A quantitative and qualitative study on university students' perceptions of soy-based food products and the aspects that influence these perceptions

by

Sadaf Azhar

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Major Professor

Kelly J.K. Getty

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Abstract

With the global population expected to surpass nine billion by 2025, there is an urgent need for sustainable plant-based protein alternatives. Soybeans, rich in essential amino acids, have emerged as a leading alternative protein source. This research investigates university students' perceptions, knowledge, and consumption patterns of soy-based food products, leveraging both qualitative and quantitative research methods, and develops a scalable soy taco crumble for university dining services.

The initial phase of the study employed a qualitative research design using focus group discussions to explore students' perceptions of soy-based food products. Participants were recruited through a pre-survey and by posting flyers in the university dining centers and residence halls, resulting in two focus groups, each consisting of five and six participants. Discussions, guided by a structured questionnaire, were audio-recorded, transcribed, and analyzed using thematic analysis. Six main themes emerged: 1) awareness of soybeans and soy products was influenced by past experiences and exposure, either geographical or educational; 2) participants had limited knowledge about soy's nutritional value but recognized it as a protein source; 3) a preference for familiar foods was noted, but participants were receptive to innovative products; 4) a preference for new soy products in savory dishes were favored, culinary insights were shared; 5) concerns about soy-related stigma were highlighted; and 6) a preference for well-organized infographics was emphasized. These findings underscore the need for educational initiatives to raise awareness about soy's nutritional benefits and suggest that product development should balance familiarity and innovation to cater to diverse tastes.

In the second phase, an online survey was conducted to quantitatively assess students' attitude, social norms, and perceived behavioral control concerning the intention to consume soy-

based food products, leveraging the Theory of Planned Behavior (TPB) as a framework. The survey targeted students' dining at the university's dining centers, with seventy-six respondents completing the survey. The study created four infographics with different titles (meat-alternative protein, plant-based protein, soy-based protein, and soybean-based protein) to determine the effectiveness of infographics in influencing consumer consumption behavior. Results indicated that all infographics positively influenced students' intentions to consume soy-based foods. The "plant-based protein" infographic showed the highest reliability ($\alpha=0.808$), followed by "soy-based protein" ($\alpha=0.736$). Positive attitudes had a strong correlation with intention across all infographics, with coefficients ranging from 0.623 to 0.784 ($p<0.001$). Social norms also showed positive relationships with intention, particularly for the "plant-based protein" ($r=0.731$, $p<0.001$) and "soy-based protein" ($r=0.556$, $p=0.002$) infographics. Infographic presence increased the consumption of soy taco crumble in university dining centers, with twenty consumers compared to nine without the infographic.

The final phase focused on developing and scaling up a texturized soy protein taco crumble. The formulation was optimized and evaluated for physicochemical properties such as moisture content, pH, color, cooking loss, and water-holding capacity to ensure product stability and quality under typical dining center conditions. Key physicochemical properties included moisture content (freshly cooked product retained the same moisture during holding for 60 minutes, while refrigerated samples for 3 and 7 days had reduced moisture content), cooking loss (13.22 ± 3.07), and water-holding capacity (96.44 ± 1.14). Sensory evaluations among 208 students and dining center staff using the nine-point Hedonic scale (1=dislike extremely, 9=like extremely) demonstrated high acceptability, particularly for aroma, flavor, and seasonings, with overall acceptability scores of 7.54 ± 1.17. For cooked taco crumble, pH was 6.47 ± 0.12, and color

was L*=39.63±4.26, a*=15.64±0.81, and b*=29.35±0.98. Nutritional analysis showed that one serving containing 2 ounces (67g) contained 11 grams of protein, 4 grams of dietary fiber, and 100 calories, with a cost of $0.18 per serving. Over 82% of the students tasting the product were willing to consume the product again in the dining center, with several students commenting that they could not tell the product was plant-based.

In conclusion, this research successfully developed a scalable soy taco crumble that aligns with consumer preferences for taste, texture, and sustainability for university students. Through ongoing commitment to product refinement, education, and addressing societal preconceptions, soy-based products can significantly contribute to a diverse and sustainable food ecosystem.

Keywords: Soy-based food, university students, nutritional awareness, food preferences, consumer education, Theory of Planned Behavior, consumer behavior, sustainable plant-based protein, soy taco crumble, plant-based meat alternative, food product development, sustainable protein sources.

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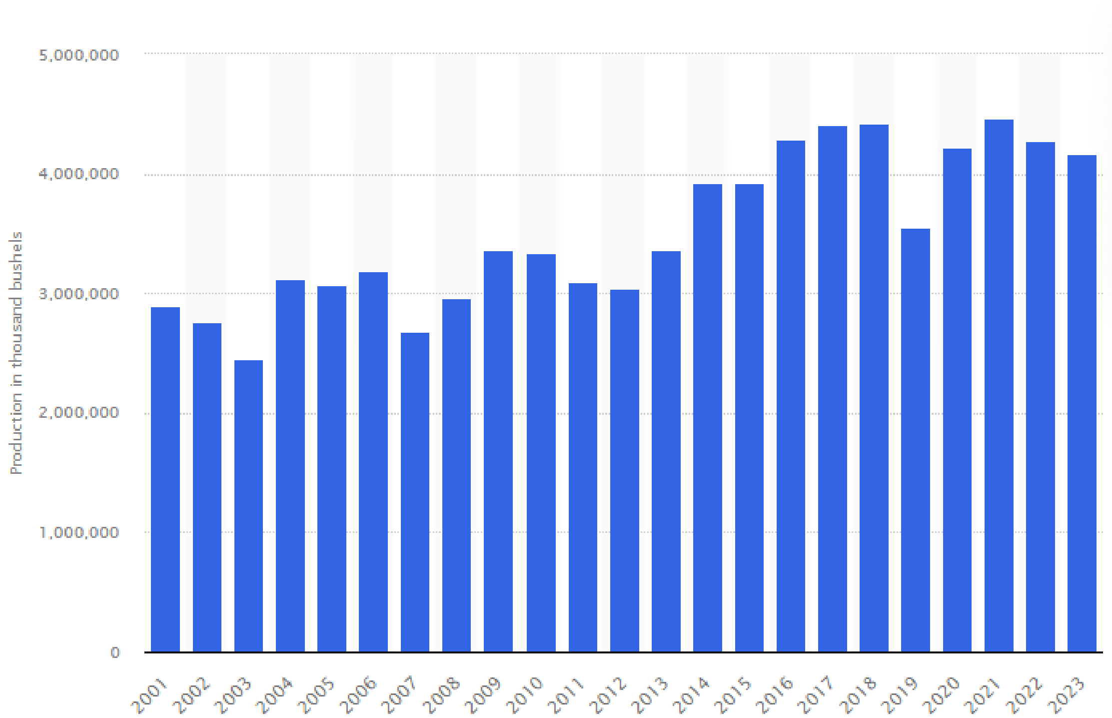
Chapter 1 - Introduction

1.1 Overview

Soybeans (*Glycine max* (L.) Merr.) are one of the most abundant crops that are produced globally, having a very long history of safe use in human nutrition (Dias et al., 2024). The United States of America (U.S.) and Brazil are the leading producers of soybeans, with Brazil producing 139 million metric tons in 2021/2022. In 2023, the U.S. produced approximately 4.16 billion bushels of soybeans. The value of soybean production in the U.S. experienced growth, escalating from around 36.8 billion U.S. dollars in 2018 to about 57.5 billion U.S. dollars by 2021. (U.S. Department of Agriculture, 2024).



Adapted from US Department of Agriculture, 2024.

Figure 1.1 Production of soybeans in the U.S. from 2001 to 2023.

Soybeans are a cost-effective source of high-quality plant-based protein. The incorporation of soy-based ingredients in different food formulations intends to enrich the food with a higher protein while reducing the overall food cost compared to other animal-based proteins (e.g., meat or dairy) (Dias et al., 2024). Proteomic analysis through liquid chromatography with tandem mass spectrometry (LC-MS-MS) revealed that soybeans contain 209 unique proteins, including the nine essential amino acids necessary for a balanced human diet, confirming soybeans status as a complete protein source (Capriotti et al., 2014). This comprehensive protein profile has led to its widespread use in the food industry, both as a primary ingredient in various food products like tofu, tempeh, soy milk, edamame, and soy sauce (Kumar et al., 2022) and as food additives like soy lecithin, soy flour, soy oil, and texturized vegetable protein (TVP) (Modgil et al., 2020; Rybowska, 2016). Historically, soybeans can be utilized to make food products such as soy milk, soy sauce, miso, tofu, and tempeh which are staples in Asian cuisine. Soybeans also produce a variety of food products including pastes, spreads, and replacements for common cereal-based foods, dairy, and meat products (Sadler, 2004). Specifically, soy milk is a key ingredient in the production of tofu, soy yogurt, and various cheeses.

Soybean seeds are composed of 39-45% protein, which imparts them with various functional characteristics like emulsification, binding, gelling, textural enhancement, and a high capacity for water retention (Wiederstein et al., 2023). Owing to their rich protein content and status as a complete protein source, soybeans are the most used vegetarian protein. Soybeans account for nearly 70% of the global protein meal consumption (Wiederstein et al., 2023). As the world's population is expected to reach 9.5 billion by 2050 (Reynolds et al., 2015), plant-based sources are anticipated to provide a significant share of human nutritional needs.

As the global population rises, the need for meat alternatives intensifies, leading to a surge in research on proteins from plants, fungi, insects, and animal stem cells to create meat-like products (Michel et al., 2021; Shaghaghian et al., 2022). Traditional methods like extrusion are being refined to improve the texture of textured vegetable protein (TVP), ranging from low moisture extrusion (20-40%) to high moisture extrusion (40-80%), with better nutritional value (Dekkers et al., 2018; Lee et al., 2022; Zhang et al., 2019; Riaz, 2001). Although there is a market prevalence toward low moisture TVP's, research is geared towards enhancing TVP's texture to resemble meat more closely, considering factors like extrusion technology (Herz et al., 2021; Alam et al., 2016; X. Zhang et al., 2022; Choi et al., 2022; Choi et al., 2023).

Consumer behavior and preferences, a continually evolving field, enables marketers with knowledge to anticipate consumer food choices, buying habits, and preferences. The success of a new food product relies on consumer acceptability and perceptions, as these factors are decisive in whether the product will be accepted or rejected (Kwasny et al., 2022; Diaz et al., 2022; Kerslake et al., 2022). Over the past five years, research into consumer perceptions of soybeans has focused solely on topics such as genetically modified soybean oil (Zhang et al., 2021), plant-based milk alternatives (Moss et al., 2022), the quality of soybean milk (Kurnianto et al., 2020), and various plant protein substitutes (Possidónio et al., 2021). Numerous studies have been conducted to gauge consumer perceptions and attitudes toward plant-based food products and meat alternatives (Hwang et al., 2020; Escribano et al., 2021; Bryant & Sanctorum, 2021; Hartmann et al., 2022), yet specific research focusing on consumer perceptions of texturized soy-protein is absent. Moreover, there has been a lack of studies specifically addressing consumer perceptions of soy-based food products among university students and/or a young population aged 18 to 24.

Qualitative and quantitative methodologies are instrumental in grasping consumer perceptions. Focus groups and online surveys are often used to collect data regarding consumer perceptions (Schiano et al., 2020). Focus group discussions are a prevalent qualitative approach to gaining in-depth insights into social matters. Focus groups involve collecting insights from a purposefully selected group of individuals, rather than from a statistically representative segment of a broader population (O. Nyumba et al., 2018). For quantitative research, online surveys are increasingly favored for data collection (Saleh & Bista, 2017). The growing preference for online surveys is due to several advantages, such as lower research costs, quicker deployment times, fewer transcription errors, and easier data analysis (Saleh & Bista, 2017).

Infographics have become a preferred method of communication as they quickly capture interest, distill intricate ideas, and link elements of complex subjects (Damman et al., 2018). In qualitative research, particularly when gathering perceptions, the use of infographics has become a popular method, due to their easy comprehension and assimilation of complex information (Jacob, 2020). In today's fast-paced and complex society, people favor receiving information more insightfully. Furthermore, infographics, especially when used in the context of health-related information, can influence consumer behavior (Jacob, 2020).

Despite the growing demand for alternative proteins and the advancement of plant-based texturization methods, there remains a research void concerning consumer attitudes towards soybean-based protein food products, particularly texturized soy protein products. This study comprises five primary objectives. Firstly, it aims to gather qualitative data about university students’ perceptions of soybeans and soy-based food products. Secondly, it seeks to create four infographics based on the qualitative insights derived from students' perceptions. Thirdly, it involves assessing university students' opinions of the infographics and messages through a survey instrument to find the effects of infographics on students' perceptions of soy-based food products. The fourth objective is to develop new texturized soy-based food products to be served in the dining centers for Kansas State University students. Lastly, the study aims to determine if the presence of an infographic alongside the texturized soy-based food product influences students' willingness to consume the new soy-based products more. By pursuing these objectives, the research study strives to acquire valuable insights into students' perceptions of soybean and soy-based food products, develop effective infographics that are evaluated by the student population, evaluate consumer behavior towards new soy-based food products, and contribute to the improvement of soy-based offerings within university dining centers.

