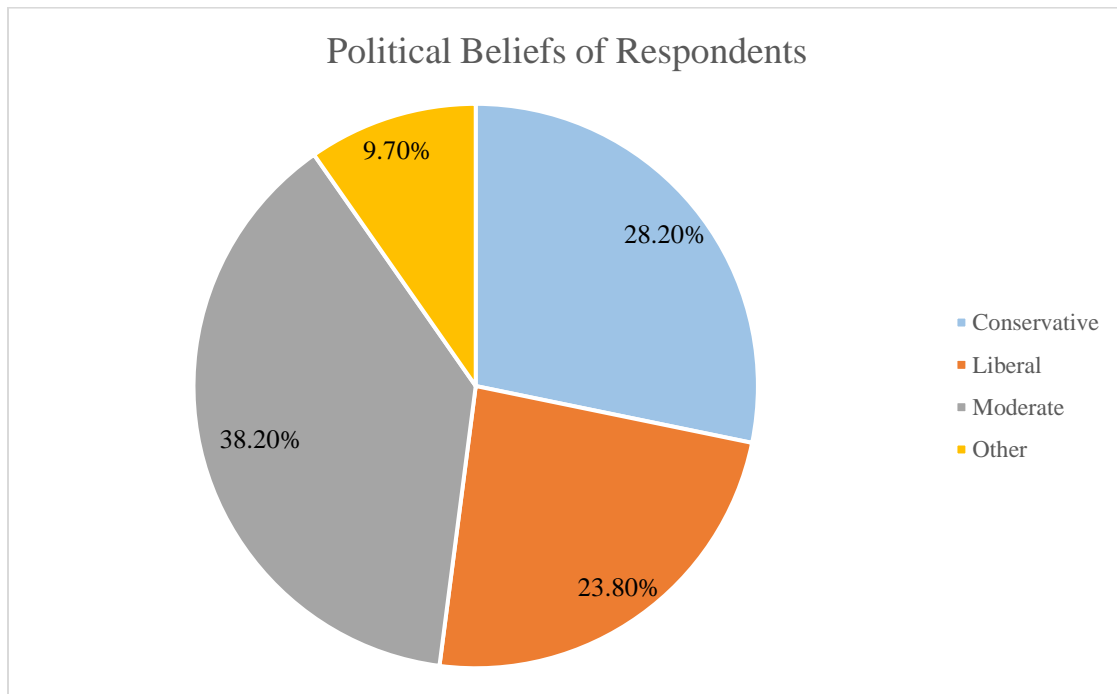
Characteristic	Frequency (n)	Frequency Percent (%)
Parental Status		
Children	388	57.8
No Children	282	42.0
Marital Status		
Married	319	47.5
Single	233	34.7
Divorced	75	11.2
Separated	7	1.0
Widowed	36	5.4

Respondent Political Beliefs

According to the survey, most respondents 38.2% ($n = 256$), identified as moderate in terms of their political beliefs. A significant portion of respondents 28.2%, ($n = 289$) described themselves as conservative, while 23.8% ($n = 160$) identified as liberal. A small percentage of respondents 9.7% ($n = 65$) recorded their political beliefs as "other," suggesting a diverse range of views beyond the traditional liberal-conservative spectrum.

The prevalence of moderate political beliefs among the respondents suggests a political climate that is not heavily polarized towards one end of the spectrum or the other. It is noteworthy that the proportion of self-identified conservatives is only slightly larger than that of self-identified liberals, indicating a balanced distribution of political views. The distribution of respondent political beliefs is represented in Figure 3.1.

Figure 3.1 *Political Beliefs of Respondents (n = 670)*



Respondent Residence Characteristics

A general location of respondent residence is reported by region in Table 3.4. The most frequently reported region of the US where respondents reported to reside was in the southern states with 38.2% ($n = 256$). There were 23.4% ($n = 157$) of responses that were recorded in the West, followed by 21.2% ($n = 142$) in the Midwest. Lastly 17.0% ($n = 114$) of the recorded responses placed themselves in the Northeast region of the US.

For more detailed location characteristics organized by the US state refer to (Appendix B).

To get a simplified idea of the general population density that respondents populate, participants were asked to identify which of the following best described their surroundings; urban, rural, or suburban. Participants responded with 46.6% ($n = 313$) as suburban, and 30.0% ($n = 201$) as urban. In addition, 23.2% ($n = 156$) of respondents reported that they lived in a rural setting.

Table 3.4 *Respondent Residence Characteristics (n = 670)*

Characteristic	Frequency (n)	Frequency Percent (%)
Region (US)		
Midwest	142	21.2
Northeast	114	17.0
South	256	38.2
West	157	23.4
Housing		
Urban	201	30.0
Rural	156	23.2
Suburban	313	46.6

CHAPTER IV

RESULTS

Overview

This research aimed to assess the relative knowledge level of US consumers concerning sorghum and its use as a food source. Additionally, the study aimed to explore potential stigmas and attitudes and their level of concern that US consumers have with sorghum and its consumption. Lastly, this research sought to get a better understanding of what consumers consider when making their grocery purchasing selections. The findings of the study provide insights into the consideration of potential benefits and possible hindrances of consuming sorghum, which can inform efforts to increase its adoption as a food source in the US. Following, are the research questions guiding this study:

RQ1: What is the Level of Awareness and Knowledge Concerning Sorghum among US consumers?

RQ2: At what Level of Importance do US Consumers hold for Common Perceived Benefits of Consuming Sorghum?

RQ3: What is the Pervasiveness of Stigmas to Consuming Sorghum for US Consumers?

RQ4: What Opportunities Exist for Increasing Food Grade Sorghum Consumption in the US and what Marketing Strategies can be Employed to Achieve this?

This chapter of the document describes the results of the study to answer the provided research questions. The descriptive statistics for the results are provided in the

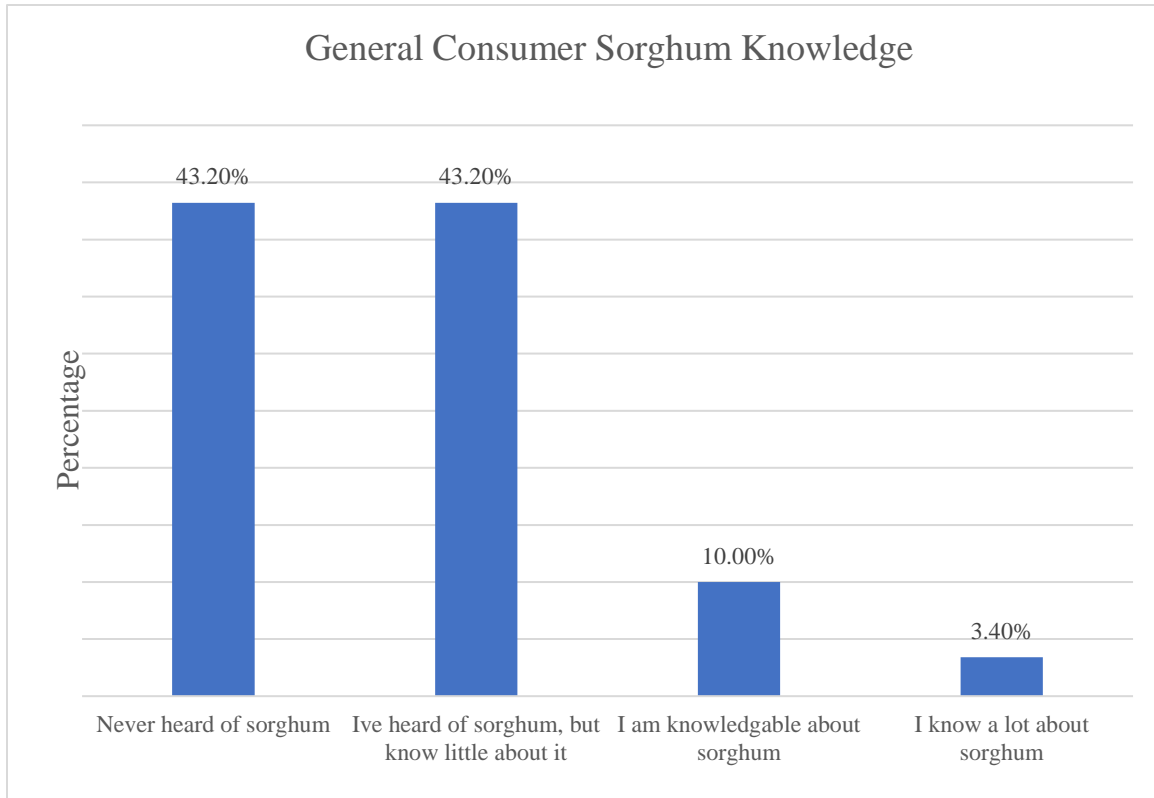
provided tables and figures. Data are organized according to the corresponding research question they contribute to answering.

RQ1: What is the Level of Awareness and Knowledge Concerning Sorghum among US Consumers?

To measure the level of pre-existing knowledge that is held, participants were asked a series of five questions related to familiarity, usage, and recognition of sorghum grain. Descriptive statistics from these measurements of knowledge are provided in the next figures. The first question was designed to gauge the participants' initial exposure to sorghum. They were asked, "Prior to taking this survey, had you ever heard of sorghum?" The provided answers were "never heard of it," "I've heard of it, but know little about it," "I am knowledgeable about sorghum," and "I know a lot about sorghum." This question was meant to provide a baseline of the participants' knowledge about sorghum, and it allowed the researchers to identify any potential gaps in the participants' understanding of sorghum grain for human consumption.

The same number of respondents indicated they had either "never heard of sorghum" 43.2% ($n = 290$) or that they had "heard of it but knew little about it" 43.2% ($n = 290$). Combining the responses from these two options resulted in the measured level of general knowledge being very low at 86.4% ($n = 580$). Respondents who indicated they felt they were knowledgeable regarding sorghum was 10.0% ($n = 67$). Lastly, 3.40% ($n = 23$) reported that they knew a lot about sorghum. A visualization of these statistics is provided in Figure 4.1.