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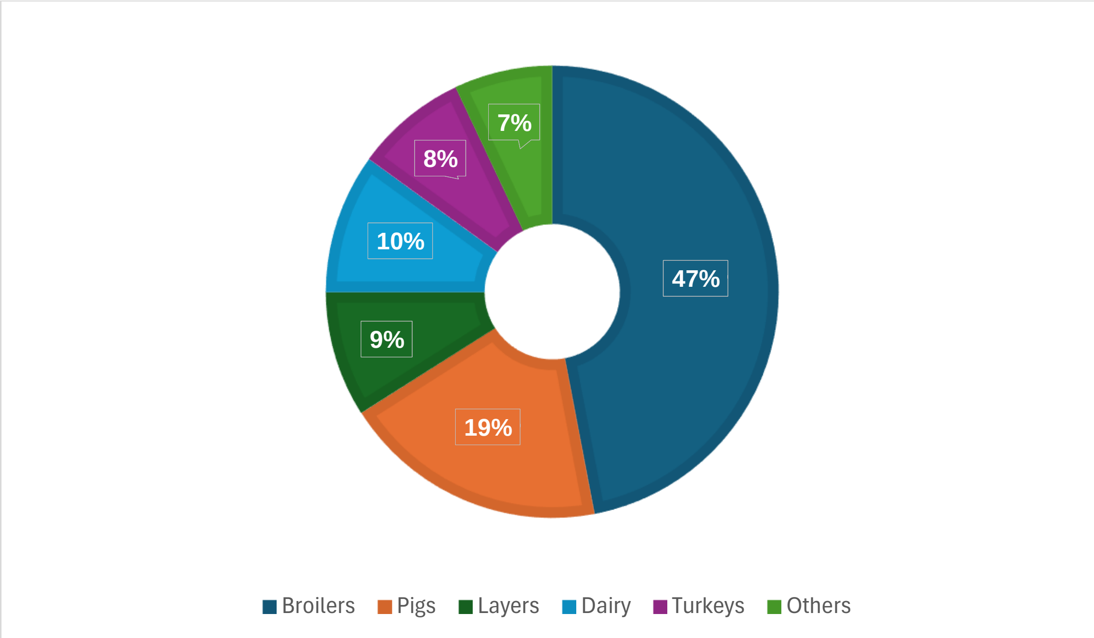
Chapter 2 - Review of Literature

2.1 Soybeans

The soybean, scientifically known as Glycine max (L.) Merr., is a legume crop that originates from East Asia (Perkins, 1995). The term "soy" originates from the Japanese word "shoyu" and is commonly utilized in Asia to produce tofu, soy sauce, and miso (Cheng, 2017). The cultivation of soybeans in the United States (U.S.) began in the 19th century but the demand for soybeans surged in the mid-20th century, driven by the U.S. food processing industry and livestock farming. Presently, the U.S. holds a significant position as a worldwide producer of soybeans (Vaiknoras & Hubbs, 2023).

Worldwide the primary consumers of soybean products are livestock animals. Farmers depend on high-quality feed, rich in nutrients from soybean meal, to nourish various animals such as chickens, pigs, turkeys, cattle, and fish. These animals require consistent levels of quality protein and digestible energy for growth, all of which are found in soybean meal (United Soybean Board, 2022). Soybean meal refers to the product obtained from grinding soybean cake, soybean chips, or soybean flakes. The United States Department of Agriculture (USDA) indicates that soybean meal consumed in the U.S. is distributed across several sectors of animal agriculture (United Soybean Board). The U.S. total 2020 soybean meal consumption in the animal agriculture sector is shown in Figure 2.1.



Adopted from (*Soybean Meal Information Center*. 2020)

Figure 2.1 Total U.S. animal agriculture soybean meal consumption in 2020.

Soybeans also provide high plant-based protein, complete with essential amino acids and nutrients for human consumption. The amino acid composition of soy flour is shown in Table 2.1. The comparison of amino acid content in wheat, soy, egg, milk, pea, and oat is summarized in Table 2.2. It should be noted that soy has the next highest level of amino acids amount plant-based proteins compared to pea proteins.

Table 2.1 Amino acid composition of soy flour.

Amino Acids	Amino acid content (g/100g)
	Soy Flour
Alanine	4.0
Arginine	7.0
Aspartic acid	11.3
Cystine	1.6
Glutamic acid	17.2
Glycine	4.0
Histidine	2.7
Isoleucine	4.9
Leucine	8.0
Lysine	6.4
Methionine	1.4
Phenylalanine	5.3
Proline	4.7
Serine	5.0
Threonine	4.2
Tryptophane	1.2
Tyrosine	3.9
Valine	5.3

Note. Adapted from (Perkins, 1995)

Table 2.2 Essential amino acid content comparison among common protein sources.

Amino Acids	Amino acid content (g/100g)					
	Wheat	Soy	Egg	Milk	Peas	Oat
Threonine	1.8	2.3	2.0	3.5	2.5	1.5
Methionine	0.7	0.3	1.4	2.1	0.3	0.1
Phenylalanine	3.7	3.2	2.3	3.5	3.7	2.7
Histidine	1.4	1.5	0.9	1.9	1.6	0.9
Lysine	1.1	3.4	2.7	5.9	4.7	1.3
Valine	2.3	2.2	2.0	3.6	2.7	2.0
Isoleucine	2.0	1.9	1.6	2.9	2.3	1.3
Leucine	5.0	5.0	3.6	7.0	5.7	3.8
[1]ΣEAA	18.0	19.9	16.5	30.3	23.6	13.7

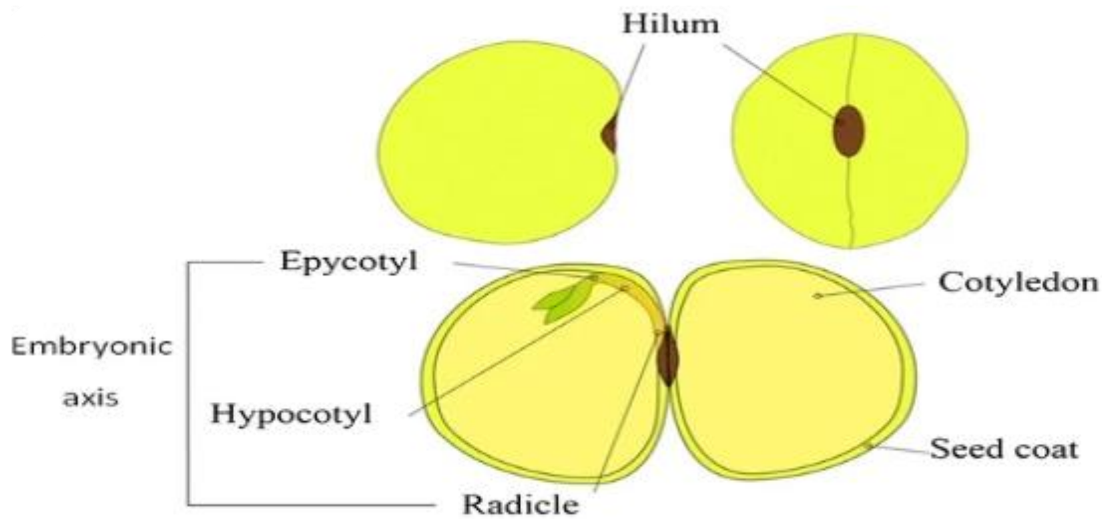
[1]ΣEAA sum of all essential amino acids

Note. adapted from Gorissen et al. (2018)

Soybean meal contributes protein to items such as protein bars, meat substitutes, and soymilk. The Food and Drug Administration (FDA) has acknowledged research suggesting that consuming 25 grams of soy protein daily, as part of a diet low in saturated fat and cholesterol, may lower the risk of heart disease. This claim is also allowed to be used on food labels (21CFR101.82). Soybean oil is the most prevalent vegetable oil in the U.S., often labeled and sold simply as vegetable oil. In the U.S. 52.3% of the soybean oil used is consumed by the food industry (United Soybean Board, 2022).

2.2 Structure of Soybeans

Soybeans, known for their spherical shape, exhibit significant variation depending on the cultivar and growing conditions. A mature soybean seed comprises two main parts: the seed coat or hull, and the embryo (Figure 2.1). The embryo, which constitutes 90% of the seed's weight, is made up of two cotyledons and an embryonic axis, which includes the radicle, hypocotyl, and epicotyl (Medic et al., 2014; Wolf, 1972). Within the seed coat lies the hilum, which serves as the point of attachment to the pod. The soybeans are classified as dicotyledon seeds due to their two cotyledons that are held together by the seed coat (hull) (Perkins, 1995). As the seed starts to germinate, the cotyledons function as a source of nutrients for the emerging plant (Cheng, 2017). The radicle develops into the primary root, the hypocotyl elevates the cotyledons and epicotyl above the soil, and the epicotyl grows into the stem of the plant (Medic et al., 2014).



Adopted from (Kawamura, 1967)

Figure 2.2 Structure of soybean seed.

2.3 Composition of Soybeans

The composition of soybeans is approximately 8% seed coat, 90% cotyledons, and 2% embryonic axis (Perkins, 1995). The seed coat contains cellulose, hemicellulose, and valuable minerals like zinc and iron. The cotyledon consists of elongated palisade-like cells rich in oil and protein in the form of oil and protein bodies (Smith & Circle, 1972). The nutritional makeup of a soybean seed is primarily protein, constituting 37% of its content. Additionally, it contains 24% fatty acids and 34% carbohydrates, underlining the seed's rich nutrient profile. The chemical composition of soybeans and their components are shown in Table 2.3.

Table 2.3 Chemical composition of soybeans and their components (dry weight basis).

Components	Yield (%)	Protein (%)	Oil/Fatty Acids (%)	Carbohydrate (%)	Ash (%)
Whole seed	100	37	24	34	5
Seed coat (hull)	7.3	9	1	86	4
Cotyledons	90.3	43	23	29	5
Embryonic axis	2.4	41	11	44	4

Source: (Kawamura, 1967; Perkins, 1995).

2.4 Soybean Protein

On a dry-weight basis, soybean seeds typically consist of about 40 to 41% protein (Krishnan, 2000). Soybean proteins are stored in distinct spherical subcellular compartments known as protein bodies, located in the palisade-like cells of soybean cotyledons (Bair & Snyder, 1980). The diameters of these protein bodies typically range from 2 to 20 μm, with an average size of 8 to 10 μm (Snyder & Kwon, 1987).

While soybeans serve as a substantial protein source for both livestock and humans, the nutritional value of their proteins is not ideal. Several issues linked with soybean proteins include the existence of anti-nutritional elements like trypsin inhibitors, an unfavorable beany taste, the potential to trigger allergic responses in sensitive individuals, subpar digestibility of the proteins, and a lack of sulfur-containing amino acids. There are ongoing dedicated efforts to enhance the overall nutritional quality of soybean proteins, employing both traditional plant breeding techniques and modern molecular biology methods (Krishnan, 2000).

Soy protein isolates and concentrates are widely used in making plant-based meat alternative products due to their availability, cost-effectiveness, ability to provide a meat-like texture and flavor upon hydration, and a well-balanced amino acid profile (Sun et al., 2021).

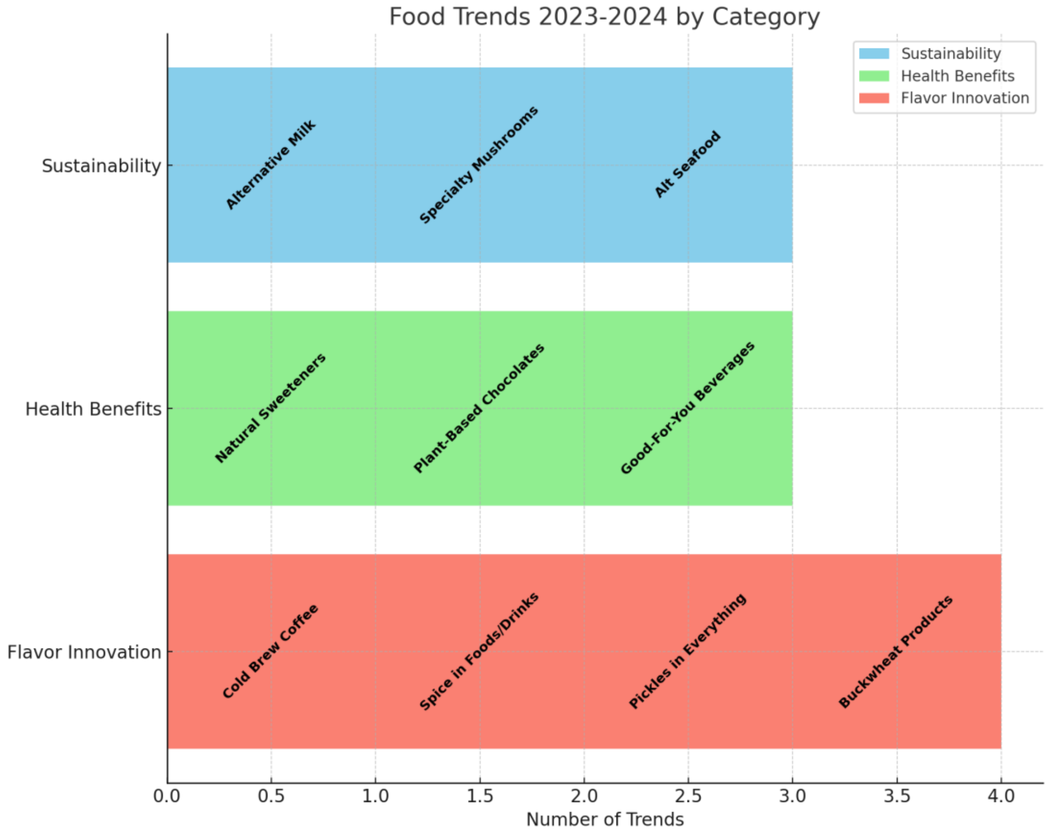
Soybeans are rich in two primary proteins, β-conglycinin (trimeric) and glycinin (hexameric), with molecular weights ranging from 150–380 kDa and an isoelectric point between 4.5–5 (Asgar et al., 2010; McClements et al., 2021). The texture and sensory characteristics of soy-based meat analogs are influenced using soy flour, soy protein isolates, and concentrates (Joshi et al., 2015). Soy protein in its various forms—such as isolate, concentrate, textured, and flour—is employed in meat substitutes for its nutritional value, fat replacement, binding, texturizing, and emulsifying properties in products like burgers, patties, minced meat, and sausages (Kyriakopoulou et al., 2021).

Soy flour, with about 50% protein content, is made by grinding soy flakes, while soy protein concentrates and isolates, containing around 70% and 90% protein respectively, are derived from fractionated soy flour. These soy proteins are hydrophilic, aiding in stabilizing the gel matrix through water and fat binding. Texturized soy proteins, created through hot extrusion, mimic the chewiness and flavor of meat, especially when hydrated, mimicking meat's texture (Joshi et al., 2015). Studies have shown that soy protein can trap fat, preventing its loss during cooking (Kamani et al., 2019), and when used as extenders, they enhance moisture retention, juiciness, and chewiness, and reduce cooking loss in beef patties (Kassama et al., 2003).

Mixing soy with other proteins like wheat gluten can create layered and fibrous structures in plant-based meat alternatives, resembling real meat (Krintiras et al., 2016). Research indicates that soy protein concentrates, naturally containing polysaccharides requires less fractionation, offer advantages in lowering the costs of raw materials. Conversely, soy protein isolate requires mixing with additional proteins to achieve anisotropic fibrous textures in meat alternatives (Grabowska et al., 2016). Alterations in processing conditions can change the molecular structure of soy protein isolates and meat analogs (Pietsch et al., 2017). Furthermore, soy-derived leghemoglobin (legH) proteins are utilized for adding red color and authentic meat flavor to plant-based meat alternative products (Bohrer, 2019; Fraser et al., 2018). The various functional properties of soy protein, including water/oil holding capacity, emulsifying activity, and texturizing ability, make it a valuable component in the development of plant-based meat alternative products.

2.5 Consumer Perceptions

It is crucial to understand the significance of consumer perceptions of plant-based food products and/or soy-based food products. Consumer perceptions are influenced by consumer needs and options available to fulfill their demands (Troy & Kerry, 2010). Consumer perceptions not only understand consumer behavior, but also contribute to researchers' understanding of consumers' attitudes, emotions, and beliefs towards the specific product (Zakhour & Yousefnavaz, 2023). Furthermore, consumer behavior and preferences are unpredictable due to rapidly changing food and nutrition trends. According to Zeller (2024), the food industry is witnessing a dynamic shift with 10 pivotal food trends shaping consumer preferences in 2023-2024. These trends underscore a growing demand for sustainability, health-conscious choices, and flavor innovation. Consumers are increasingly seeking options that are both beneficial for their health and the environment. Food trends of 2023-2024 by category also are summarized in Figure 2.3.



Source: (Zeller, 2024)

Figure 2.3 Food trends of 2023-2024 by category.

These trends, as shown in Figure 2.3 reflect a broader shift toward foods that are not only environmentally friendly and healthy but also innovative in flavor. The landscape of food consumption is rapidly evolving, influenced by a range of factors beyond those previously described in Figure 2.3. These include, but are not limited to, economic instability, health consciousness, and a growing emphasis on sustainability (Consumer Trends, IFT 2022). A more detailed discussion on the primary drivers of consumer trends and consumer behavior towards these shifts is shown in Table 2.4.

Table 2.4 Primary drivers of consumer trends and consumer behavior.

Consumer Trends	Primary Drivers	Consumer Behaviors
Redefining Value	Economic instability, inflation (COVID-19)	Buying in bulk, opting for less expensive brands, cooking from scratch
Private Labels Gain Popularity	Cost of living crisis, search for affordability	Shifting to private label products for affordability
Conscious Consumption	Sustainability, ethical production	Supporting brands with transparent and ethical practices
Plant-based Growth	Health and environmental considerations	Adopting plant-based diets for health and environmental reasons
Functional Foods for Mental Health	Focus on mental well-being and health benefits	Seeking foods with specific health benefits, particularly for mental health

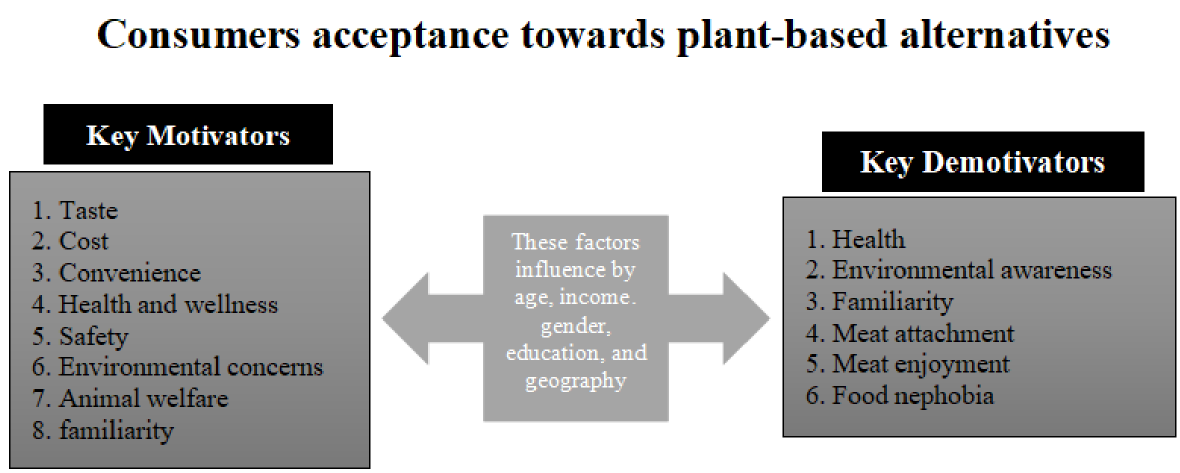
Source: (Consumer Trends, IFT 2022).

Therefore, food product developers are constantly anticipating consumer food choices, buying habits, and preferences (Lin-Schilstra & Fischer, 2022). It is crucial for food product developers to identify consumers' perceptions and needs to adopt a new demand and offer more value-added products to the market to meet consumer needs (Mondéjar-Jiménez et al., 2022). The success of a new food product relies on consumer acceptability and perceptions, as these factors are decisive in whether the product will be accepted or rejected (Kwasny et al., 2022; Diaz et al., 2022; Kerslake et al., 2022).

2.6 Consumer Perceptions of Plant-based Food Products

Recent advancements in the development of food products have focused on making plant-based food alternatives identical to existing foods (meat and milk) to meet consumer needs and demands (Acquah et al., 2023). The demand for plant-based alternatives surged due to the shifting consumer perceptions regarding their health, sustainability of the environment, and food resources (Sun et al., 2021; Baune et al., 2022). Plant-based alternatives have also transcended their niche vegetarian origin to become mainstream products, experiencing rapid market growth, with global valuation increasing from U.S. Dollar (USD) of 1.89 billion in 2021 to an estimated USD of 4.04 billion by 2027 (Boukid, 2021; Markets and Markets, 2024). This expansion shows the rapid adoption and increasing consumer demand for plant-based meat alternatives. Market expansion is driven primarily by consumer perceptions of plant-based meat alternatives as "better for you" and "better for the environment" trends (Boukid, 2021).

The major significant portion of animal-based foods contains milk, cheese, yogurt, and meat (Henchion et al., 2021; Adesogan and Dahl, 2020). Consumers are demanding the same appearance, flavor (aroma and taste), texture, and quality in plant-based alternatives as compared to animal-based products. The taste and texture are highly valued by many consumers and are crucial to consumer acceptance (Hoek et al., 2011). Some key factors behind consumers' acceptance to consume/purchase plant-based alternatives are shown in Figure 2.4.



Adopted from (Boukid, 2021)

Figure 2.4 Consumers' acceptance towards plant-based alternatives.

The quality of the plant-based food products is also a very important factor which cannot be compromised during food production. Therefore, plant-based alternatives should also mimic animal-based food products in terms of nutritional content, specifically protein amount (Choudhury et al., 2020). For example, all plant-based alternatives should have more than 20 g of protein per 100 g (Starowicz et al., 2022). Consumers' acceptance of plant-based alternatives can be increased by achieving similarity with animal-based food products in taste, texture, affordability, and nutritional content (Boukid et al., 2022). Therefore, improvements and innovations in technology and food product formulations are steadily trying to enhance the quality of plant-based foods, aiming for equivalence with existing foods like eggs, seafood, dairy, and various meat products in terms of texture, flavor, and nutritional value (Boukid, 2021).

The increased demand for meat alternatives has also increased the demand for texturized vegetable proteins. Texturized vegetable protein is a key component in many meat alternatives (Boukid & Gagaoua, 2022). Texturized vegetable proteins are derived from sources like soy, wheat, and peas, and can either enhance the texture and flavor of meat alternatives or serve as standalone meat alternatives (Kyriakopoulou et al., 2021; Baune et al., 2022). Some main plant-based proteins used in developing meat alternative formulations are shown in Table 2.5

Table 2.5 Main plant-based proteins used in developing meat alternative formulations.

Protein Source	Total Products Percent	Protein Isolates Percent	Protein Concentrates Percent	Texturized Protein Percent
Soy proteins	63.3	20.3	33.4	9.6
Wheat	46.8	14.7	32.1	-
Pea	40.2	12.2	28.4	-
Rice Protein	7.2	-	-	-

Source: (Boukid, 2021)

Current research does not fully clarify which factors most significantly affect consumer acceptance or how these factors are different among various alternative proteins due to limited research on these factors and alternative proteins (Onwezen et al., 2021). The consistent factors identified so far that influence the acceptance of all alternative proteins include healthiness and taste preferences, familiarity, attitudes, food neophobia, disgust, and social norms (Onwezen et al., 2021).

Demand for milk products is high in both developed and developing countries (Islam, et al., 2021). Research on plant-based beverages is growing due to health and environmental concerns, for example, lactose intolerance and flexitarian diets (Jaeger & Giacalone, 2021). Plant-based beverages are considered healthier options due to their lactose-free and cholesterol-free nature (Acquah et al., 2023). Popular sources of plant-based beverages include legumes (such as soybeans and peas), grains (such as rice, quinoa, and oats), and nuts (such as almonds, coconut, cashew, and hazelnuts) (Jaeger & Giacalone, 2021; USDA, 2023). Some of the popular plant-based beverages include soymilk, almond milk, and coconut milk (Acquah et al., 2023). Table 2.6 presents a comparative analysis of the nutritional values of cow's milk and various famous plant-based beverages. Among these beverages, soy stands out with the highest protein concentration, offering 2.88g per 100 mL. It contains 38% less fat and 28% fewer calories compared to cow's milk, yet it provides an equivalent amount of calcium (Chalupa-Krebzdak et al., 2018).

Table 2.6 Nutritional content of plant-based beverages as compared to cow's milk.

	Per 100mL				
Milk Type	**Calories (kcal)**	**Protein (g)**	**Fat (g)**	**Carbohydrates (g)**	**Calcium (mg)**
Cow, whole	61.0	3.15	3.27	4.78	113
Soy	44.20	2.88	2.03	3.53	113
Coconut	72.67	1.28	5.04	6.72	58.67
Almond	18.00	0.76	1.02	1.66	160
Cashew	52.00	1.31	3.16	4.74	98.5

Adopted from (Chalupa-Krebzdak et al., 2018)

Research has been conducted on consumer attitudes and perceptions regarding plant-based milk alternatives. For example, Acquah et al. (2023) conducted a research study and focused on plant-based beverages that resemble cow's milk in look and consistency. Focus groups were utilized in the study to explore factors that influence consumer acceptance of plant-based beverages (like tiger nut milk and cocoa pulp). The findings revealed consumer awareness of plant-based beverages, with healthier and nutritional being the primary motivation for consumption. However, taste, cost, availability, and cultural factors were identified as barriers (Acquah et al., 2023). More details about these barriers are shown in Table 2.7.