Figure 4.1. *Consumer General Sorghum Knowledge (n = 670)*

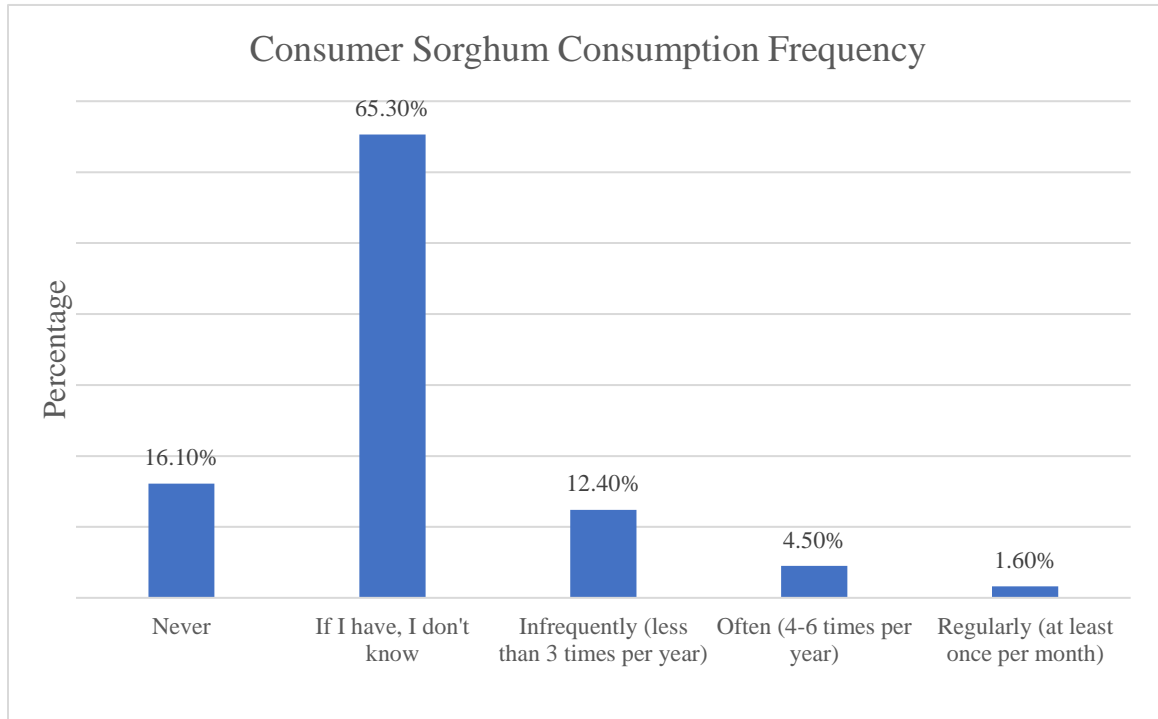


To gain a better understanding of the basic level of current consumption of sorghum by respondents, survey participants were asked, “have you consumed sorghum as a food ingredient?” The provided answer options were determined on a scale and included “never,” “if I have, I do not know,” “infrequently” (less than three times per year), “often” (four to six times per year), and “regularly” (at least once per month). The descriptive statistics for this question are displayed in Figure 4.2.

Respondents reported that 16.1% ($n = 108$) of them have never tried sorghum, and 65.3% ($n = 438$) said that if they had consumed sorghum, they did it unintentionally. When you combine the overall percentages of these two responses, we see that 81.4% ($n = 546$) have not knowingly consumed sorghum. Additionally, 12.4% ($n = 83$) of respondents claimed they consumed sorghum “infrequently” (less than three times per

year). Furthermore, 4.5% ($n = 30$) reported that they consume sorghum “often” (4-6 times per year), while only 1.6% ($n = 11$) said they consume sorghum “regularly” (once a month).

Figure 4.2 *Consumer Sorghum Consumption Frequency (n = 670)*



The subsequent two questions were designed to measure respondents’ level of sorghum knowledge in respect to its common uses. These questions were designed to determine the participants' basic understanding of the common uses of sorghum both internationally and in the US. Additionally, a question was included to determine the participants' ability to recognize sorghum as a crop growing in the field. These three questions solicited a yes/no response from the participants, the descriptive statistics describing the responses are illustrated in Table 4.1. This information provided an understanding into the participants' knowledge of the uses and basic recognition of sorghum.

When asked, “Do you know how sorghum is utilized outside of the US,” most respondents answered “no”, 86.3% ($n = 579$). The percentage of respondents that did know what sorghum was used for outside the US was 13.6% ($n = 91$). Responses to the question “Do you know how sorghum is utilized within the US,” had 80.6% ($n = 541$) that did not know and 19.2% ($n = 129$) that claimed they were aware of its use in this country. The final question was asked to determine if respondents could identify sorghum as a crop. Responses to this question were characterized by the majority 85.2% ($n = 572$) not knowing, and 14.6% ($n = 98$) answering that they had in fact seen sorghum growing in the field.

Table 4.1. *Consumer General Sorghum Utilization Awareness (n = 670)*

Question	No (%)	Yes (%)
Do you know how sorghum is utilized in the US?	80.6	19.2
Do you know how sorghum is utilized outside of the US?	86.3	13.6
Have you ever seen sorghum growing in the field?	85.2	14.6

RQ2: At what Level of Importance do US Consumers hold for Common Perceived Benefits of Consuming Sorghum?

Research has shown many benefits to humans regarding the consumption of sorghum (Xiong, Zhang, Warner & Fang, 2019). These benefits include health benefits, availability benefits, and environmental benefits (Stefoska-Needham & Tapsell, 2020). To gauge which of these benefits were of greatest concern to the US consumer, a rank order question was asked on the survey instrument. The question identified six specific benefits of consuming sorghum and asked respondents to rank them according to how

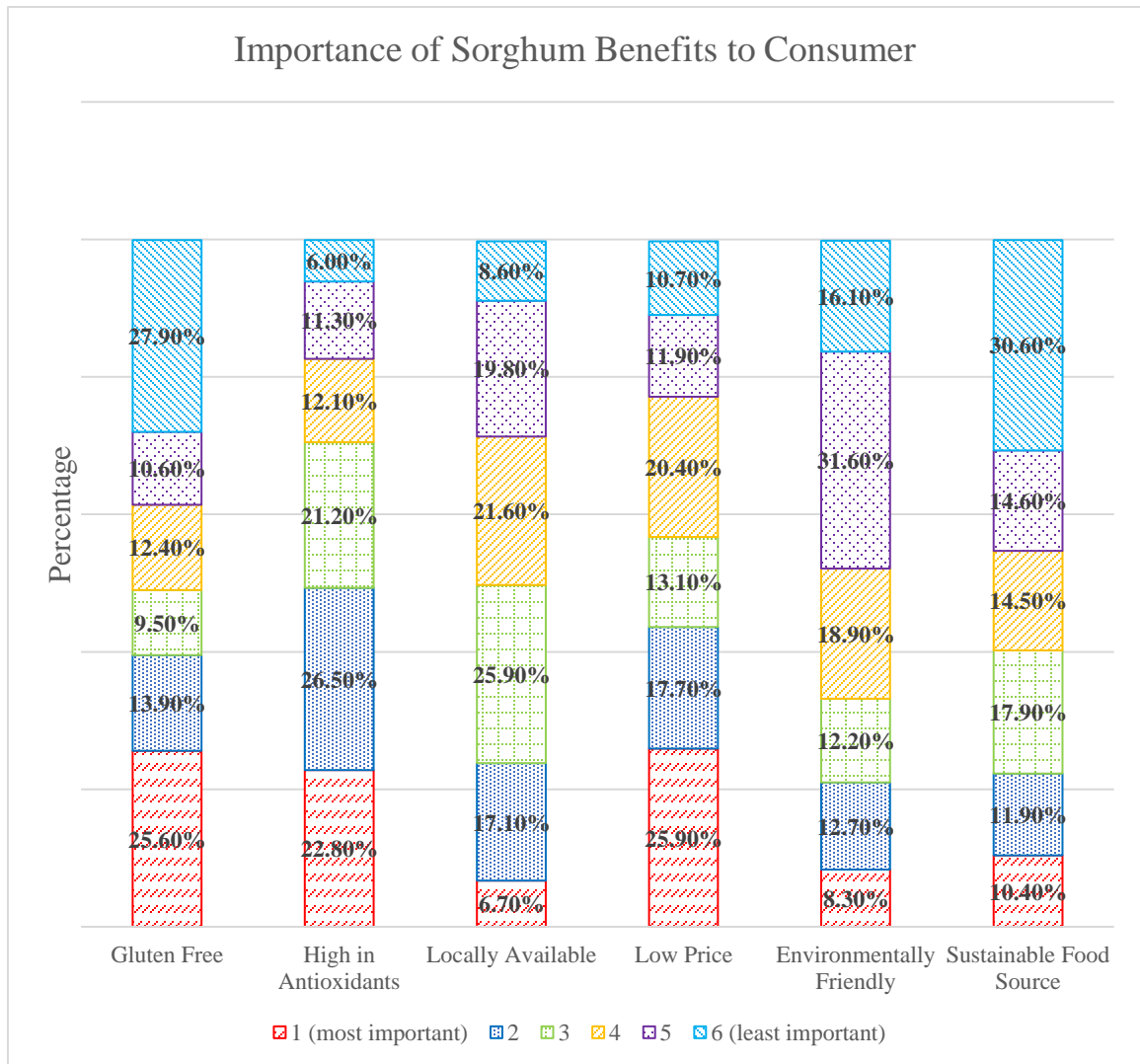
important each participant felt toward a specific benefit, as relative to the others.

Descriptive statistics for the responses to this question are displayed in Figure 4.3.

The benefits listed in this question were “gluten free,” “high in antioxidants,” “locally available,” “low price,” “environmentally friendly,” and “sustainable food source.” To summarize the results displayed in Figure 4.3, we calculate which benefit had the highest number of respondents who ranked each benefit in the top two levels of importance (1 or 2). We see that the benefit referring to sorghum being “high in antioxidants” was the most important to almost half of the respondents 49.3% ($n = 331$). The second highest ranked sorghum benefit was its potential to be priced lower than similar products 43.6% ($n = 291$).

Similarly, we calculated which of the benefits were of the lowest importance to respondents by grouping the two lower levels of importance (5 or 6). We find that the benefit that ranked the lowest was “environmentally friendly”, at 47.7% ($n = 320$). The next least important benefit as ranked by respondents was “sustainable food source” with 45.2% ($n = 303$). Interestingly, both lowest ranked attributes fell into the category of environmental benefits.

Figure 4.3. *Ranking of Sorghum Benefit Importance to Consumer (n = 670)*



RQ3: What is the Pervasiveness of Stigmas to Consuming Sorghum for US Consumers?

In order to answer the question as to why sorghum has yet to be popularized in the US, it is crucial to examine some of the commonly perceived negative characteristics of the practice. While some of these aspects might not apply to all consumers, the researcher presented eight perceived negative ideas or stigmas surrounding the act of

humans eating sorghum. The specific stigmas or attitudes used in this question were adapted and added upon from previous sorghum and millet consumption research (Kane-Potaka et al., 2021). These aspects were shown to the respondents, and they were asked to rank them on a Likert-type scale depending on the likelihood of each aspect to deter them from purchasing a sorghum product. Understanding any misconceptions or misunderstandings about sorghum that US consumers hold is key to addressing any possible barriers preventing popularization of sorghum consumption.

Table 4.2 illustrates the descriptive statistics for the responses from survey participants on their likelihood of being deterred from purchasing a sorghum product due to negative perceptions or stigmas associated with sorghum consumption. The responses were ranked on a Likert-type scale ranging from "Extremely Unlikely" to "Extremely Likely." Table 4.2 indicates the percentage of participants who selected each response category for each of the eight negative characteristics of sorghum consumption.