Table 2.7 Barriers to the consumption of plant-based beverages with reasons.

Barriers	Reasons
Taste	Consumers found the flavor of plant-based beverages less appealing, lacking creaminess and often having an undesirable beany/nutty taste compared to dairy milk.
Cost	Plant-based beverages were perceived as more expensive than dairy milk, making them less attractive financially to consumers.
Availability	Limited accessibility, with plant-based options often only available in high-end supermarkets, reducing exposure and purchase opportunities.
Cultural	Resistance is rooted in traditional dietary preferences and habits, making consumers hesitant to switch from familiar dairy options.

Source: (Acquah et al., 2023)

2.7 Enhancing Consumer Acceptance of Plant-Based Food Products

Consumers' adoption of plant-based food alternatives depends on similarities in functions like composition, structure, texture, flavor, and nutritional value to animal-based food products (McClements, 2020). For example, cow's milk exhibits a colloidal dispersion comprising fat globules with a mean diameter of 4-5 μm, alongside casein micelles consisting of many different types of nano-flexible proteins such as α_{S1}, α_{S2}, β, and κ caseins. These fat globules and casein micelles contribute to the milky appearance and creamy texture of cow's milk (Jukkola & Rojas, 2017). The lactose (3-4%) and minerals (0.8%) found in cow's milk provide the flavor (McClements et al., 2019). Consequently, achieving a comparable or superior structure and composition in plant-based beverages is crucial for meeting consumer expectations. The main structural and compositional factor that is required to replicate in plant-based drinks is fat globules, as fat globules are responsible for the appealing creamy appearance, texture, and mouthfeel of the milk. To attain such structure and composition in plant-based beverages, two main approaches have been developed: disintegrating natural structures to access oil bodies within certain plant materials and fabricating simulated fat globules utilizing plant-based ingredients (McClements et al., 2019; Sethi et al., 2016; Do et al., 2018).

Soy has a high content of protein (35-45g/100g) and fat (15-25g/100g). Therefore, soymilk is recognized to have a closely resembled nutritional profile as compared to cow's milk (Aslan & Bilgiçli, 2021; do Prado et al., 2022). However, a significant issue with plant-based beverages is their often-reported unsatisfactory taste, beany flavor, and problematic textures such as being watery or separated (Anuyahong et al., 2020; Grasso et al., 2020; Greis et al., 2020; Gupta et al., 2022; Hasani et al., 2016; Huang et al., 2022; Luana et al., 2014; Mousavi et al., 2019; Oduro et al., 2021). To address this taste and flavor issue researchers have leveraged various technologies to improve the taste of soymilk, making them more appealing to consumers (Barbosa et al., 2020). One of the most commonly used methods involves creating new or combined formulations (like mixing nut milk) to diminish the less desirable traits of soybean milk (Aslan & Bilgiçli, 2021). Huang et al. (2022) adopted a similar strategy by inoculating lactic acid bacteria into quinoa (*Chenopodium quinoa* Willd) and soybean to make yogurt, aiming for a high nutritional value and sensory acceptance. Their exploration included various substrate ratios of quinoa to soy milk, inoculated with lactic acid bacteria (LAB) to ferment the mixture. Quinoa has high nutritional value with gluten-free protein (9.1-15.7 g/100g), total fat (4.0-7.6g/100g), and dietary fiber (8.8.-14.1g/100g) (Zannini et al., 2018; Nowak et al., 2016). Fermenting soy-based products with lactic acid bacteria is also a promising approach to enhance texture, digestibility, and sensory attributes (Zannini et al., 2018; Pachekrepapol et al., 2021). Studies indicate that soybeans, being protein-rich, serve as an excellent medium for the proliferation of lactic acid bacteria (7.5 log CFU/mL after 48 h) (Niccolai et al., 2020). Among the formulations, the 4:6 ratio of quinoa to soy milk was highlighted for its balanced approach to enhancing the yogurt's stability, sensory, and textural attributes. This specific ratio not only maintained the LAB viability over 21-days storage period but also significantly improved the water holding capacity (WHC) and sensory appeal compared to control soy milk. The inclusion of quinoa contributed to a decrease in yellowness (b* value), and a reduction in WHC during storage, reflecting positively on consumers' sensory evaluations. For the sensory analysis, the study by Haung et al. (2022) employed a 9-point hedonic scale. This scale ranges from 1(dislike extremely) to 9(like extremely), allowing the panelists to rate various sensory attributes of the yogurt samples, including color, odor, appearance, texture, flavor, and overall acceptance. The use of a 9-point hedonic scale is a common practice in sensory evaluation to capture consumer preferences and perceptions of food products effectively (Huang et al., 2022). See Table 2.8 for a summary of results from Huang et al. (2022) study.

Table 2.8 Significant changes and values related to 4:6 quinoa to soymilk ratio.

After 21 days of storage at 4 ℃			
Attributes	**Control Soymilk (100%)**	**4:6 Quinoa: Soymilk Ratio**	**Changes**
WHC (%)	38.7±0.54	50.1±0.24 (Significantly increased)	Quinoa addition improved WHC, indicating better water retention.
b* (Yellowness)	11.82±0.31	10.58±0.15 (Significantly decreased)	Decrease in yellowness, indicating a lighter color.
TPC (CFU/g)		Maintained >106-7 CFU/g	High viability of LAB maintained over 21 days, enhancing yogurt's probiotic quality.
Sensory Evaluation		Higher	The 4:6 ratio received increased liking scores in sensory evaluation, suggesting a preferred taste and texture.

Note: Significant change ($p<0.05$), Water Holding Capacity (WHC), Lactic Acid Bacteria (LAB), Total Phenolic Content (TPC), Source: (Huang et al., 2022)

Developing plant-based meat alternatives that consumers find acceptable hinges on replicating the texture and flavor of meat (Herz et al., 2021). Various techniques, including extrusion, freeze structuring, electrospinning, high-temperature induced shearing, mixing plant proteins and hydrocolloids, bioprinting (3D printing technology), and electrospinning, have been explored to match the texture of meat to meet consumer needs and demands (Elzerman et al., 2011; Hoek et al., 2011; Dekkers et al., 2018; Bhushani & Anandharamakrishnan, 2014; Krintiras et al., 2016). Some advantages and disadvantages of using these techniques are shown in Table 2.9.

Table 2.9 Advantages and disadvantages of texturizing technologies of plant-based meat alternatives.

Texturizing Technology	Advantages	Disadvantages
Extrusion	Highly productive, cost-efficient, versatile, conserves energy, reduces anti-nutritional factors and enhances protein digestibility	Can cause color changes due to the Maillard reaction, promotes caramelization, hydrolysis, and pigment degradation
High-temperature Induced Shearing	Cost-effective and yields a defined fibrous structure	Requires further research for scalability
Electrospinning	Cost-effective, scalable, creates very thin fibrils	Needs careful control of several parameters, challenges in electrospinning plant proteins
Freeze Structuring	Allows modulation of the texture of plant proteins	Involves complex freezing conditions that need to be carefully optimized and monitored
Mixing Plant Proteins and Hydrocolloids	Forms fibrous structures that can be modulated	Requires hydrocolloids and metal ions for precipitation
Bioprinting (3D Printing Technology)	Facilitates the design of textured products similar to muscle fibers and allows nutritional content customization	Needs specific maturation conditions, high cost of complexity in product structure

Adopted from (Boukid, 2021)

Flavor enhancers and texture modifiers have also been used to improve the sensory profile of plant-based products. For example, Grasso et al. (2020) found that unflavored soy and cashew-based yogurts were less appealing than flavored. Huang et al. (2022) observed that soy-based yogurts required the addition of quinoa in high percentages like a 4:6 ratio of quinoa and soy to improve the texture and flavor of the yogurt.

In recent research conducted by Bakhsh et al. (2021), the study explored the efficacy of methylcellulose (MC) as a binder in enhancing the physicochemical, textural, and sensory attributes of plant-based meat substitutes. Methylcellulose (MC) can be used as a binder, for moisture retention, bio-cut control, to increase volume, and to improve the texture of different kinds of meat alternatives (Al-Tabakha, 2010). The study utilized texturized soy protein (TSP) as an alternative to meat, citing its economic and functional advantages (Arora et al., 2017). Texturized soy protein (TSP), a plant-based protein, is notable for its low levels of saturated fats, high content of essential amino acids, and cholesterol-free nature (Ranasinghesagara et al., 2005). The production of texturized soy protein (TSP) is characterized by a high-pressure extrusion process followed by a spinning or extraction phase, which prepares the final product to use as a meat alternative (Sadler, 2004). Bakhsh et al. (2021) research methodically assessed the influence of varying concentrations of methylcellulose (MC) on the physicochemical, textural, and sensory properties of texturized soy protein (TSP) and compared it with controlled beef patty. Proximate analysis results showed that although the beef control patty exhibited higher protein levels, texturized soy protein (TSP) patties demonstrated a promising capability to replicate at a certain level the meat’s moisture profile after incorporation of methylcellulose (MC) (Bakhsh et al., 2021). Due to the formation of an adhesive layer by methylcellulose (MC) during heating, which acts as a barrier to prevent moisture loss (Amboon et al., 2012). Methylcellulose (MC) effectively acts as a binder and moisture barrier in plant-based meat substitutes, impacting the moisture content and physicochemical properties of texturized soy protein (TSP) patties differently from beef patties. While moisture content in beef patties increased with higher MC concentrations, TSP patties experienced a reduction in moisture at a 3% MC concentration, followed by a minor increase at 4% MC concentration (Bakhsh et al., 2021).

Furthermore, physiochemical analysis highlighted a significant difference in pH values between the texturized soy protein (TSP) and the control beef patties. The control meat patties showed low pH might be due to the regular glycolytic changes in meat (Chauhan et al., 2019). The texturized soy protein (TSP) patties showed a high concentration of pH (more than 6), might be due to the alkaline nature of texturized soy protein (pH 7.42-7.43) (Anjum et al., 2011). Findings from the study conducted by Bakhsh et al. (2021) are summarized in Table 2.10.

Table 2.10 Effect of methylcellulose (MC) concentration on moisture content and pH value of beef and texturized soy protein (TSP) patties.

Attribute	Beef Control Patty	Texturized Soy Protein (TSP) Patty
Moisture content at 1.5% MC	57.49%	57.80%
Moisture content at 3% MC	Increased to 59.49%	Decreased to 53.77%
Moisture content at 4% MC	Further increased to 62.64%	Slightly increased to 54.28%
Ph value	Lower, due to glycolytic changes	Higher (more than 6), due to the alkaline nature of texturized soy protein

Source: (Bakhsh et al., 2021)

In alignment with the findings of Bakhsh et al. (2021) studies, Bell & Shelef (1978) observed that minced meat incorporated with vegetable protein exhibited a higher pH in comparison to control meat. Similarly, Ahmad et al. (2010) found that the inclusion of soy protein isolates at a concentration of 25% significantly elevated the pH levels in meat sausages. Texture analysis revealed that texturized soy protein (TSP) patties were softer compared to the beef control, a characteristic that may be beneficial, as consumers favor a less dense texture in plant-based meat alternatives. Sensory evaluation played a pivotal role in assessing consumer acceptance. Although texturized soy protein (TSP) patties with 3% methylcellulose (MC) concentration exhibited sensory improvements, they did not surpass the beef control patties in overall acceptability. This finding implies that while texturized soy protein (TSP) shows potential as a viable meat substitute, further advancements are imperative to increase its sensory appeal, aiming to either meet or exceed that of conventional beef (Bakhsh et al., 2021).

2.8 Focus Groups

As consumer demographics become increasingly varied and unpredictable, food developers are finding it challenging to understand and anticipate consumer preferences in food (Grasso et al., 2023). Studies indicate that between 50-80% of newly developed food products either never make it to the market or fail within their first year (Salnikova et al., 2019). When developing a new food product, it is crucial to employ a strategy that prioritizes consumer needs, demands, and market orientation. A consumer-centric approach allows for the integration of consumer feedback throughout the development process, aiding in the development of food products that meet consumer needs and demands (Case & Given, 2016). The consumer-centric approach differs markedly from traditional methods, which relies more on the knowledge and opinions of engineers and food product developers.