Most respondents chose the neutral response (neither likely nor unlikely), ranging from 27.3% ($n = 183$) to 37.0% ($n = 248$) for each of the listed characteristics. In analyzing the remaining responses, we find that the characteristic with the highest percentage of respondents who indicated that it was "extremely likely" to deter them from purchasing a sorghum product was the fact that "sorghum is used to make fuel (ethanol)", at 23.8% ($n = 160$). The responses to this characteristic had a mean score of 20.0 and the standard deviation was 12.68. The characteristic that had the highest number of respondents who reported that it was "extremely unlikely" to deter them from making a sorghum product purchase was "I like corn and corn does all the things that sorghum

does”, at 19.7% ($n = 132$). The responses to this characteristic had a mean score of 19.98 and the standard deviation was 31.73.

In further summarization of Table 4.2, we grouped the responses into either “likely” or “unlikely” by grouping the highest likelihood responses together, and the lowest likelihood responses together respectively. The characteristic most unlikely to deter respondents from purchasing a product made with sorghum again was the statement “I like corn and corn does all the things that sorghum does” at 37.0% ($n = 248$). The second most unlikely aspect to deter a sorghum product purchase was “I didn’t know people could eat sorghum”, at 35.9% ($n = 241$). Responses to the likelihood of this characteristic to deter respondents from purchasing sorghum products had a mean score of 19.96 and the standard deviation was 29.98.

The negative characteristic that was most likely to deter respondents from purchasing sorghum products was identified as “Sorghum is used to make fuel (ethanol).” The percentage of responses that confirmed this was 45.1% ($n = 303$). The second most likely stigma to deter purchase was that “It is not as readily available as other food products in supermarkets”. The percentage of responses that indicated this response was 40.3% ($n = 270$). Responses to the likelihood of this characteristic to deter respondents from purchasing sorghum products had a mean score of 20.0 and the standard deviation was 12.46.

Table 4.2. *Likelihood of Stigmas to Deter Purchase (n = 670)*

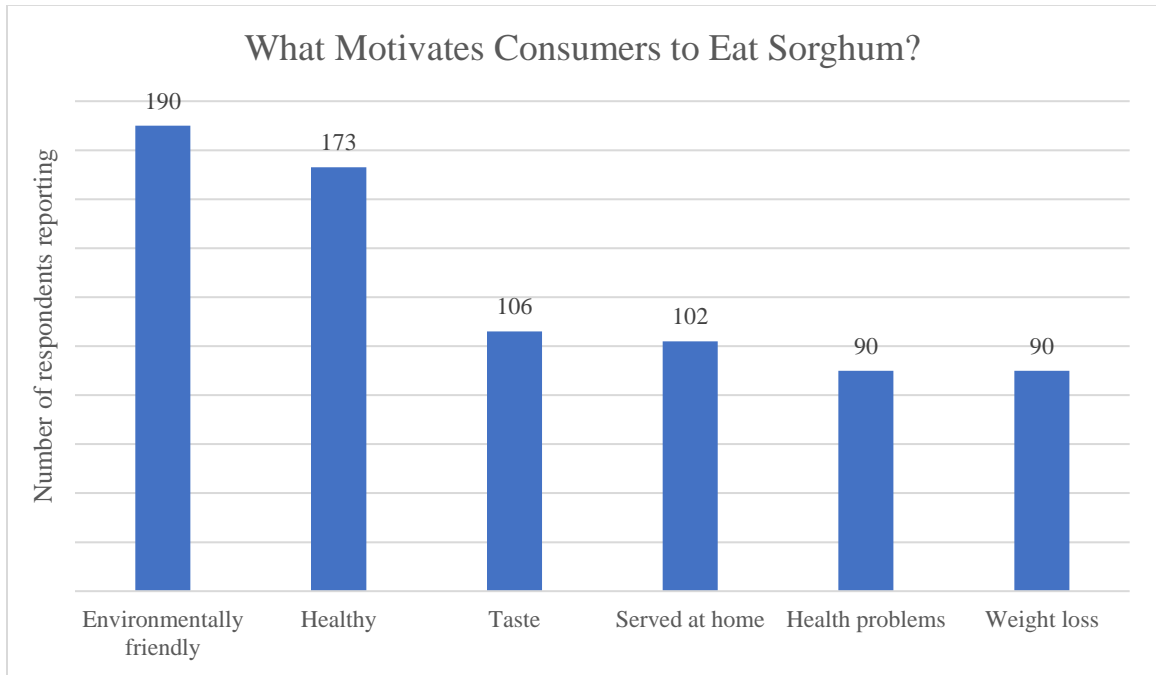
Characteristic	Extremely Unlikely %	Somewhat Unlikely %	Neither Likely nor Unlikely %	Somewhat Likely %	Extremely Likely %	M(SD)
I didn't know people could eat sorghum	18.9	17.0	36.5	19.4	8.0	19.96 (29.98)
Sorghum is eaten by people in 3 rd world countries	18.2	14.9	36.2	19.5	11.0	20.16 (29.34)
Farmers feed sorghum to their livestock	14.9	14.3	37.0	24.0	9.7	19.98 (32.28)
I like corn, corn does the same thing	19.7	17.3	36.1	15.5	11.3	19.98 (31.73)
Sorghum is used to make fuel (ethanol)	13.0	14.5	27.3	21.3	23.8	20.0 (12.68)
I don't know how to cook with sorghum	17.4	15.1	29.1	17.7	20.6	20.0 (9.18)
I don't know anyone who eats sorghum	19.1	12.2	32.2	19.1	17.3	20.0 (12.40)
Sorghum is not as readily available as other products	12.4	14.5	32.8	25.8	14.5	20.0 (12.46)

RQ4: What Opportunities Exist for Increasing Food Grade Sorghum Consumption in the US and what Marketing Strategies can be Employed to Achieve this?

In answering Research Question 4, we begin by providing a visualization of the different motivations that respondents reported in reference to adding sorghum as an ingredient in their diets. Figure 4.4 shows the percentages of responses by each participant regarding the six different motivations for consumers to adopt sorghum consumption.

Figure 4.4 illustrates that the highest of the six listed motivations was reported as the fact that sorghum was environmentally friendly, at 28.30% ($n = 190$). The second highest motivation that was recorded was in fact the characteristic of sorghum to be very healthy for people to eat 25.8% ($n = 173$). Following, was the motivation that consumers simply liked the taste of products made with sorghum 15.8% ($n = 106$). Next, consumers said that they were motivated to eat sorghum because that is something that is served at home 15.2% ($n = 102$). The last two consumer motivations represented in Figure 4.4 are because they desire to lose weight and because they are battling with health problems. Both of the last listed motivations were weighed the same for the respondents at 13.4% ($n = 90$).

Figure 4.4 *What Motivates Consumers to Eat Sorghum (n = 670)*



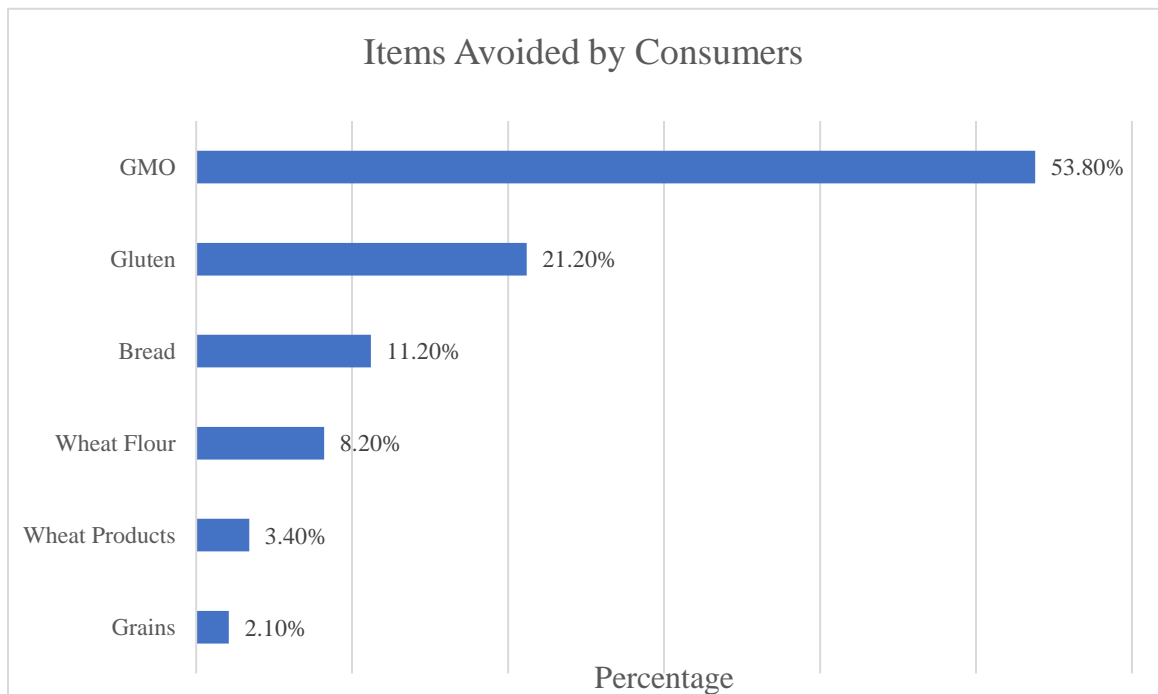
To further understand why consumers make the food choices they make, the survey questionnaire included a question asking respondents to indicate items they specifically avoid when making their selections. The question asked, “Do you avoid any of the following in your diet?” Six commonly avoided items related to sorghum grain were listed, and respondents were asked to check all that apply. The items listed were products produced using genetically modified organism technology (GMO), gluten, wheat flour, wheat products, grains, and bread. The items included in this question were specifically chosen to illustrate the potential of sorghum as a popular product that consumers would choose to utilize. A graph providing the descriptive statistics for answers to this question are provided in Figure 4.5.

In reference to Figure 4.5, we discover that 53.8% ($n = 361$) reported that they avoid products that have been produced using GMO technology. The next most avoided

item reported by consumers was products that contain gluten, at 21.2% ($n = 142$).

Respondents were then asked if they avoid wheat products and wheat flour. For responses to wheat flour, 8.2% ($n = 55$) of participants reported this to be an avoided item. For wheat products, 3.4% ($n = 23$) reported this to be something that they stay away from in their diet. Combining these last two items we find that overall, 11.6% ($n = 78$) of respondents consciously try to avoid wheat in their diet. Participants were then asked if they avoid grains in their diet, this item was the least avoided item, at 2.1% ($n = 14$). Lastly, it was reported by 11.2% ($n = 75$) of respondents that they avoid bread in their diet.

Figure 4.5 *Items Avoided by Consumers in their Diet (n = 670)*



The question regarding grocery buying selections aimed to gather data on what factors influence consumers' purchasing behavior. The question listed seven statements and asked respondents to indicate which statement would be most and least likely to

influence their behavior. The responses were measured using a Likert-type scale ranging from 1 to 5, with 1 being "extremely unlikely" and 5 being "extremely likely." This type of question allows researchers to determine which factors are most important to consumers when making grocery buying decisions. The results can help retailers and marketers tailor their products and promotions to better meet consumers' needs and preferences. Descriptive statistics for the responses to this question are provided in Table 4.3.

To summarize the descriptive statistics provided in Table 4.3, the two "likely" responses were grouped together, and the two "unlikely" responses were similarly grouped together. For the statement "I've never heard of it", 45.9% ($n = 308$) reported this to be likely to influence their decisions, while 25.9% ($n = 174$) said that having never heard of it was unlikely to influence them. In regard to a product claiming to be "healthy", 55.6% ($n = 413$) said this is likely to influence them and 14.2% ($n = 95$) said that it was unlikely that the health claim would influence their decision. In response to if a product was "gluten free" would influence them, 38.0% ($n = 255$) said it was likely, and 30.4% ($n = 204$) said that it was unlikely. When asked if a claim by a product to be "reduced fat" would influence their purchasing decision, 44.1% ($n = 296$) said it was likely and 21.6% ($n = 145$) reported it to be unlikely. The next statement presented was if the product was considered "all natural", 59.7% ($n = 401$) indicated this was a likely source of influence, and 12.8% ($n = 86$) said it was not. Respondents were then asked if a product being "high in protein" would likely influence their decision to purchase said item or not. The responses reported that 62.7% ($n = 421$) were likely influenced by this factor and 11.9% ($n = 80$) were not. Lastly respondents were asked to indicate the

likelihood of the fact that a product is considered “environmentally healthy” would influence their decision to purchase or not. Participants reported that 52.5% ($n = 352$) were likely to be influenced by an “environmentally friendly” product and 16.2% ($n = 109$) said they were unlikely influenced by this claim. The sample size for each attribute varied, ranging from 174 to 421 respondents.

Table 4.3 *Statements Likely to Influence Grocery Purchasing Selections (n = 670)*

Characteristic	Extremely Unlikely %	Somewhat Unlikely %	Neither Likely nor Unlikely %	Somewhat Likely %	Extremely Likely %	M(SD)
I've never heard of it	11.6	14.3	28.0	23.4	22.5	19.96 (13.15)
Product claims to be healthy	3.9	10.3	30.1	36.2	19.4	19.98 (25.51)
Product is gluten free	16.5	13.9	31.4	23.2	14.8	20.0 (10.94)
Product claims reduced fat	10.6	11.0	34.1	31.6	12.5	20.16 (19.06)
Product is all natural	5.1	7.7	27.3	35.6	24.1	20.16 (21.52)
Product is high in protein	5.5	6.4	25.2	36.5	26.2	19.96 (21.64)
Product claims to be environmentally friendly	7.0	9.2	31.1	30.7	21.8	19.96 (20.24)

To further our understanding of what consumers are considering when they are selecting groceries to purchase, we asked survey participants to rank five different considerations from least to greatest importance. Asking survey participants to rank their considerations when selecting groceries to purchase can provide better understanding into consumer behavior and preferences at the point of sale. It is interesting to note the differences between the answers provided when asked about motivations, versus when asked about product attribute importance when making purchases.

In this survey question, the five considerations listed were “price/value,” “health benefits,” “the same product you always get,” “you saw it advertised,” and “environmentally friendly.” The recorded results from this question are displayed in Figure 4.6.

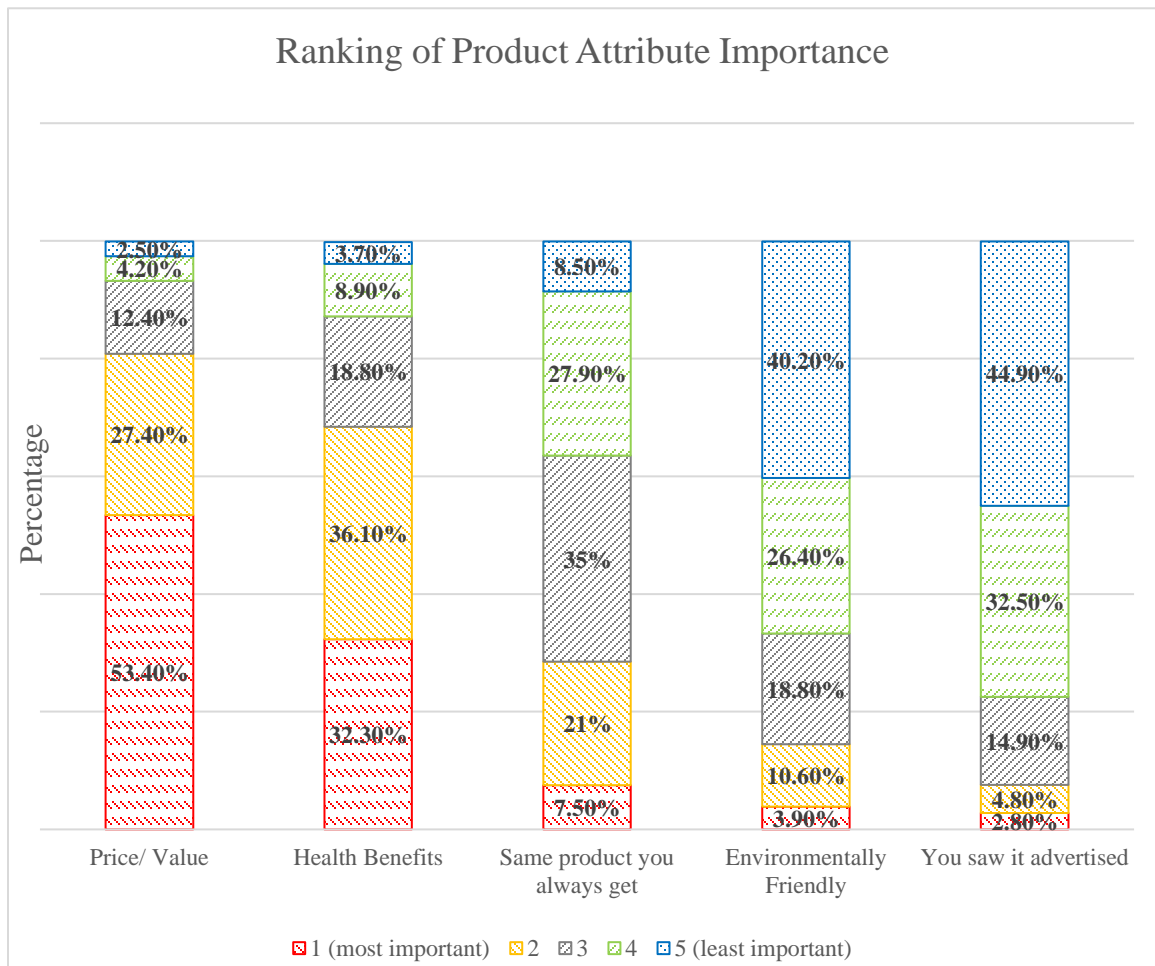
To summarize the results displayed in Figure 4.6, we calculated the responses that had the greatest number of rankings in the two highest positions of importance (1 and 2). Additionally, we calculated the order of the responses that were ranked in the two lowest positions of importance (5 and 6). When we compare the rankings in respect to both the highest and the lowest rankings, we find that the ranking of importance remains the same from both perspectives for all characteristics.

For the purposes of this summarization, we report the ranking of the responses in reference to the number of respondents that placed each characteristic in the top two levels of importance (1 and 2). The highest ranked criteria were “price/value”, 80.8% ($n = 542$) of respondents’ ranked this in the top two rankings of importance. Following “price/value”, the second highest ranked criteria was “health benefits”, with 68.4% ($n = 459$) or respondents ranking these criteria in the first or second levels of importance. The

next highest-ranking criteria was “the same product you always get” with 28.5% ($n = 191$) of respondents ranking this element as a 1 or a 2 in level of importance. The least two important criteria as ranked by respondents were “environmentally friendly” 14.5% ($n = 97$) and “saw it advertised” 7.6% ($n = 51$).

By asking participants to rank these considerations from least to greatest importance, researchers can gain a sense of which factors carry the most weight in the minds of consumers. For example, since price/value is ranked as the most important factor, then organizations may want to focus on highlighting the affordability and value of sorghum products in order to increase consumer interest.

Figure 4.6 *Ranking of Product Attribute Importance (n=670)*



Chapter Summary

To summarize chapter four, our findings indicate that most participants had either never heard of sorghum or had heard of it but knew little about it. When these two options are combined, it shows that the measured level of general knowledge about sorghum among participants was very low at 86.4% ($n = 580$). Additionally, only a small proportion of respondents felt knowledgeable about sorghum 10.0% ($n = 67$), and even fewer reported knowing a lot about it 3.4% ($n = 23$).

The study analyzed the importance of benefits to consumers associated with sorghum grain consumption by listing six benefits of sorghum consumption and asking respondents to rank them. The results showed that the benefit of sorghum grain being "high in antioxidants" was the most important to almost half of the respondents, followed by its potential to be priced lower than similar products. On the other hand, the benefits of sorghum grain being "environmentally friendly" and a "sustainable food source" were of the lowest importance to the respondents.

The results show that most respondents chose a neutral response when asked about the likelihood of certain characteristics deterring them from purchasing sorghum products. However, among those who did provide a response, the characteristic most likely to deter respondents from purchasing sorghum products was the fact that sorghum is used to make fuel (ethanol). In contrast, the characteristic least likely to deter respondents was the statement "I like corn and corn does all the things that sorghum does."

When grouping the responses into "likely" or "unlikely," the characteristic most likely to deter respondents from purchasing sorghum products remained the fact that sorghum is used to make fuel (ethanol). The second most likely characteristic to deter respondents when we group the data was the fact that sorghum is not as readily available as other food products in supermarkets.

The data collected to answer Research Question 4 show that the most popular motivation for consuming sorghum products was that it is environmentally friendly, followed closely by its health benefits. The taste of sorghum products was also a significant motivator for consumers, as well as the fact that it is a common food in their homes. Two other motivations for consuming sorghum products were to lose weight and to address health issues, both motivations were equally important to the respondents.

In exploring what types of things consumers purposely avoid at the grocery store, we found that respondents reported avoiding products produced using GMO technology the most. The second most avoided item was gluten, followed by bread, wheat flour, and wheat products in general. In contrast, participants reported avoiding grains the least in their diet.

Further exploring Research Question 4, we measured the likelihood of various product claims on influencing consumers' purchasing decisions, responses were grouped into two categories: "likely" and "unlikely". Most respondents reported that a product claiming to be "high in protein" and "all natural" were likely to influence their purchasing decisions. Ranked below these were the claim of a product to be "healthy" and then "environmentally friendly." Respondents were less likely to be influenced by having "never heard of a product," as well as products claim to be "reduced fat." According to

this data, the least likely claim to influence consumer grocery purchases was the claim to be “gluten free.”