Among many approaches to obtain consumer perceptions, one of the best approaches is utilizing focus groups. Focus groups are recognized as a very effective method to conduct qualitative research (Keemink et al., 2022). Focus groups are utilized to collect deep information about consumer preferences (Schifferstein, 2015). In focus groups, qualitative data is gathered by the discussion of a group of individuals on a specific research topic, guided by one or two moderators (Keemink et al., 2022). Conducting focus groups at the beginning stage of new food product development is one of the recommended approaches to get consumer perceptions. Before launching a food product, it is recommended that the insights gained through the focus groups be systematically introduced into the development of the food product (Bogue and Repar, 2022).

Focus group discussions are considered a good method for conducting qualitative research due to their proven effectiveness in getting the participants' viewpoints and perceptions (Maitiniyazi and Canavari, 2020). This method also allows participants to expand on their perceptions in response to others during focus group discussions, leading to quality data collection where agreements and disagreements on the discussed topic can be more closely observed (Belk et al., 2013).

Several studies have employed focus groups to explore consumer perceptions of plant-based food alternatives. Acquah et al. (2023) used focus groups to delve into consumer perceptions regarding plant-based drinks, including tiger nut milk and cocoa pulp. Varela et al. (2022) utilized focus groups to examine consumer attitudes toward foods high in protein. Additionally, Adamczyk et al. (2022) applied focus groups to investigate consumer perceptions, motivations, and barriers to plant-based dairy alternatives. These studies highlight the effectiveness of focus groups to gather in-depth consumer opinions on food choices and in the collection of quantitative data.

2.9 Survey

Qualitative research methods, including online surveys, provide a means to obtain underlying perceptions of consumers (Schiano et al., 2020). Techniques such as focus groups and online questionnaires are commonly utilized to gather insights on how consumers view various commercial products (Schiano et al., 2020). Surveys play a crucial role in uncovering aspects like consumer knowledge, beliefs, attitudes, and thought processes. With the advent of mobile technology and digital platforms, online questionnaires have become a key tool for reaching either broad or targeted participant groups. Online surveys offer the advantage of being adaptable and engaging, enhancing the experience for participants. Furthermore, online surveys enable researchers to efficiently carry out extensive studies and investigate new topics (Stantcheva, 2023). These surveys provide the capability to gather both in-depth qualitative insights and quantifiable data from a vast array of participants spread across different regions (Schiano et al., 2020).

Many research studies have utilized online surveys to capture consumer attitudes toward plant-based food alternatives. Banovic & Sveinsdóttir (2021) conducted an online survey to assess the behaviors of female participants (n=1397) towards plant-based meat alternatives made with rapeseed protein. Wattick et al. (2023) employed the Qualtrics platform (Qualtrics, Provo, IT, USA) for an online survey to investigate the diet quality and eating behaviors among college students, including their food choices. Similarly, Pandey et al. (2021) used online surveys to gather insights into consumer perceptions of plant-based yogurt alternatives. These studies have demonstrated the effectiveness of online surveys in gathering consumer opinions on food choices and collecting quantitative data, highlighting their reliability as a research tool.

2.10 Infographics

Infographics are widely recognized as an effective means of communication, capable of easily capturing attention and simplifying complex concepts quickly and straightforwardly (Abbazio & Yang, 2022). An infographic can be defined as "a larger graphic design that combines data visualizations, illustrations, text, and images to tell a complete story" (Krum, 2013). Infographics integrate information and graphics to create visually impressive and engaging representations of data, information, or knowledge, particularly appealing to younger audiences (Chan et al., 2020; Cheng et al., 2020; Lam et al., 2022). People respond differently to information presented with visuals compared to text-only formats (Pittman & Reich, 2016). Infographics are generally seen as more comprehensible and reader-friendly (Buljan et al., 2018), making them a recommended alternative to text-only content for disseminating information. This is especially true for younger generations, who are more likely to engage with infographics over plain text (Chan et al., 2020; Lam et al., 2022).

Many studies have utilized infographics to gather perceptions from individuals on various topics. For example, infographics have been used to understand perceptions about health (Besomi et al., 2024), consumer behavior towards food brands (Bedetti & Coeurderoy, n.d.), and attitudes towards sustainable water consumption (Patsiaouras, 2024). This demonstrates that using infographics to gauge people's perceptions of specific topics is an effective research method.

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Chapter 3 - Qualitative Research Via Focus Group: University Students' Perceptions About Soybeans and Soy-Based Food Products

3.1 Abstract

The soybean (Glycine max), introduced to the United States in 1765, is a rich source of essential vitamins, flavonoids, polysaccharides, and complete protein. With the recent interest in plant-based foods, the variety of available plant proteins has expanded. However, acceptance and consumption of soy products among university students remains underexplored. This study aimed to investigate students' perceptions, knowledge, and consumption patterns of soy-based food products and their opinions of soy-based infographics. A qualitative research design using focus group discussions was employed to collect data from university students. Participants were recruited through a pre-survey and posters in university dining centers and residence halls. Two focus groups, each consisting of 5 or 6 participants, were conducted. Discussions were guided by a structured questionnaire and were audio-recorded, transcribed, and analyzed using thematic analysis. Six main themes emerged: (1) awareness of soybeans and soy products was influenced by past experiences and exposure, either geographical or educational, (2) participants had limited knowledge about soy's nutritional value but recognized it as a protein source, (3) preference for familiar foods was noted, but participants were receptive to innovative products, (4) tofu and soy sauce were identified as prominent soy products, and participants favored new soy products in savory dishes, sharing culinary insights like soy protein pizza dough and soy milk-based juices, (5) concerns about soy-related stigma were highlighted, with a desire for soy-based products to have a distinct identity beyond being meat alternatives, (6) well-organized and aesthetically pleasing infographics were preferred, emphasizing the importance of clarity in titles and a reader-friendly layout. The study highlights the need for educational initiatives to raise awareness about soy's nutritional benefits and address misconceptions. It also suggests that product development should balance familiarity and innovation to cater to diverse tastes and counter soy-related stigma by emphasizing its distinctive attributes and sustainability. The positive reception of well-organized infographics underscores the importance of consumer preferences in information presentation. Through ongoing commitment to product refinement, education, and addressing societal preconceptions, soy-based products can contribute to a diverse and sustainable food ecosystem.

Keywords: soy products, university students, nutritional awareness, food preferences, consumer education

3.2 Introduction

The soybean (*Glycine max*) was brought to the United States (U.S.) from Asia by Mr. Samuel in 1765 (Chen et al., 2012). Soybeans have a significant amount of protein (40%) and a high oil content (21%), which is approximately 60% of the dry weight (Henkel, 2000; Kawamura, 1967; Perkins, 1995). Carbohydrates make up around 35% of the remaining components, while ash accounts for approximately 5%. Soybeans are rich in essential vitamins, flavonoids, and polysaccharides (Sasi et al., 2022). With a high soy protein content containing essential amino acids, soybeans serve as an excellent source of complete protein.

In the contemporary global landscape, there is a pronounced shift towards sustainable and health-conscious diets, with plant-based proteins (soybeans and pulses). Concerns are related to environment, health, and animal welfare (Lin et al., 2017; Sun et al., 2018) thus resulting in a concurrent reduction in the reliance on animal-based foods, such as meat, seafood, eggs, and dairy (McClements & Grossmann, 2022). There has been a noticeable rise in consumer interest and attention towards veganism and other forms of plant-based diets (Jallinoja et al., 2019). Research has explored consumer perspectives on plant-based eating (de Boer et al., 2014; Niva & Vainio, 2021; Niva et al., 2017; Schosler et al., 2012; Vanhonacker et al., 2013). As a result, the range of available plant proteins has expanded significantly, encompassing options such as tofu, textured soy protein, lentils, and convenient plant protein products (quinoa burger, protein bars, and protein powders), that have been increasingly embraced as substitutes for animal-based proteins, including whey protein isolates, caseins, and gelatines.

The shift is driven by the comparatively negligible environmental repercussions associated with the production and consumption of plant-based proteins, in contrast to the substantial environmental burden associated with animal-based proteins (Koneswaran &

Nierenberg, 2008; Zheng et al., 2020). But despite the well-documented health (Messina, 2016) and environmental advantages of soy-based foods, a discernible gap exists in understanding university students' perceptions of soy-based food products.

Aligned with market trends, this study investigates perceptions of soybeans and soy-based food products among a specific group—Kansas State University students eating in on-campus dining centers. By exploring their attitudes, valuable insights are gained into consumer preferences and needs. Conducting focus groups for qualitative research is one of the methodologies to understand consumer needs as it offers qualitative insights into consumer behavior (van Kleef et al., 2005). A focus group study gathers the opinions of a small group of participants in a relaxed setting, exploring a chosen topic of interest (Krueger & Casey, 2000). The number of participants varies among researchers, typically ranging from 3 to 8 (Stewart et al., 1994), 8 to 12 (Chalofsky, 2001), or 6 to 8 (Krueger & Casey, 2000). Mini-focus groups with 4 to 6 participants per group have become popular due to easier recruitment and a more comfortable environment for sharing views (Krueger & Casey, 2000). Focus groups also primarily serve to explore new concepts and uncover opportunities (McQuarrie & McIntyre, 1986; Sheth et al., 1999). Successful focus groups require careful planning, including setting clear objectives, selecting suitable moderators, excluding recent participants, conducting multiple groups per consumer segment, and creating a non-threatening environment (Casey and Krueger, 1994; Stewart et al., 1994).

3.3 Conceptual Framework

The dietary habits of university students are influenced by a plethora of factors, ranging from cultural preferences, and social and physical environment to personal health beliefs (Deliens et al., 2014) within this spectrum, specific food items, such as soybeans and soy-based food products, may have unique determinants affecting their consumption. While some research has touched upon general food literacy (Malan et al., 2020). There is a gap in understanding the holistic perceptions and acceptance of soy-based food among university students.

Soybeans, as a sustainable protein source, align with the broader push towards sustainable eating habits. Various studies have linked sustainability with eating habits like consuming local and organic food, more plant-based products, and reducing food waste (Austgulen et al., 2018; Carlsson-Kanyama and González, 2009). However, the determinants of these sustainable eating habits, such as sensory characteristics, traditions, and personal values, need further exploration, especially in the context of soy-based foods (Aslihan Nasir & Karakaya, 2014; Perrea et al., 2014).

Based on the previous findings our primary goal of this study is to elucidate university students' perceptions and understanding of soybeans and soy-based food products by conducting focus groups. Consequently, our research questions are:

RQ1. What are university students' perceptions and understanding of soybeans and soy-based food products?

RQ2. How do soy-related infographics and educational materials influence participants' consumption choices?

RQ3. What are participants' perceptions of innovative soybean-based food?

3.4 Materials and Methods

3.4(1) Reflective Statement

As an Asian Muslim, I am familiar with soy's role in Asian cuisines and its use as a Halal meat alternative. I am also aware of debates within Muslim circles about GMOs in soy products and recognizing the existence of non-GMO soybeans. With this awareness, I approach this research with knowledge about soybeans but strive to ensure the information presented is accurate and relevant to a diverse audience.

Faculty members, Dr. Jacqueline Aenlle and Dr. Kelly Getty completed the research team for this project. Dr. Kelly Getty is a faculty member in the Kansas State University, Food Science Department. Dr. Kelly Getty is an expert in food science and provided in-depth insights on soybeans and soy-based foods. Dr. Jacqueline Aenlle's background is in agricultural communication. Dr. Jacqueline Aenlle qualitative researcher and provided support by training focus group moderators and navigating qualitative data analysis.

3.4(2) Experimental Design

Faculty members at Kansas State University in the Food Science Institute (Getty) and the Department of Communications and Agricultural Education (Aenlle) collaborated with author (Azhar) to conduct this qualitative research study. Focus groups were utilized to collect perceptions of soybeans and soy-based food products among university students eating in dining centers. Focus groups were utilized to facilitate the extraction of diverse views and understandings from participants (Stewart & Shamdasani, 2017; van Lierop et al., 2019) and offer flexibility in uncovering new themes during discussions (Kitzinger, 2005; Morgan, 1996). Azhar developed the initial moderator guide, which was then reviewed and modified by eight undergraduate students under the direction of Aenlle to improve the quality of the moderator guide (**Appendix A**) and reduce bias. The undergraduate students were enrolled in the course "Undergraduate Research in Agricultural Communications" and were taught qualitative methods for conducting research and procedures for conducting focus groups.

Azhar created a focus group registration survey (**Appendix D**), and two informed consent forms (focus survey registration and focus group), as outlined in **Appendix C** and **Appendix F**. To gather registrations through the pre-focus survey, a flyer containing a quick response (QR) code was created by an undergraduate student majoring in Agricultural Communications under the direction of Aenlle. The QR code in the flyer led to the pre-focus group survey registration form. The flyers (~150) were circulated among students who frequently ate in the dining centers. In addition, 37 flyers were posted in prominent public areas around the dining centers, including the main lobbies of residence halls, to attract potential participants. On the day of the focus groups, additional flyers were created and strategically placed in the dining centers and residence halls to provide clear directions to the respective focus group rooms. All the research materials (moderator guide, pre-focus group survey form, informed consent forms, and flyers) were approved by the University Institutional Review Board (IRB# 11516).