Respondents were then asked to rank various criteria in terms of importance when making purchasing decisions. The criteria included price/value, health benefits, brand loyalty, convenience, environmentally friendly, and having had seen the product advertised. The highest ranked criteria were price/value, followed by health benefits. Brand loyalty (same product you always get) was ranked third by respondents. And the least important criteria were “environmentally friendly” and having had previously “seen a product advertised.” The ranking of importance remained consistent when considering both the highest and lowest rankings.

CHAPTER V

FINDINGS AND DISCUSSION

Overview

The research study aimed to investigate factors and conditions that prevent the popularization of sorghum consumption in the United States. The survey questionnaire included several components, including an examination of consumers' knowledge of sorghum, potential benefits and hindrances of consuming sorghum, motivations for adding sorghum products to the diet, and factors influencing grocery buying habits.

The study provided a background on sorghum production and use in different regions of the world and discussed relevant literature and the theoretical framework used to guide the study. The methodology was described in detail, and the survey results were presented.

The findings of the study indicated that most consumers had minimal knowledge of sorghum or simply had never heard of it. However, when presented with information about sorghum's potential health benefits, consumers expressed interest in trying sorghum products. Factors such as taste, price, and convenience were identified as important considerations for consumers when making grocery purchases (Petrescu, Vermeir, & Petrescu-Mag, 2019), and the study suggested that incorporating sorghum into existing products or marketing it as a healthy alternative could increase its appeal to consumers (Khoddami et al., 2021).

It is interesting to note that both lowest ranked benefits fell into the category of environmental benefits. The data suggests this might be because environmental benefits are often seen as indirect or long-term benefits, while the respondents might have been

more focused on immediate or tangible benefits. The findings can have implications for the promotion and marketing of sorghum grain as a healthy and sustainable food source. The study suggests that highlighting the immediate and tangible benefits, such as being high in antioxidants and priced lower than similar products, might be more effective in promoting the consumption of sorghum grain than focusing on the long-term and indirect benefits, such as being environmentally friendly and sorghum's potential to increase food security.

The study's practical implications suggest that increasing consumer awareness of sorghum's benefits and incorporating it into existing products could help popularize its consumption in the US. Additionally, the study identified several areas for future research, including investigating consumer perceptions of sorghum and its taste, examining the role of marketing in promoting sorghum consumption, and exploring the potential of sorghum as a sustainable food source. The following are the research questions that guided this study:

RQ1: What is the Level of Awareness and Knowledge Concerning Sorghum among US Consumers?

RQ2: At what Level of Importance do US Consumers hold for Common Perceived Benefits of Consuming Sorghum?

RQ3: What is the Pervasiveness of Stigmas to Consuming Sorghum for US Consumers?

RQ4: What Opportunities Exist for Increasing Food Grade Sorghum Consumption in the US and what Marketing Strategies can be Employed to Achieve this?

Research Question 1: What is the Level of Awareness and Knowledge Concerning Sorghum among US Consumers?

Consumer General Sorghum Knowledge

In review of the data collected to answer this research question, we see overall the general knowledge concerning sorghum and its' uses is generally very low. Most respondents had either never heard of sorghum, or that they had heard of it but knew very little about it.

The lack of knowledge about sorghum and its uses may be attributed to various factors such as limited exposure to the crop, lack of marketing and promotion, and limited research and development in some regions. Sorghum is not as widely known as other major crops such as corn, wheat, and rice, which have been staples in the US food system for decades (Welch, 2011).

Efforts are underway to increase awareness and utilization of sorghum, particularly in developing countries where the crop has significant potential to contribute to food security and economic development (ICRISAT, 2021). Research is being conducted to develop new sorghum varieties with enhanced traits and explore new uses for the crop (Khoddami et al., 2021).

Education and outreach efforts can also play a key role in increasing awareness and understanding of sorghum and its uses. This can be done through targeted marketing campaigns, educational programs, and partnerships with local communities and organizations.

Consumer Sorghum Consumption Frequency

Consequently, we also discovered that most of the survey respondents had never consumed products made with sorghum, or if they had, it was done unintentionally. These findings come as no surprise, as we do see a lack of products made with sorghum available for purchase on grocery store shelves (Stefoska-Needham & Tapsell, 2020). Sorghum lacks the cultural background and history with US consumers, as compared to areas such as China, Asia, or India (Khoddami et al., 2021). Where we do see sorghum products is within the niche markets of health foods, or as an alternative marketed to consumers who are unable to eat other grains due to disorders such as CD or general gluten intolerance (Ducksbury, Neale, & Stefoska-Needham, 2021).

Based on the findings, it can be inferred that the lack of popularity of sorghum in the US may be attributed to a general lack of consumer awareness regarding sorghum and its potential as a valuable food item. By understanding these gaps in knowledge, researchers and organizations can work to provide more information and education, potentially leading to increased utilization of this versatile and nutritious crop (Stefoska-Needham & Tapsell, 2020).

Consumer Sorghum Utilization Awareness

In furthering our comprehensive view of the knowledge level concerning sorghum to the respondents of the study, three additional questions were asked. These questions asked if respondents knew how sorghum was utilized, both within the US and internationally. In addition, it was measured if participants could identify the sorghum crop by asking if they had ever seen sorghum growing in the field.

Most respondents were not aware of the common uses of sorghum internationally or within the US. Additionally, most of the respondents reported that they have never seen sorghum as a crop growing in the field.

This suggests that efforts to increase awareness and educate consumers on the benefits of sorghum could potentially increase its adoption as a dietary choice. Such efforts may include promotional campaigns, educational initiatives, and targeted marketing to increase demand and availability of sorghum-based products. Through these measures, it may be possible to overcome the barriers to the widespread adoption of sorghum and popularize it as a dietary staple in the US.

Research Question 2: At what Level of Importance do US Consumers hold for Common Perceived Benefits of Consuming Sorghum?

As discussed in the previous chapters, sorghum consumption brings many potential benefits to the consumer. To assess how these benefits affected the decision-making process we listed six benefits and asked respondents to rank their relative personal importance in relation to the others. In adhering to the theoretical framework, we grouped these benefits according to the three categories of beliefs outlined within the TPB. These beliefs include behavioral beliefs (what do I think?), normative beliefs (what do others think?), and control beliefs (can I do this?) (Bosnjak, Ajzen, & Schmidt, 2020).

In relation to behavioral beliefs, we listed the health-related benefits of sorghum being high in antioxidants and the fact that sorghum is a gluten-free product (Steinhauser & Hamm, 2018). When grouped together we find that the health benefits were of most concern to the respondents of the study. The modern consumer is now, more than ever,

aware of what they are putting into their bodies to live a healthier lifestyle (Renner & Ringquist, 2016). Sorghum is a product that can fill this requirement for people because it is a whole grain that is less processed than other foods (Stefoska-Needham & Tapsell, 2020). The natural components of sorghum have been proven to aid in the fight against many of the common dietary disorders that US consumers suffer from (Ducksbury, Neale, & Stefoska-Needham, 2021). Adding sorghum as an ingredient in a person's diet can help to combat these disorders (Xiong, Zhang, Warner, & Fang, 2019), thus checking many of the boxes for grocery buyers when they are considering healthy options in their decision-making process.

The second set of benefits were benefits related to control beliefs (can I do this?) (Armitage & Christian, 2003). Is this something that consumers could potentially adopt in terms of availability and price/value? When grouped together, we find these benefits were of second highest importance to consumers. Standing alone, the data show that the potential for sorghum products to be economically priced was the second highest favored benefit 43.6% ($n = 291$), behind the fact that sorghum is high in antioxidants 49.3% ($n = 331$). This is understandable when we consider the overall rise in grocery prices that we are seeing with inflation and overall cost of living on the rise in the US (Statista, 2022). The average consumer is more conscious currently with making their dollars stretch at the grocery store, while still being able to provide wholesome meals for their families.

Also related to control beliefs, was the mention of the benefit that sorghum is a beneficial product because of the local availability of the crop (Stroade, Boland, Huntrods, & Taylor, 2022). Sorghum is grown in many regions of the US and has the potential to expand its growing area with innovations in plant breeding technology

(Dessalegn, Ogbonna, Agbo, & Dagnachew, 2021). Traits such as cold and heat tolerance, paired with drought and environmental stress tolerances are paving the way for sorghum to be grown in regions of the country experiencing challenges from factors related to climate change (Shukla et al., 2019). With sorghum being domestically available, costs associated with logistical factors are minimized and the grain could be produced and sold by farmers much closer to the point of consumption (NASS, 2022). This makes the potential availability of sorghum products much higher for consumers in the US.

The third category of beliefs in reference to the theoretical framework refers to the normative beliefs. The two benefits included in this category were the benefits of sorghum being more environmentally friendly 47.7% ($n = 320$), as compared to similar crops and the potential for sorghum to be a sustainable food source 45.2% ($n = 303$). Although these benefits were ranked lower than the others, they are still of importance to consumers as society strives to minimize human impact on the environment as they consider not only what is best for them, but also those around them. In doing so, the agriculture industry is constantly innovating, which includes adopting new crops and techniques to improve responsible growing practices (Oliveira et al., 2019). Sorghum is a crop that outperforms other crops in relation to environmental stresses, consequently sorghum requires less water and less inputs thus reducing its production impact on the environment (Smith & Fredricksen, 2000). This reduced impact, paired with sorghum's ability to increase its available growing area, contributes to sorghum's potential to become a widely utilized sustainable food source in this country (Stefoska-Needham & Tapsell, 2020). Due in part to the growing population and the increased aridization that

the US is experiencing, food security is becoming more of a concern to the average consumer (Coleman-Jensen, Rabbitt, & Singh, 2020). Although the benefits regarding the environmental and social responsibility of consuming sorghum ranked lowest to the respondents in this question, we still see how these factors are being considered when consumers are making their grocery purchasing decisions.

Overall, the data collected here shows what is considered most important and which benefits are of greater impact to consumers. This information could be used to guide innovation in sorghum product development as well as how these products could potentially be marketed to best appeal to the values and intentions of consumers in US markets.

The data suggests that marketing efforts should be designed to appeal to the behavioral beliefs of consumers above others. This could be executed by marketing sorghum products based on the health benefits that they offer the individual. Second in importance to consumers were control beliefs. Marketing and promotional efforts could appeal to this belief category by emphasizing and improving the price/value of sorghum products, as well as increasing the availability of these products on grocery store shelves. Ranked third in relation to belief categories were aspects appealing to the normative beliefs of consumers. This suggests that environmental and sustainability benefits appeal less than the other benefits to consumers. It remains a useful tool being able to highlight the normative beliefs in marketing efforts being that social responsibility is identified as one of the “evolving value drivers.” It should be noted that these value drivers are considered by consumers, and it is suggested that as time progresses and food

environments evolve, normative beliefs will increase in importance (Renner & Ringquist, 2016).

Research Question 3: What is the Pervasiveness of Stigmas to Consuming Sorghum for US Consumers?

Very closely related to the general knowledge of sorghum, are preconceived ideas, attitudes, and stigmas surrounding the crop and its use as a product for human consumption. In understanding which benefits of this product are most likely to appeal to the consumer, we must also look at the negative ideas surrounding the product.