After successful recruitment, two focus groups were conducted. Each focus group was moderated by four undergraduate students and each focus group was expected to last for 60-75 minutes. Focus groups took place in private rooms near the dining center. To ensure an accurate and thorough analysis of the focus groups, conversations (audio) of each focus group were captured through Owl microphones (360° video conferencing device, Makeev & Schnittman, 2014), and recorded through the Zoom software (Zoom Video Communication, Inc., San Jose, CA) on a laptop. For backup recording, a mobile phone with Otter app Transcription Software (Mountain View, California) also captured and transcribed the audio in real time and kept for future analysis. The data was stored in Microsoft Teams (Microsoft, Redmond, WA) for security and shared only with the research authors (Aenlle, Getty, Azhar) to allow for collaboration.

3.4(3) Institutional Review Board (IRB) Exemption

The moderator guide, pre-focus group survey, sample infographics, and recruitment flyers were recognized as exempt by Kansas State University's Institutional Review Board (IRB) to conduct and analyze focus groups about soybeans and soy-based food products. This exemption determination is in accordance with the specifications stated in 45 CFR §104(d), particularly falling under Exempt Category 2 Subsection ii, as outlined in **Appendix E**. Undergraduate students and authors completed CITI training (Export Compliance, Responsible Conduct of Research).

3.4(4) Electronic Pre-Focus Group Survey

As a prerequisite for participating in the focus group study, potential participants were requested to complete an online pre-focus group survey as part of the registration process. The primary objective of this initial survey was to gather essential demographic information, personal dietary preferences related to soy-based food products, language proficiency, marketing influences, and scheduling availability. The survey consisted of ten comprehensive questions and was created and hosted on the Qualtrics® platform (American Experience Management Company Seattle, Washington, and Provo, Utah. To ensure the inclusion of eligible participants, a skip-logic mechanism was implemented in Qualtrics, automatically excluding individuals who did not meet the predetermined requirements for the focus group. During the recruitment process, adjustments were made to the participation requirements to accommodate students who did not initially meet the predetermined criteria. Initially, the survey design included skip-to-end logic for the question regarding students consuming 12-14 meals per week, as part of the predetermined requirements. However, considering the limited number of participants and concerns raised about automatic exclusion from the survey due to requirement non-compliance, the researchers decided to remove the skip-to-end survey logic from the survey design. Moreover, specific details regarding the survey and its integration into the research stage are outlined in Table 3.1.

Accompanying the pre-focus group survey, a concise and explicit statement was provided, outlining the studies, and emphasizing the voluntary nature of participation. Participants were assured that their responses would remain anonymous and confidential, with the freedom to withdraw at any time without consequences. After reviewing the information, participants were asked to complete an electronic informed consent form found in Appendix B. This form ensured participants' understanding of the study's purpose and obtained their explicit agreement for the registration survey.

Table 3.1 Details of the Qualtrics® surveys used in the process of data collection.

Survey Title	Research Phase	Survey Launch Month	Data Collection
Focus group registration	Approximately one week prior to the scheduled focus group sessions	Apr 17, 2023, at 6:11 PM	Encompassed a range of questions that delved into participant demographics, personal dietary preferences, language skills, marketing, any potential soy allergies, as well as scheduling.

3.4(5) Focus Groups

The focus groups were conducted in two sections on different days, taking into consideration the availability of participants, moderators, and rooms. All sessions took place in Mezzanine Rooms 241B and 242, located in the Kramer dining center at Kansas State University (KSU). These rooms featured a round table seating style, providing an even floor and chairs around the circular table. This seating arrangement promotes inclusivity, collaboration, and equal participation among participants. Circular table seating configurations are commonly used in focus group research to encourage open dialogue and shared responsibility (Stewart & Shamdasani, 2014).

Prior to the start of each focus group, the rooms were prepared in a specific manner. Tables were set in a round table seating arrangement, then an owl microphone was placed in the center of the table. Two audio recording devices were configured, a Zoom session on a laptop for audio recording and the Otter app on a phone for audio recording and transcription purposes.

The focus group moderator guide, inclusive of the research questions, was initially developed by a graduate student after thorough deliberations on the core research aspects with fellow researchers. After this, the guide and questions underwent a meticulous review by undergraduate students, who also served as moderators, to ensure the precision and authenticity of the research questions (Creswell & Creswell., 2017). The first focus group had two moderators and two note-takers with five participants. The second focus group had two moderators and one note-taker with six participants. At the beginning of each session, moderators provided participants with pre-assembled informed consent forms and sample infographics. To prevent bias, the collaborators Azhar, Aenlle, and Getty deliberately refrained from participating in the focus group discussions. The moderators introduced themselves and read aloud the informed consent form, which participants signed before proceeding. The consent form covered important aspects such as the research objective, potential risks and discomforts, participant rights, incentives, and contact information disclosure. The focus group topics and their respective durations are shown in Table 3.2. As a token of appreciation, each participant received a complimentary free ice cream coupon upon the completion of their respective focus group sessions.

Table 3.2 Timing topics presented in the focus groups.

Running Time[1]	Topics
2 min.	Welcome
8 min. and 23 sec.	Read the consent form
34 min. and 51 sec.	Questions and answer session
18 min. 12 sec.	Discuss infographics
2 min.	Distribute ice-cream coupons

[1]The moderator guide aimed for a 50–60-minute running time, but one focus group exceeded this duration due to extensive discussions on infographics, and latecomers.

3.4(6) Sample Infographics

Three sample infographics were selected by the collaborators from the internet to present in the focus groups. Participants were given all three infographics to review at the same time. Questions were asked about the educational messages and visual appeal of the three infographics. Infographic 1 employed a white color scheme alongside multiple graphics to effectively illustrate the hidden sources of soy in food products (Figure 3.1). On the other hand, Infographic 2 took a minimalist approach, utilizing a single off-white color scheme, graphics, and messages to explain the uses of various soy food products such as soy milk, tempeh, tofu, and edamame (Figure 3.2). Lastly, Infographic 3 had a vibrant array of colors (blue, purple, black, orange, yellow, and maroon) and accompanying graphics, providing comprehensive information on the history, general details, uses, composition, usage trends, and flavor profile of soy sauce (Figure 3.3).

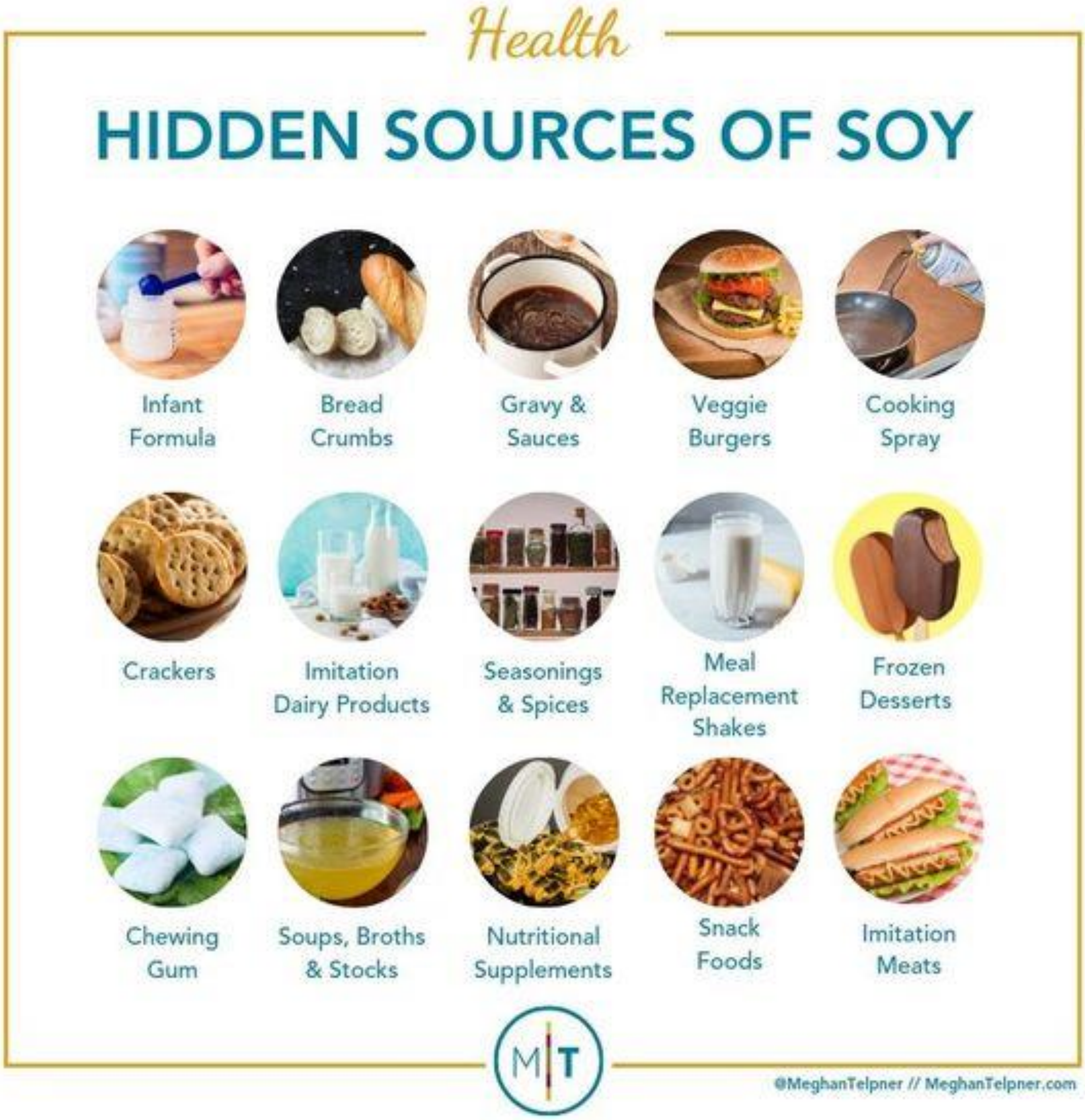

Figure 3.1 Educational message on hidden sources of soy (infographic 1).

Figure 3.2 Educational message on soy-based food products (infographic 2).

Figure 3.3 Educational message on soy sauce (infographic 3).

3.4(7) Data Analysis

Qualitative data analysis entails the researcher's interpretive approach to understanding and attributing significance to a specific dataset (Earl Rinehart, 2021). Through this analysis, researchers can delve into the social world, gaining deeper insights into the true meanings and interpretations of participants (Coffey & Atkinson, 1996). Qualitative analysis enables the provision of rich and detailed descriptions of various situations (Miles & Huberman, 1994; Morse, 1994).

To analyze the focus groups data, the Zoom audio recordings were transcribed using the Otter app. The accuracy of the transcriptions was ensured through a thorough review and editing process conducted by Azhar and an undergraduate student from the "Undergraduate Research in Agricultural Communications" course. This step aimed to eliminate any technical transcription errors and facilitate familiarity with the data. Following the transcription process, Azhar proceeded to develop codes and themes, utilizing the Microsoft "comments" feature. Thematic analysis was employed to analyze the data. Thematic analysis empowers researchers with multiple choices, prompting them to make critical decisions. Thematic analysis is a popular method for analyzing qualitative data and it can be applied to both inductive and deductive research designs. This approach involves organizing large bodies of data into thematic groups based on similarities (Braun et al., 2019; Campbell et al., 2021; Boyatzis, 1998; Braun & Clarke, 2006; Kiger & Varpio, 2020). These themes facilitate the interpretation of the context and the derivation of meaningful insights from the data.

To develop themes in the focus group data analysis, the researchers employed a systematic approach to coding. This systematic approach involves identifying the key components and weaving them together in a logical manner to form a coherent and authentic "story". The systematic approach addresses the research questions and provides insights that accurately reflect the data. In this context, the term "story" represents the process of coding (Linneberg & Korsgaard, 2019). Coding is an essential first step in qualitative analysis. Coding entails examining a coherent portion of the empirical material, such as words, sentences, or paragraphs, and assigning a concise label or phrase that captures its content (Linneberg & Korsegaard, 2019). The purpose of coding is to condense extensive data, making it more manageable for analysis and improving the quality of the analysis. It enables the drawing and verification of "final conclusions" (Linneberg & Korsegaard, 2019).

The analysis of the focus group data involved two coding cycles for theme development. In the first cycle, the researcher Azhar aimed to maintain an open-minded approach, exploring innovative ideas and concepts related to students' perceptions of soybeans and soy-based food products. To accomplish this, an inductive coding approach was employed, aligning with the work of Miles, Huberman, and Saldana (as cited in Bingham & Witkowsky, 2021), which emphasizes the emergence of codes, categories, patterns, and themes directly from the data. During this process, careful examination of each word, phrase, and term used by the participants was conducted. The researcher focused on understanding the intrinsic meaning of the collected data and used participant-centric language to develop the codes, ensuring they avoided imposing their own vocabulary. Initially, a line-by-line coding approach was employed, and subsequently, a descriptive coding method was utilized to organize the line-by-line codes into groups based on similar topics. For the second coding cycle, a pattern coding technique was adopted. In this phase, the researcher employed research questions terminologies, and concepts to explore patterns across the previously coded data. The primary objective was to identify recurring themes and group the data into meaningful sets for further analysis.