In researching the literature pertaining to human consumption of sorghum, we uncovered several reasons that consumers might be convinced to avoid the consumption of this product (Kane-Potaka et al., 2021). To get a better idea of how these factors might affect the potential for sorghum to be popularized in the US, we identified eight possible hindrances to sorghum consumption. Respondents were asked to indicate the likelihood of each influencing them in their decision-making process.

The results of this question were promising in that most respondents reported these negative factors were neither likely nor unlikely to influence them for all eight of the provided ideas or stigmas. This would suggest that these hindrances have less of an impact on consumers decision making process than previously thought (Kane-Potaka et al., 2021).

From the responses that did not take a neutral stance in reporting the likelihood of the listed stigmas from deterring a sorghum related purchase, we find that idea that

sorghum is used to make fuel (ethanol) was of most concern to respondents 23.8% ($n = 160$).

The second most likely factor to deter consumers from adding sorghum as an ingredient in their diet was the fact that sorghum is not as readily available as similar products made with more popular grains at local grocery stores (Khoddami et al., 2021). As previously mentioned, sorghum product availability in the US is limited to a very niche market, thus resulting in the mainstream availability of sorghum products being low (Stefoska-Needham & Tapsell, 2020). Going back to our theoretical framework we see that individuals consider control beliefs when deciding to make an intention to act on a behavior (Bosnjak, Ajzen, & Schmidt, 2020). If sorghum products are not as readily available as other products, then the added effort in locating these products is likely to deter purchases and thus inhibit popularization. Referring to the mention of a benefit of sorghum being that it is locally available, only pertains to the fact that sorghum is grown or can potentially be grown in many different regions of the country. If sorghum products are not available to purchase at a consumers' local grocer, then it is simply a crop in the field and not a readily available food item.

The identification of the lack of availability to be a likely deterrent to consumers in adopting sorghum consumption is not necessarily a negative factor in reference to demand for sorghum products. In fact, this response implies that there is a potential for sorghum to be popularized if it is in fact an available option for purchase. This data carries implications to the sorghum industry, being that it confirms that consumers are willing to adopt sorghum and more consumers will potentially purchase sorghum products as availability increases (Arendt & Zannini, 2013).

Research Question 4: What Opportunities Exist for Increasing Food Grade Sorghum Consumption in the US and what Marketing Strategies can be Employed to Achieve this?

Motivations

To address research question 4, the survey instrument included several questions in an attempt to get a more comprehensive view of potential opportunities and strategies for increasing sorghum consumption among US consumers. The first question asked respondents to identify what would motivate them to want to eat sorghum products. Six possible motivations were listed, and respondents were prompted to indicate which of these pertained to them.

The three of the provided possible motivations that were reported to have the greatest influence were that sorghum production was environmentally friendly, that it was healthy, and that they enjoyed the taste of sorghum products respectively. The results of these findings confirm the importance of the health and environmental benefits to consumers that sorghum inherently possesses (Khoddami et al., 2021). The implications of this importance to consumers suggests that including these facts in future marketing efforts is a valuable tool in appealing to potential customers.

Being that taste was also listed as a significant motivation for consumers to adopt sorghum reinforces the idea that traditional value drivers still play an important role in consumer food purchasing decisions (Renner & Ringquist, 2016). While the modern consumer is more aware of factors such as healthy eating, environmental factors, and social responsibility, a product still must appeal to the consumers taste preferences

(Renner & Ringquist, 2016). The implications of this lie in the importance of quality product development that involves flavors, consistencies, and textures that are favorable to customers (Stefoska-Needham & Tapsell, 2020).

Items Avoided

To further investigate the potential of sorghum to be popularized in the US, the researcher asked survey participants to provide information regarding the things that they consciously avoid when they are purchasing groceries. This question on the instrument provided six ingredients or attributes of products and asked them to report which they avoid. The choices listed included GMO, gluten, bread, wheat flour, wheat products, and grains. These choices were carefully considered and chosen by the researcher to specifically illustrate sorghum's potential with US consumers.

The most avoided item was products produced using GMO technology with 53.8% ($n = 361$) of participants reporting that they avoid GMOs. This is a beneficial avoidance to sorghum popularization because sorghum is yet to employ transgenic breeding strategies in its production and plant breeding trait development (Simply Sorghum, 2023). The following most avoided ingredient reported by respondents was gluten at 21.2% ($n = 142$). Mentioned throughout this study is the advantage that sorghum has over other grains due to the absence of gluten in its physical make up (Ducksbury, Neale, & Stefoska-Needham, 2021; Taylor & Duodu, 2019). This has both positive and negative implications for the potential of sorghum to be popularized. The advantage comes with the appeal that the gluten-free qualities of sorghum appeal to the large number of US consumers who are gluten intolerant (White, Bannerman, & Gillett, 2016). The disadvantage is that gluten is a binding agent, which is a factor in the

development of sorghum-based products (Ratnavathi & Patil, 2013). Gluten helps to hold ingredients together and products made with sorghum with the absence of these binders tend to be crumbly and do not share the same consistencies of products made with gluten containing grains such as wheat (Xiong, Zhang, Warner, & Fang, 2019).

Techniques to combat this include adding supplementary binding elements, such as xanthan gum or by using a mixture of sorghum flour and wheat flour (Ratnavathi & Patil, 2013). Although many successes have been made using these techniques, most notably in tortilla and flat bread production, the presence of gluten in these additives still presents a challenge for sorghum product development (Smith & Fredricksen, 2000).

The next most avoided items were bread, followed by wheat flour and then all other wheat products. The fact that all these items were reportedly avoided by respondents all contribute to the reinforcement of the distinct advantages that sorghum has over products made with other grains (Gobbetti et al., 2018). The sixth item listed in this question, which was the least avoided item, was the mention of grains in general. This is significant because of the fact that sorghum is a grain, this is a label that sorghum cannot avoid. Popular diets and healthy eating experts have suggested that avoiding grains could be beneficial (Jones, Garcia, & Braun, 2020). These recommendations tend to group all grains together, without accounting for the presence/ absence of components that are contained in different types of grains. Even so, this research data shows us that only 2.1% ($n = 14$) of respondents reported that they actively avoid grains in their diet.

Statements Likely to Influence Grocery Purchasing Selections

To further examine the potential of sorghum grain to be popularized among US consumers, the survey instrument listed seven statements specifically related to sorghum grain consumption. Respondents were prompted to report how likely each of these statements were to influence grocery purchases. The responses varied among participants and the ranking of which were most likely and least likely are discussed in the results chapter.

The overall takeaway from this collected data results from the fact that most respondents claimed that all these statements were in fact likely to influence them. The first statement asked if having never heard of a product was likely to influence them. The results show that 45.9% ($n = 308$) of participants reported that familiarity was likely to influence them. This strengthens the thinking that the lack of sorghum knowledge is the major and underlying barrier to seeing progress in the popularization of sorghum grain for human consumption in this country (Stefoska-Needham & Tapsell, 2020). These results also suggest that sorghum has significant potential as a popular food option in the US market. However, increased efforts to educate and inform consumers about the benefits of sorghum may be necessary to overcome the current lack of knowledge and familiarity with the grain (Ratnavathi & Patil, 2013).

The six statements included all reflected claims that sorghum grain could potentially be used in hypothetical future promotion and advertising efforts. These included a general health claim, gluten free, reduced fat, all-natural, high in protein, and the claim of a product to be environmentally friendly. As mentioned previously, all these statements were likely to influence consumers. The implications of this data direct us to

what information could potentially be highlighted in future informational, educational, and advertising campaigns.

Ranking of Product Attribute Importance

The final element of the survey instrument which was included to help answer RQ4 was a ranking of product attribute importance, which is illustrated in Figure 4.6. Respondents were provided with five product attributes and were asked to rank their relative level of importance in relation to the others. The results from this inquiry suggest that overall, the most important aspect that consumers consider over the rest is the price/value of products they are purchasing. Other attributes are considered, such as health benefits, familiarity, and environmental concerns respectively. This implies that these are all important requirements for consumers, but overall price/ value is considered either first or with higher consideration than the others.

There was also an implication related to this question that the researcher found particularly informative. The attribute that was ranked as least important for consumers in this ranking table was if they had seen the certain product advertised. This leads us to conclude that specific advertising of a product has its limitations in relation to the purchasing behavior of consumers. The findings related to these rankings imply that effective strategies for establishing sorghum as a popular food item advisedly should focus on providing consumers with a variety of products which are competitively priced. While advertising is crucial in increasing awareness and familiarity of specific products, the prominent availability of a variety of products incorporating sorghum as an ingredient is crucial in the establishment of popularization (Arendt & Zannini, 2013).

Implications and Discussion

In review, the research shows there is a significant knowledge gap among US consumers when it comes to sorghum and its uses. The majority of respondents in the survey had little to no knowledge about sorghum and had never consumed products made from it. This lack of familiarity is likely due to a combination of factors, including a lack of cultural background, and limited availability of sorghum-based products on grocery store shelves (Stefoska-Needham & Tapsell, 2020).

The results from this research show how the TPB framework comes into account amongst consumers and why this theory is useful in attempting to assess consumer behavior. The results show how individuals utilize the three belief categories when making their grocery purchasing decisions. Different individuals adhere to different belief categories when answering these questions, as a group we found that the responses did in fact utilize all three belief categories in their decision-making process.

For example, in reviewing the responses from the question which asked participants to rank the benefits of sorghum, we see that the sorghum being high in antioxidants was the most popular answer. This would suggest that behavioral beliefs were the belief category that was being considered when participants were responding to this question. In the question which asked respondents to report what would motivate them to eat sorghum products we see that the highest response was that sorghum is environmentally healthy. While the environmental benefits could be argued that they could be classified as pertaining to behavioral belief or normative beliefs, the researcher classified the environmental beliefs as normative. This was done in the idea that consumers want to contribute to a healthy environment for the benefit of not only

themselves but for society as a whole and for future generations. The consumer is not only considering what is good for themselves, they are also taking into account the opinions and well-being of those around them. In the question which prompted participants to rank the product attributes, the majority responded that the price or relative value of a product is often the aspect that is the deciding factor when grocery purchasing decisions are being made. This category of consideration clearly is adherent to the control beliefs category of the theoretical framework. If the product is not available and at a price which they can afford, then the considerations from all the belief categories will be overlooked.

The utilization of all three of the belief categories suggests there is not a single attribute or attitude that is preventing the popularization of sorghum products within US markets. Rather a multidimensional approach is what is being utilized by consumers when they are making their purchasing decisions while shopping for groceries. The implications of this point to the need for marketing and educational efforts which appeal to the consumer in terms of all three TPB belief categories to maximize their effectiveness. While simply telling consumers that sorghum products are healthy might persuade some consumers to want to try them, a multi-faceted approach would gather more attention. This could be done by informing individuals that sorghum is a healthy food, its production is more environmentally friendly than comparable grains, and it costs less because we are able to produce it closer to home.