After developing codes, the researcher Azhar proceeded to develop themes by categorizing the codes into groups that shared similar characteristics, enabling the identification of the central ideas regarding students' perceptions of soybeans and soy-based food products. The process of theme development involves establishing connections between codes and organizing them into cohesive groups that collectively explain the underlying story within the data. In this context, the term "story" can be understood as a label for themes (Thompson, 2022).

To ensure the trustworthiness of the qualitative findings, the analyzed data was subjected to peer debriefing. Peer debriefing, also known as "analytical triangulation," involves ongoing discussions between the researcher and a peer who is not directly involved in the research project. In this study, Azhar was the sole researcher responsible for code and theme development, making peer debriefing crucial for validation. An ideal peer debriefer is an experienced qualitative researcher who plays a vital role in challenging the researcher's interpretations, encouraging critical thinking, and providing alternative perspectives and explanations. By engaging in peer debriefing, the credibility and trustworthiness of the emerging hypotheses, themes, or theories are enhanced, as they are assessed by an impartial debriefer (Hadi & José Closs, 2016). In this case, Aenlle conducted the peer debriefing for the focus group data analysis, and subsequent changes were implemented based on her feedback. This process strengthens the rigor and reliability of the qualitative findings (Hadi & José Closs, 2016).

3.5 Findings

3.5(1) Focus Group Responses

The pre-focus group online registration survey received 27 responses, indicating that all students eat meals in the dining centers. However, only 21 out of 27 respondents reported consuming 12-14 meals per week in the dining centers. Some participants were excluded due to skipping logic implementation, resulting in a reduced participant count of 18 for subsequent questions. Among these 18 students, 17 did not have a soybean allergy, while one student reported having a soybean allergy. All students confirmed their proficiency in understanding and speaking English. Among the 18 students, 6 learned about the focus groups through flyers, 4 heard about them from friends, and others found the information through alternative sources. The two focus groups had a total of 11 students. After analyzing the focus group data, the emerging themes are presented in Table 3.3.

Table 3.3 Developed themes after analyzing the focus groups.

Number	Themes
1	Participants' awareness of soybeans and soy products stemmed from past experiences and exposure to soy either from geographical exposure or education.
2	Most participants had limited knowledge about the nutritional value of soy but recognized it as a source of protein.
3	Participants showed a preference toward familiar foods but were receptive to innovative food products.
4	Participants favored the use of new soy products in savory dishes and shared culinary insights.
5	Participants highlighted concerns about soy-related stigma and expressed a desire for soy-based products to have a distinct identity beyond being meat alternatives.
6	Participants were drawn to infographics due to their captivating blend of aesthetics, information, and color scheme while underscoring the importance of clarity in titles and a well-structured and reader-friendly layout.

Theme 1: Participants' awareness of soybeans and soy products stemmed from past experiences and exposure to soy either from geographical exposure or education.

The focus group participants indicated that they obtained information about soybeans from diverse sources, such as educational institutions, word of mouth, direct experience, geographic exposure, and personal exploration. Participant 11 said, “My dad is a farm manager. So, a big part of the company’s production is related to soybeans. Similarly, Participant 3 said, “I am from Brazil, and I know that my country is one of the biggest producers of soybeans.” Some participants expressed familiarity with specific soy products they regularly consumed like soy juice. Education also played a role in their awareness, as highlighted by Participant 4 who stated, “I know a lot about soybeans because I’m an agriculture major.” Participant 5 said, “I just know that Paraguay is a big production country for soybeans.” And Participant 8 said, “I eat a lot of Biscoff they give it on American Airlines.”

Theme 2: Most participants had limited knowledge about the nutritional value of soy but recognized it as a source of protein.

Most of the participants in the focus groups expressed having limited awareness of the nutritional benefits of soy beyond its reputation as a protein source. They primarily associated soy with being an alternative protein option to meat. As Participant 1 stated, "Soy is an alternative protein source." Building on the idea of soy as a protein source, Participant 5 said, "High protein and the neighbor's field that's all I know about it." Additionally, some participants held the misconception that soy protein-based products are exclusively meant for individuals who abstain from consuming meat. As Participant 8 mentioned:

> When I worked at Chipotle, it was common for people to react negatively and express apprehension towards soy-based food products. They would often exclaim things like 'Oh my god, no thanks!' because they preferred real meat and considered soy as a substitute rather than a separate option.

Participant 3 said, “Soybeans is like, began in protein production, also in oils.” And Participant 1 also acknowledged that soybeans are alternative source of protein by saying, “Soy is an alternative protein source.”

Theme 3: Participants showed a preference toward familiar foods but were receptive to innovative food products.

Most of the participants in the focus groups expressed the importance of striking a balance between familiarity and exploration. Participant 10 explained: “would stand up for the regular [product without soybeans], but definitely also want to spread it out and try different things.” Participants also recognized that while familiar foods provide comfort, they also acknowledged the value of embracing new and innovative products when opportunities arise. When asked about encountering new foods, Participant 9 said, “I am just an adventurous eater. So, if I do see something new, I usually at least want to try it.” The participants understood the need to enjoy familiar foods while remaining open to trying new culinary experiences.

Theme 4: Participants favored the use of new soy products in savory dishes and shared culinary insights.

Most of the focus groups participants in the focus group expressed their comfort and familiarity with using soy sauce, both in terms of its taste and its application in cooking. They also acknowledged that tofu can be enjoyed in several ways, either as a standalone ingredient, a featured component, or as a complementary addition to dishes. Participant 11 said:

> I would be more inclined to consume tofu if it were included alongside meat products, such as in a meat dish at a restaurant. However, this does not mean that tofu cannot stand

> on its own. In my opinion, when tofu is incorporated with meat, it is displayed as a distinct component rather than merely a substitute. It is not a matter of offering tofu as an alternative, but rather presenting it as its own enticing option alongside other choices.

Most participants also expressed a preference for incorporating soy into savory dishes rather than sweet ones. They shared culinary insights and ideas for creating innovative soy-based products, such as using soy protein extract or soy flour in pizza dough or utilizing soy milk as a base for creating unique smoothies or juice blends. Participant 7 commented:

> In terms of flavor association, I find that soy aligns more with savory products rather than sweet ones. For example, when it comes to muffins, which are typically sweet, I am not sure how well soy flour would fit in. It has more or a neutral, bread-like taste. However, with pizza, you can put toppings on it if the soy flour tastes weird.

Theme 5: Participants highlighted concerns about soy-related stigma and expressed a desire for soy-based products to have a distinct identity beyond being meat alternatives.

Most of the focus groups' participants raised concerns about the perpetuation and promotion of stigma linked to soy. In this context, the stigma refers to the overuse and constant association of soy with every food product. They expressed that the presence of soy in a food item is not a significant issue for them. However, they disliked the way soy is often presented as a hidden source of protein or solely as a meat alternative. They preferred that soy-based products have a distinct identity beyond being categorized primarily as substitutes or alternatives to meat. Participant 7 articulated this perspective, stating:

> It frustrates me that soy milk and tofu are often portrayed as direct substitutes for cow milk and meat, particularly in media that takes an anti-dairy and meat industry stance. This perception bothers me. I believe soy-based products should be recognized and appreciated. It is perfectly acceptable for them to exist as unique entities. In fact, many countries already embrace soy-based products as distinct culinary offerings.

Participants desired a new narrative that focused on the unique qualities of soy-based products rather than positioning them solely as an alternative as Participant 10 stated:

> In my experience, there is certainly a stigma attached to soy consumption. Personally, having been raised on a diet that included meat and dairy milk, I tended to lean towards those options more often. I perceived soy as a substitute or alternative, so more often, I would choose animal-based proteins over soy-based ones.

Theme 6: Participants were drawn to infographics due to their captivating blend of aesthetics, information, and color scheme while underscoring the importance of clarity in titles and a well-structured and reader-friendly layout.

Most participants in the focus groups mentioned that Infographic 3 (Figure 3) struck a good balance between visual appeal and providing information. However, they expressed their dislike for the small format of Infographic 3 and emphasized the need for clear titles. Regarding Infographic 2 (Figure 2), participants felt that it required more graphics. They also expressed their dissatisfaction with the color schemes used in Infographic (Figure 1). On a positive note, participants appreciated the messages conveyed in both Infographic 3 and Infographic 2. For instance, Participant 1 stated, “The second infographic provides more comprehensive information by showcasing the process of making soy products and offering guidance on their usage." This sentiment of appreciation was echoed by others, emphasizing the value they found in this detailed approach. Delving deeper into individual preferences, Participant 8 shared that:

> Personally, I would somehow be drawn to the second infographic. When I spot the section about soy sauce in the third Infographic, it instantly clicks with me since I use it a lot. So, I would just glance at it without really reading and then move on to the second infographic where I would actually read the content. But in Infographic 1, hidden sources of soy, it makes me wonder, why soy? It kind of gives off this vibe of trying to replace everything with soy instead of just letting it be its own thing. So, I would definitely pay more attention to the second one compared to the other two.

3.6 Recommendations

Based on the focus group themes, several recommendations emerge. Firstly, there is a need to promote awareness about soy among consumers, especially university students through educational initiatives that provide accurate information about its nutritional value and dispel misconceptions. Additionally, nutritional education programs can be implemented to highlight the health benefits of soy, enabling individuals to make informed dietary choices and incorporate soy products into their meals. To diverse consumer preferences, it is important to strike a balance between familiarity and innovation in the development of soy-based products. This can be achieved by creating new and exciting options that bridge the gap between traditional and innovative flavors, appealing to a wide range of tastes and culinary preferences. Addressing the stigma associated with soy is crucial. By positioning soy-based products beyond being mere meat alternatives and emphasizing their unique qualities, sustainability, and potential for creating delicious plant-based options, negative perceptions can be overcome, leading to greater acceptance and appreciation. Considering individual preferences and dietary restrictions is essential in promoting soy-based products. Providing options that cater to different dietary needs, such as gluten-free alternatives, ensures inclusivity and accessibility for a wider range of consumers.

Finally, continuous product refinement based on ongoing research and consumer feedback is recommended. This iterative process allows for the adaptation and improvement of soy-based products to meet evolving consumer demands, preferences, and expectations. In conclusion, these identified themes provide valuable insights for promoting soy awareness, encouraging culinary exploration, and enhancing the acceptance of soy-based products among consumers, contributing to a more diversified and sustainable food landscape.

3.7 Conclusion

The focus group study underscores the need for increased soy awareness among young adults aged 18-24 (university students). With participants displaying varied levels of knowledge and a range of perceptions regarding soy, it is imperative to implement educational initiatives that highlight the nutritional benefits of soy and address common misconceptions. Additionally, the development of soy-based products should strike a balance between familiarity and innovation to cater to a broad spectrum of tastes. There is also a need to counter the stigma associated with soy by emphasizing its distinctive attributes and sustainability, rather than solely portraying it as an alternative to meat. The study further highlights the significance of consumer preferences in the presentation of information, as evidenced by the positive reception of well-organized and aesthetically pleasing infographics. Through an ongoing commitment to product refinement, education, and addressing societal preconceptions, soy-based products can carve a niche within the food market, contributing to a richly diverse and sustainable food ecosystem.

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Chapter 4 - Assessing the Impact of Soy-based Food Infographics on Consumer Engagement; An Exploration of Theory of Planned Behavior

4.1 Abstract

Soybeans, rich in essential amino acids, have emerged as a leading alternative protein. The primary goal of this research was to determine university students' attitude, perceived behavioral control, and social norms concerning the intention and actual consumption of soy-based food products, leveraging the Theory of Planned Behavior (TPB) as a framework. The secondary aim was to create four infographics, each with different titles, meat-alternative protein, plant-based protein, soy-based protein, and soybean-based protein, to determine which infographic was most effective at influencing consumer behavior.

The study targeted students dining at the university's dining centers. Seventy-six respondents completed an online survey that measured attitude, social norms, and perceived behavioral control before viewing an infographic, and intention after viewing an infographic. Before viewing an infographic, 69% of respondents believed that consuming soy-based food products are an environmentally friendly choice whereas 56% believed soy-based food products are beneficial for their health and are a sustainable choice.

The survey results indicated that all four infographics positively influenced students' intentions to consume soy-based foods. The "plant-based protein" infographic showed the highest reliability ($\alpha=0.808$), followed by "soy-based protein" ($\alpha=0.736$). Positive attitude had a positive correlation with intention across all infographics, with coefficients ranging from 0.623 to 0.784 ($p<0.001$). Social norms also showed positive relationships with intention, particularly

for the "plant-based protein" ($r=0.731$, $p<0.001$) and "soy-based protein" ($r=0.556$, $p=0.002$) infographics. Perceived behavioral control had varied significance, with the "meat-alternative protein" infographic showing a positive but non-significant correlation ($r=0.556$, $p=0.039$).