While the listed stigmas and perceived negative ideas seemed to be of minimal importance to the majority of respondents, they still have the potential to be possible obstacles toward popularization. The negative idea that was most likely to deter consumers from consuming sorghum was the fact that sorghum is utilized in the US to

make fuel (ethanol). It is unclear as to what specific intentions lead to this being the most likely to deter sorghum consumption, this result solicits further research into this perception. The researcher assumes that this is because there is growing interest in moving away from our society's dependence on fossil fuels and the utilization of more bio-based fuels is one method employed to combat this (Liu et al., 2021). Regardless of the specific reason respondents ranked this to be the most concerning deterrent, it illustrates that this is a factor that needs to be addressed by the sorghum industry.

The results of this study indicate there is potential for sorghum to become a popular food source in the US. The absence of GMO technology and gluten in sorghum make it an appealing option for consumers who are concerned about these attributes (Simply Sorghum, 2023). Additionally, the nutritional benefits of sorghum and its potential to be a sustainable crop make it an attractive option for consumers who are mindful of their health, as well as environmental and social responsibility (Arendt & Zannini, 2013). However, the challenge lies in developing sorghum-based products that appeal to consumers' taste preferences and have the desired texture and consistency (Smith & Fredricksen, 2000).

Sorghum's ability to outperform other crops in relation to environmental stresses and its potential to increase available growing areas make it an attractive crop for sustainable agriculture (Akinseye et al., 2020). As concerns over food security continue to rise with the growing population and increased aridization in the US (Coleman-Jensen, Rabbitt, & Singh, 2020), the potential for sorghum as a sustainable food source becomes increasingly important (Khoddami et al., 2021). It is interesting to note that environmental factors ranked very high when consumers were asked about what would

motivate them to eat sorghum. Inversely, when consumers were asked to rank product attribute importance, environmental factors were ranked very low. The author attributes this to the respondents considering different TPB belief categories when answering different questions.

The findings suggest that there is an opportunity to educate consumers about sorghum and its potential use as a food item. Establishing a knowledge base for average consumers regarding the basic uses of sorghum as well as potential benefits of consuming this resource would greatly improve awareness. These educational opportunities could include increased marketing efforts to raise awareness, as well as efforts to make sorghum-based products more widely available to consumers (Stefoska-Needham & Tapsell, 2020). By doing so, sorghum has the potential to become a valuable food item in the US, particularly as food environments evolve and consumers are taking new considerations into account when purchasing groceries (Renner & Ringquist, 2016).

The research highlights the importance of balancing traditional value drivers such as taste and value, with evolving value drivers such as health and sustainability when introducing new food items to the market (Renner & Ringquist, 2016). Producers, marketers, commodity groups, and stake holders must consider the specific qualities of products that appeal most to consumers in today's markets. By doing so, producers and marketers can create products that appeal to a wide range of consumers, while also promoting the benefits of sorghum as a healthy and environmentally sustainable food source (Arendt & Zannini, 2013).

Recommendations

The recommendations that are solicited by the knowledge gained in this study point to the need for development of more sorghum-based convenience foods. It is apparent that with more options available to consumers, demand for these products will increase.

Popped Sorghum

One of the easier and more feasible methods to get these products integrated into the market is by introducing more popped sorghum options available for purchase. There are already several products available that are made from popped sorghum, but in researching these products it was found they are available to purchase from on-line retailers and not found at the grocery store. The integration of these products into local grocery retailers' stock would be advantageous to the increased consumer awareness of this resource.

Popped sorghum is very similar to popcorn in its taste, aroma, and consistency and could employ the consumer familiarity with popcorn as an advantage in marketing and promotion efforts. Popped sorghum by itself or with the addition of flavorings is inherently a convenience food as we see with a plethora of different popcorn-based snacks available for purchase at grocery and convenience type establishments.

The characteristic of sorghum being able to be popped like popcorn is a distinct advantage for several reasons. The first is that existing appliances that are meant to prepare popcorn such as air poppers, can be utilized in the preparation of popped sorghum. In addition, many recipes and techniques that exist for popcorn could

effortlessly be substituted with popped sorghum. This diminishes the idea that people do not know how to cook with sorghum and avoids the laborious and time-consuming processes that other home-made edible forms of sorghum require. In looking at this from a commercialization standpoint, popping sorghum also increases the volume of the raw commodity.

Price and Value

It was observed in this research that one of the most important qualities that consumers are basing their grocery buying decisions on is the price point and value as compared to similar products. While consumers are increasingly considering the mentioned evolving value drivers, such as health and social responsibility, how much a product costs are often put above other considerations.

It is recommended that in making these products more available, producers and retailers should employ practices to keep prices low. While there are some sorghum products currently available, the prices of these items appeared to be the same or higher than similar products made with other grains. Techniques to combat these higher prices should include things like employing local growers to produce food-grade sorghum and also to offer promotions and discounts to consumers.

As more sorghum products are introduced into the market, competition would lend itself to lower prices. As we see most current sorghum products marketed to a health food niche market, the prices could render sorghum products prohibitive to the cost-conscious consumer.

Marketing, Promotion, and Labeling

While the most prolific move toward the popularization of human consumption of sorghum in the US is getting more products on store shelves. It is recommended that these products be distinguished from other products by using marketing and promotional efforts to identify the benefits that sorghum inherently possesses.

Marketing and promotion of products can be utilized to increase the familiarity of specific products by presenting the benefits and uses of these products to the average US consumer. Simply getting exposure for these products in media advertising can establish increased awareness which could potentially lead to increased demand and utilization. Specific marketing efforts could highlight the positive aspects of sorghum products by appealing to the different TPB belief categories.

Marketing sorghum as a US grown crop would help to modify the current perception of sorghum as a strictly foreign utilized food source. Promotional efforts which establish sorghum as an alternative ingredient that could be used in already established familiar foods such as popcorn products would increase the demand for these products. This would also aid in the development of new products by displaying that sorghum inherently shares many of the same uses as more commonly used grains.

Consumers are increasingly aware of what they are putting into their bodies and how the products they are consuming affect their health. Marketing the health benefits of sorghum products would establish that these products are in fact healthy to consume, and they circumvent many of the detrimental effects of similar products produced with other grains.

Due to the average US consumer becoming increasingly aware of the detrimental effects of population growth on the earth, marketing sorghum products as environmentally conscious would appeal to a growing number of consumers. Everything humans consume and participate in contributes to the amount of carbon being released into the environment. Marketing that highlights that sorghum requires less agricultural inputs in its production when compared to other grains would help to establish the environmentally beneficial nature of sorghum grain consumption. In addition, marketing that identifies sorghum grain as a locally grown commodity would appeal to the environmentally conscious consumer.

In taking cues from the results of this study, it is apparent that labeling these products as non-GMO would appeal to a large demographic. While the author makes no claim to the validity of claims that products which employ GMO technology are inferior, the numbers show that this is something that is important to the average consumer. Promotional efforts highlighting the other listed benefits, such as gluten-free, healthy, and environmentally friendly are also value-added aspects that could set sorghum-based products above the rest.

Recommendations for Future Research

From the information derived from the conclusions of this study, several recommendations can be made for future research. These could include but are not limited to economic research, research to a broader demographic, and research into the labeling and marketing of sorghum products. Overall, these recommendations could help to inform future research efforts aimed at promoting the growth and development of the

sorghum industry and expanding the availability and consumption of sorghum-based products.

Economic Research

The current study showed that consumers consider various factors related to the three belief categories of the TPB, when making purchasing decisions. It was noted that the price/value of a product is a crucial factor that can influence consumers' choices when shopping for groceries. Future research could further explore the economic factors that affect consumers' purchasing decisions, such as inflation and supply chain issues, and how these factors may impact their decision-making process.

Additionally, future economic research could investigate the factors that would influence consumers' willingness to pay a higher price for specific products based on their behavioral and normative beliefs. For instance, a study could examine how consumers' attitudes towards sustainability or health-related benefits impact their willingness to pay more for sorghum-based products. Such research could provide valuable insights into the potential for promoting the growth and development of the sorghum industry by highlighting the factors that influence consumers' willingness to pay a premium for sorghum-based products.

Research on Additional Demographics

Future studies should aim to investigate the understanding and opinions of consumers who possess characteristics that differ from those examined in this study. To achieve this, researchers can consider utilizing a more extensive sample size to yield outcomes that are more representative and inclusive of a diverse range of demographics.

This would ultimately offer more substantial evidence regarding consumer perceptions. Exploration of consumers' knowledge and perceptions across a broader population would be valuable in informing educational communications regarding the consumption of sorghum. Additionally, it may assist in developing effective marketing and promotional strategies.

Market research efforts could attain an alternative point-of-view by measuring a different target population, specifically adolescents. Further research into adolescent opinions would offer new insights into product development, being that views of consumers who are not responsible for grocery buying would encompass more sensory type input. Focusing on this alternate demographic could also decrease the considerations regarding economic environment and could possibly increase the environmental and sustainability considerations due to increased consideration into future societal food security.

Labeling and Marketing Research

This research identified several aspects or qualities of products that consumers purposely tend to avoid. The question as to why these things are avoided was not addressed during this study. A more in-depth study into why specific things are avoided could lead to identification of misinformation which could be a deciding factor when researching consumer food choice decisions.

Conducting additional research to investigate the effectiveness of third-party labels on sorghum products would be valuable in assessing the benefits these labels provide to consumers. Many product packages feature labels such as "non-GMO,"

"gluten-free," and "environmentally friendly." Examining the impact of these labels, particularly with regards to sorghum products, could offer insights into effective marketing and promotional strategies aimed at increasing the popularity of these products. Understanding how these labels influence consumer behavior when selecting sorghum products could help to enhance the visibility of sorghum-based food items in the marketplace.

Conclusion

Increased outreach and educational efforts appear to be crucial in the effort to popularize human consumption of sorghum products in the US. The average consumer has little to no knowledge of sorghum grain or how it is used and how it could potentially be used. In educating consumers about sorghum, it is apparent there is potential for sorghum to become a more mainstream ingredient in many of the foods that we already enjoy. Continued stakeholder collaborations between academia, plant breeders, growers, commodity groups, food-product manufacturers, and retailers appear to be the basis of enhancing the knowledge base of the benefits of sorghum (Khoddami et al., 2021). The popularity of sorghum as a food component is on the rise, particularly in Western societies where it is not traditionally consumed. Although there is an emerging body of food and nutrition research that supports this trend, gaining consumer acceptance will require a steadfast dedication to food innovation and the promotion of sorghum as a viable human food source (Stefoska-Needham & Tapsell, 2020).

Overall, this research highlights the importance of understanding consumer knowledge and awareness regarding the introduction of new food items into the market. Without sufficient knowledge and awareness, even valuable food items like sorghum may

struggle to gain a foothold in the market. The data collected from this study provides valuable insights into the factors that consumers consider when making grocery purchasing decisions. This information could help guide the development of new sorghum-based products, as well as educational efforts, and the marketing/ promotion of this valuable resource.

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APPENDICES

APPENDIX A

IRB APPROVAL



Oct 26, 2022, 8:18:07 AM CDT

Erica Irlbeck
Ag Education and Communication

Re: IRB2022-754 Exploring factors that prevent the popularization of sorghum grain for human consumption in the United States

Findings: *Good luck with your research.*

Dear Dr. Erica Irlbeck, Robert Cummins, Scott Burris, Matthew Nesbitt:

The Human Research Protection Program determined that your project meets at least one of the federal exempt categories under 45 CFR 46

Category 2. (i). Research that only includes interactions involving educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior (including visual or auditory recording).

The information obtained is recorded by the investigator in such a manner that the identity of the human subjects cannot readily be ascertained, directly or through identifiers linked to the subjects.

The determination was made on October 25, 2022. Annual review is not required, and no expiration date will be listed on your letter.

The research must follow Texas Tech University's Operating Procedures, the Belmont Report, and 45 CFR 46. If changes to the approved protocol occur, a **Modification Submission** must be reviewed and approved by the IRB before implementation. Please contact the Human Research Protection Program to determine if a modification is needed or submit a Modification Submission in Cayuse IRB. Please be aware that changes to the research protocol may prevent the research from qualifying for exempt review and require submission of a new IRB application or other materials to the Texas Tech University IRB.

A goal of the IRB is to prevent negative occurrences during any research study. However, despite our best intent, unforeseen circumstances or events may arise during the research. If a deviation, unanticipated problem or adverse event happens during your research,

please notify the Texas Tech University, Human Research Protection Program as soon as possible (45 CFR 46). We will ask for a complete explanation of the event and for you to submit an **Incident Submission** in Cayuse IRB.

Your study may be selected for a Post-Approval Monitoring (PAM). You will be notified if your study has been chosen for a PAM. A PAM investigator may request to observe your data collection procedures, including the consent process.

Once your research is complete, please use a **Closure Submission** to archive this study. IRBs that remain active are subject to audit by the IRB.

Sincerely,

ORIGINAL SIGNATURE

AVAILABLE ON REQUEST

Martin Binks, Ph.D.
Chair, Texas Tech University Institutional Review Board
Director, Nutrition & Metabolic Health Initiative (NMHI)
Professor, Department of Nutritional Sciences, College of Human Sciences

Human Research Protection Program
357 Administration Building
Lubbock, Texas 79409-1075
T 806.742.2064
www.hrpp.ttu.edu

APPENDIX B**RESPONDENT LOCATION BY STATE***Respondent Location by State (n = 670)*

Location	Frequency (n)	Frequency Percent (%)
State		
Alabama	12	1.8
Alaska	2	0.3
Arizona	26	3.9
Arkansas	7	1.0
California	74	11.0
Colorado	14	2.1
Connecticut	9	1.3
Delaware	4	0.6
District of Columbia	1	0.1
Florida	39	5.8
Georgia	19	2.8
Idaho	7	1.0
Illinois	24	3.6
Indiana	13	1.9
Iowa	1	0.1
Kansas	6	0.9
Kentucky	12	1.8
Louisiana	9	1.3
Maryland	8	1.2
Massachusetts	15	2.2
Michigan	22	3.3
Minnesota	8	1.2
Mississippi	1	0.1
Missouri	17	2.5
Montana	8	1.2
Nebraska	6	0.9
Nevada	12	1.8
New Jersey	13	1.9
New Mexico	5	0.7
New York	23	3.4
North Carolina	24	3.6
Ohio	28	4.2
Oklahoma	9	1.3
Oregon	15	2.2

Pennsylvania	40	6.0
Rhode Island	2	0.3
South Carolina	7	1.0
South Dakota	4	0.6
Tennessee	23	3.4
Texas	39	5.8
Utah	9	1.3
Virginia	14	2.1
Washington	16	2.4
West Virginia	10	1.5
Wisconsin	13	1.9

APPENDIX C

SURVEY INSTRUMENT

Popularization of Sorghum

Start of Block: Demographics

Hello and thank you for participating in this survey.

The purpose of this survey is to gauge attitudes and beliefs of US consumers regarding the human consumption of sorghum grain and products made from sorghum grain.

Sorghum is a cereal grain that is grown in many parts of the world. Sorghum shares many of the same uses as more popular grains such as corn. In most places where sorghum is grown a large portion of the crop is consumed by humans. Even though the US is the top producer of sorghum grain, it is yet to be popularized as a commodity for human consumption in this country.

It is our hope that this survey research will help to identify some of the possible motivations as well as any barriers that exist for consumers concerning the utilization of sorghum grain.

This survey will take approximately 15 minutes to complete. Your participation is completely voluntary. There is no penalty for not participating. There are no direct benefits to you for participating in the study. You can withdraw from the survey at any time without penalty. All answers are confidential to the extent provided by law. There are no known risks associated with this study.

Please read each question carefully and provide an appropriate and thoughtful response. If you would like to learn more about this study, please contact Dr. Erica Irlbeck by e-mail at erica.irlbeck@ttu.edu. For questions about your rights as subjects, contact the Human Research Protection Program, Office of the Vice President for Research, Texas Tech University, Lubbock, Texas 79409 by mail or phone at (806) 742-2064.

By proceeding into the survey you agree that you have read this statement, are aware of your rights, and agree to participate.

Q61 In which state do you currently reside?

▼ Alabama (1) ... I do not reside in the United States (53)

Skip To: End of Block If Q61 = I do not reside in the United States

Page Break

Q23 Age: What is your age?

- 18-24 (1)
- 25-40 (2)
- 41-55 (3)
- 56-65 (4)
- 66 or older (5)

Skip To: End of Block If Q23 = 18-24

Page Break

Q24 Ethnicity (or race): Please specify your ethnicity.

- Non-resident Alien (1)
- Hispanics of any race (2)
- American Indian or Alaska Native (3)
- Asian (4)
- Black or African American (5)
- Native Hawaiian or pacific islander (6)
- White (7)
- Two or more races (8)
- Race or ethnicity unknown (9)
- Other (10)
- Prefer not to respond (11)

Page Break

Q25 Gender: What is your gender?

- Male (1)
- Female (2)
- Non-binary / third gender (3)
- Prefer not to say (4)
- Other (5)

Page Break

Q29 Marital Status: What is your marital status?

- Single (1)
- Married (2)
- Separated (3)
- Divorced (4)
- Widowed (5)

Q30 Parental Status: Do you have children?

- Have children (1)
- Do not have children (2)

Page Break

Q31 Housing: Which best describes where you currently live?

- City/ Urban- A settlement with high population density and built infrastructure. (1)
 - Suburban- A residential district located on the outskirts of an urban area. (2)
 - Rural- All people, housing and territory that are not within an urban area. (3)
-

Q33 Income: What is your total annual income before taxes?

- less than \$30,000 (1)
 - \$31,000-\$50,000 (2)
 - \$51,000-\$80,000 (3)
 - \$81,000- \$100,000 (4)
 - \$101,000-\$150,000 (5)
 - \$150,000 + (6)
-

Q35 Politics: How would you describe your political views?

- Conservative (1)
- Moderate (2)
- Liberal (3)
- Other (4)

End of Block: Demographics

Start of Block: Dietary Requirements

Q1 Does anyone in your household suffer from gluten intolerance?

- Yes (1)
 - No (2)
-

Q4, Do you avoid any of the following in your diet? Check all that apply.

- Wheat flour (1)
- Gluten (2)
- Any wheat products (3)
- Any grains (4)
- Any breads, such as sliced, rolls, sandwich buns, tortillas, biscuits, pancakes, with or without wheat (5)
- GMOs (6)

End of Block: Dietary Requirements

Start of Block: Sorghum Knowledge

Q57 Prior to taking this survey, had you ever heard of sorghum?

- Never heard of it (1)
 - I've heard of it, but I know little about it (2)
 - I am knowledgeable about sorghum (3)
 - I know a lot about sorghum (4)
-

Q7 Have you ever seen sorghum/ milo growing in the field?

Yes (1)

No (2)

Page Break

Q9 Do you know what sorghum grain is used for in the United States?

Yes (1)

No (2)

Q10 Do you know what sorghum grain is used for in other parts of the world?

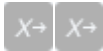
Yes (1)

No (2)

Page Break

Q58 Have you consumed sorghum as a food ingredient?

- Never (1)
 - If I have, I do not know. (2)
 - Infrequently (purchase food with sorghum as an ingredient fewer than three times per year) (3)
 - Often (purchase food with sorghum as an ingredient four to six times per year) (4)
 - Sorghum is a regular part of my diet, I consume it at least once per month (5)
-



Q12 If you have eaten sorghum, how often do you eat it?

- On Occasion (1)
 - Yearly (2)
 - Monthly (3)
 - Weekly (4)
 - Daily (5)
-

Q60 What motivates you to use products made with sorghum?

- I like the taste (1)
- Health problems (2)
- Weight loss (3)
- It is served at home (4)
- It is healthy (5)
- It is environmentally responsible (6)

End of Block: Sorghum Knowledge

Start of Block: Purchasing Habits

Q21 Would any of these aspects about sorghum be likely to deter you from purchasing a product made with sorghum?

Extremely
unlikely









Somewhat
unlikely

Neither
likely
nor
unlikely

Somewhat
likely

Extremely
likely

1 2 3 4 5

I didn't know sorghum was for human consumption. ()	
Sorghum is mostly eaten by people in 3rd world countries. ()	
Farmers feed sorghum to their animals. ()	
I like corn and corn does all the things that sorghum does. ()	
Sorghum is used to make fuel (ethanol). ()	
I don't know how to cook with sorghum. ()	
I don't know anybody that eats sorghum. ()	
It is not as readily available as other food products in supermarkets ()	

Page Break

Q22 The following are benefits of eating sorghum grain that have been identified by others. Please rank (drag and drop) these potential benefits of consuming sorghum grain products by what is most important to you.








1 being most important, 6 being least important.

- _____ Gluten free (1)
- _____ High in antioxidants (2)
- _____ Locally available (3)
- _____ Low price (4)
- _____ Environmentally friendly (5)
- _____ Sustainable food source (6)

Page Break

Q56 Which of these statements are likely to influence your grocery purchasing selections?

Extremely unlikely	Somewhat unlikely	Neither likely nor unlikely	Somewhat likely	Extremely likely
1	2	3	4	5

I have never heard of the product before ()	
The product claims to be healthy ()	
The product is gluten free ()	
The product is reduced fat ()	
The product is all natural ()	
The product is high protein ()	
It claims to be environmentally friendly ()	

Page Break

Q20 When you are selecting groceries, which of these criteria are most important/ least important to you?

Please drag and drop in order (1-5) from greatest importance (1) to least importance (5)

- _____ Price/ value (1)
- _____ Health benefits (2)
- _____ The same product you always get (3)
- _____ You saw it advertised (4)
- _____ Environmentally friendly (5)

Page Break

Q48 Does anyone in your household suffer from a food allergy?

- Yes (1)
- No (2)

Q3 If yes, please list below.

End of Block: Purchasing Habits