To further assess impact of the “plant-based protein” infographic, soy taco crumble was served on the Southwestern line of the two dining centers. The infographic was displayed with soy taco crumble at one dining center, while the same food product was served at another dining center without the infographic but displayed with a placard entitled “taco seasoned vegan protein *contains soy.” Infographic presence had a positive influence on consumption behavior by increasing soy taco crumble consumption, with 20 consumers compared to 9 without the infographic.

Research emphasized the potential of infographics as a strategic tool in promoting sustainable food choices. After reading all infographics, 38% of respondents indicated that the information provided through the infographics changed their point of view on soybeans. In addition, students viewing the infographic were more likely to try the product over just seeing the name of a soy-based product in the dining center.

Keywords: Soy-based food, infographics, Theory of Planned Behavior, consumer behavior, sustainable plant-based protein, university students.

4.2 Introduction

The world population is estimated to reach around 10 billion by 2025. This increase underscores the growing need for sustainable and nutritious protein sources, which are becoming crucial for the future of the food sector. There is a rising trend of incorporating alternative proteins into diets. Notably, plant-based proteins are gaining more acceptance among consumers than animal-based meats (IFT, 2023). Consumer shift from animal-based diets to plant-based diets is associated with environmental, health, and animal welfare concerns (Lin et al., 2017; Sun et al., 2018).

Soybeans are one of the most abundant crops produced globally and have an exceptionally long history of safe use in human nutrition (Dias et al., 2024). Soybeans are considered a high-quality plant-based protein. Soybeans contain 209 unique proteins, including the nine essential amino acids necessary for a balanced human diet, making soybeans a complete source of protein (Capriotti et al., 2014). As the global population rises, the need for meat alternatives intensifies, leading to a surge in research on plant-based proteins (Michel et al., 2021; Shaghaghian et al., 2022).

Research has explored consumer perspectives on plant-based eating (de Boer et al., 2014; Niva & Vainio, 2021; Niva et al., 2017; Schosler et al., 2012; Vanhonacker et al., 2013). But consumer behavior and preferences are continuously evolving which enables marketers with knowledge to anticipate consumer food choices, buying habits, and preferences. The success of a new food product relies on consumer acceptance and perceptions, as these factors are decisive in whether the product will be accepted or rejected (Kwasny et al., 2022; Diaz et al., 2022; Kerslake et al., 2022).

Over the past five years, research into consumer perceptions of soybeans has focused solely on topics such as genetically modified soybean oil (Zhang et al., 2021), plant-based milk alternatives (Moss et al., 2022), the quality of soybean milk (Kurnianto et al., 2020), and various plant protein substitutes (Possidónio et al., 2021). There has been limited research focused on the health benefits of soy to increase nutritional knowledge and awareness and on women's behavioral attitudes and consumption of soy products (Qin et al., 2022; Rah et al., 2004). However, in the past five years, there has been no research to the author's knowledge conducted to study university students' perceptions of soy-based food products using the Theory of Planned Behavior (TPB).

In this study, the researchers utilized results from the preliminary focus groups study to gain deeper insights into university students' perceptions of soybeans and soy-based foods. By employing three infographics sourced from the internet, the initial ideas about what makes an infographic attention-catching and influential were captured. The information gained from the focus groups assisted in the development of new soy-based infographics for an online survey aimed at assessing university students' soy consumption choices after viewing the infographics. The online survey was conducted using the Theory of Planned Behavior to evaluate university students' attitudes, social norms, and perceived behavioral control to consume soy-based foods.

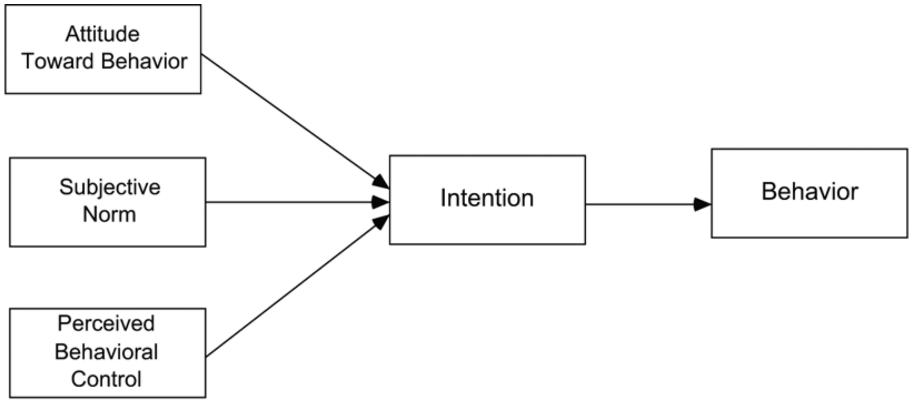
4.3 Theoretical Background

4.3(1) Theory of Planned Behavior

The most trusted theory that currently has been used to predict attitude and behavior is the theory of planned behavior (TPB). TPB is the extended version of the theory of reasoned action (TRA) which was proposed by Ajzen and Fishbein in 1980 (Sogari et al., 2023; Tian et al., 2023). These theories help to predict or understand human behaviors, and the intentions associated with human behaviors, for example why an individual may follow a certain choice behavior (Riebl et al., 2015; Arkorful et al., 2022; McEachan et al., 2011). Many studies have used the theory of planned behavior (TPB) for predicting human behavior regarding different food-related choices like the adoption of healthy diets (Biasini et al., 2021), consumption of fruits and vegetables (Carfora et al., 2016), and plant-based foods (Contini et al., 2020; Wang & Scrimgeour, 2021), and plant-based dietary intentions (Gifford et al., 2024).

The Theory of Planned Behavior (TPB) suggests that consumer behavior is shaped by intention, which itself is shaped by three critical factors: attitude, social norms, and perceived behavioral control (Ajzen, 1985) (Figure 4.1). TPB theory provides an effective framework for understanding the complexities of human behavior by highlighting the roles of key cognitive factors like attitude, social norms, and perceived behavioral control in influencing consumer intentions (Tian et al., 2023). Empirical evidence consistently supports that positive attitude, adherence to social norms, and a strong sense of perceived behavioral control significantly affect the intention to consume plant-based food products (Rosenlöw & Hansson, 2020).

The primary goal of this research was to determine consumer (university students) attitude, perceived behavioral control, and social norms concerning the intention and actual consumption of soy-based food products. The secondary aim was to create four infographics, each with different titles, meat-alternative protein, plant-based protein, soy-based protein, and soybean-based protein, to determine which infographic was most effective at influencing consumer behavior. The third goal was to investigate whether displaying or not displaying the most favored infographic alongside a soy-based food product at Kansas State University's dining centers significantly affected consumer consumption patterns.



Source: Adapted from Ajzen (1991)

Figure 4.1 Theory of planned behavior model.

4.3(2) Attitude

The concept of attitude towards a behavior refers to the emotional responses of a person to a particular task or activity (Ajzen, 1977). Understanding attitude is essential to understanding the feelings and position of a person regarding an object, indicating their preference or aversion to consuming soy-based food products. Attitude is also characterized as the evaluation of whether adopting a behavior is favorable or unfavorable (Teo & Beng Lee, 2010). Consistent evidence has demonstrated that attitude plays a pivotal role in shaping intention and behavior. According to the Theory of Planned Behavior (TPB), a significant relationship exists between attitude and intention (Ajzen,1985). Therefore, a positive attitude among university students is expected to correlate with a strong intention to consume soy-based food products.

Based on TPB's attitude construct principle concepts, the following hypotheses for this study were developed:

Hypothesis 1: Attitude toward soy-based food products after viewing the "meat-alternative protein" infographic has a significant positive relationship with intention to eat soy-based food products.

Hypothesis 2: Attitude toward soy-based food products after viewing the “plant-based protein” infographic has a significant positive relationship with intention to eat soy-based food products.

Hypothesis 3: Attitude toward soy-based food products after viewing the “soy-based protein” infographic has a significant positive relationship with intention to eat soy-based food products.

Hypothesis 4: Attitude toward soy-based food products after viewing the “soybean-based protein” infographic has a significant positive relationship with intention to eat soy-based food products.

4.3(3) Social Norms

Social norms are the individual’s belief that influential people in their life expect them to perform or refrain from certain behaviors (Ajzen, 1991). This concept is crucial in understanding how opinions and mandates from influential figures or bodies, such as friends, family, co-workers, and class fellows can compel individuals to adopt eating habits. This research positions social norms as a key determinant in university students’ intention to eat soy-based food products within the university dining centers, influenced by expectations from significant others or groups. The likelihood of adopting a behavior increases with the perceived social pressure to conform, suggesting that individuals are more inclined to act in ways they believe are expected by others (Arkorful et al., 2022). According to the Theory of Planned Behavior (TPB), a significant relationship exists between social norms and intention (Ajzen,1985). Therefore, positive social norms among university students are expected to correlate with a strong intention to consume soy-based food products.

Based on TPB’s social norms construct principle concepts, the following hypotheses for this study were developed:

Hypothesis 5: Social norms after viewing the “meat-alternative protein” infographic have a significant positive relationship with eating soy-based food products’ intention.

Hypothesis 6: Social norms after viewing the “plant-based protein” infographic have a significant positive relationship with eating soy-based food products’ intention.

Hypothesis 7: Social norms after viewing the “soy-based protein” infographic have a significant positive relationship with eating soy-based food products’ intention.

Hypothesis 8: Social norms after viewing the “soybean-based protein” infographic have a significant positive relationship with eating soy-based food products’ intention.

4.3(4) Perceived Behavioral Control

Perceived behavioral control (PBC) is described as an individual’s assessment of the ease or difficulty associated with performing a specific behavior (Ajzen, 1991). It concerns the personal perception of various elements that may either facilitate or obstruct the manifestation of behavior and intent (Guido et al., 2010). Perceived behavioral control (PBC) only impacts actual behavior when the individual does not have full voluntary control over their actions (Ajzen, 1991). According to the Theory of Planned Behavior (TPB), a significant relationship exists between perceived behavioral control and intention (Ajzen,1985). Therefore, a positive perceived behavioral control among university students is expected to correlate with a strong intention to consume soy-based food products.

Based on TPB’s perceived behavioral control construct principle concepts, the following hypotheses for this study were developed:

Hypothesis 9: Perceived behavioral control after viewing the “meat-alternative protein” infographic has a significant positive relationship with eating soy-based food products’ intention.

Hypothesis 10: Perceived behavioral control after viewing the "plant-based protein" infographic has a significant positive relationship with eating soy-based food products' intention.

Hypothesis 11: Perceived behavioral control after viewing the "soy-based protein" infographic has a significant positive relationship with eating soy-based food products' intention.

Hypothesis 12: Perceived behavioral control after viewing the "soybean-based protein" infographic has a significant positive relationship with eating soy-based food products' intention.

4.3(5) Intention

The Theory of Planned Behavior (TPB) model views predicting intentions as something that comes from a series of related actions. Essentially, intentions are seen as indicators of the factors that influence behavior, showing how willing people are to do something. Intentions reflect how hard it might be for someone to carry out a behavior and indicate the amount of effort they are prepared to put into doing it (Sheeran, 2002).

4.4 Methods

4.4(1) Experimental Design

The study leveraged the Theory of Planned Behavior (TPB) to understand the constructs of attitude, perceived behavioral control, and social norms before and after viewing the infographics, and their impact on the intention to consume soy-based food products. The study consisted of three components: 1) the use of results from a preliminary study to further understand university students' perceptions of soybeans and soy-based foods and to gain their opinions of three internet available infographics; 2) to understand the constructs of TPB, a survey was completed by university students that ate meals in the dining centers; and 3) to evaluate the impact of infographics on university students' willingness to consume soy-based food products. Research approval was obtained from Kansas State University's Institutional Review Board (IRB# 11516) (**Appendix E**).

4.4 (2) Infographic Development

An initial study involving focus groups was carried out to solicit feedback from students at the Kansas State University dining center on three internet available infographics, as detailed in Chapter Three. Students were presented with three different infographics, one on soy sauce, one on hidden sources of soy, and another on various soy-based food products like tofu, to gauge their preferences. Analysis of their feedback indicated a preference for infographics that combined engaging aesthetics, informative content, and appealing color schemes while emphasizing the need for clear titles and a well-organized, easy-to-read layout.

To accomplish the objectives of the study, four infographics were created under the titles: meat-alternative protein, plant-based protein, soy-based protein, or soybean-based protein (Figures 4.1, 4.2, 4.3, and 4.4) to assess their influence on consumer consumption behavior. The infographics contained some health benefits of soy, adding information about the health benefits of soy to the infographics was crucial for educating university students. Soy is a complete protein containing all the 9 essential amino acids, beneficial for maintaining a balanced diet (Capriotti et al., 2014). Highlighting these health benefits can increase awareness and potentially influence positive dietary choices among university students, promoting better health outcomes.

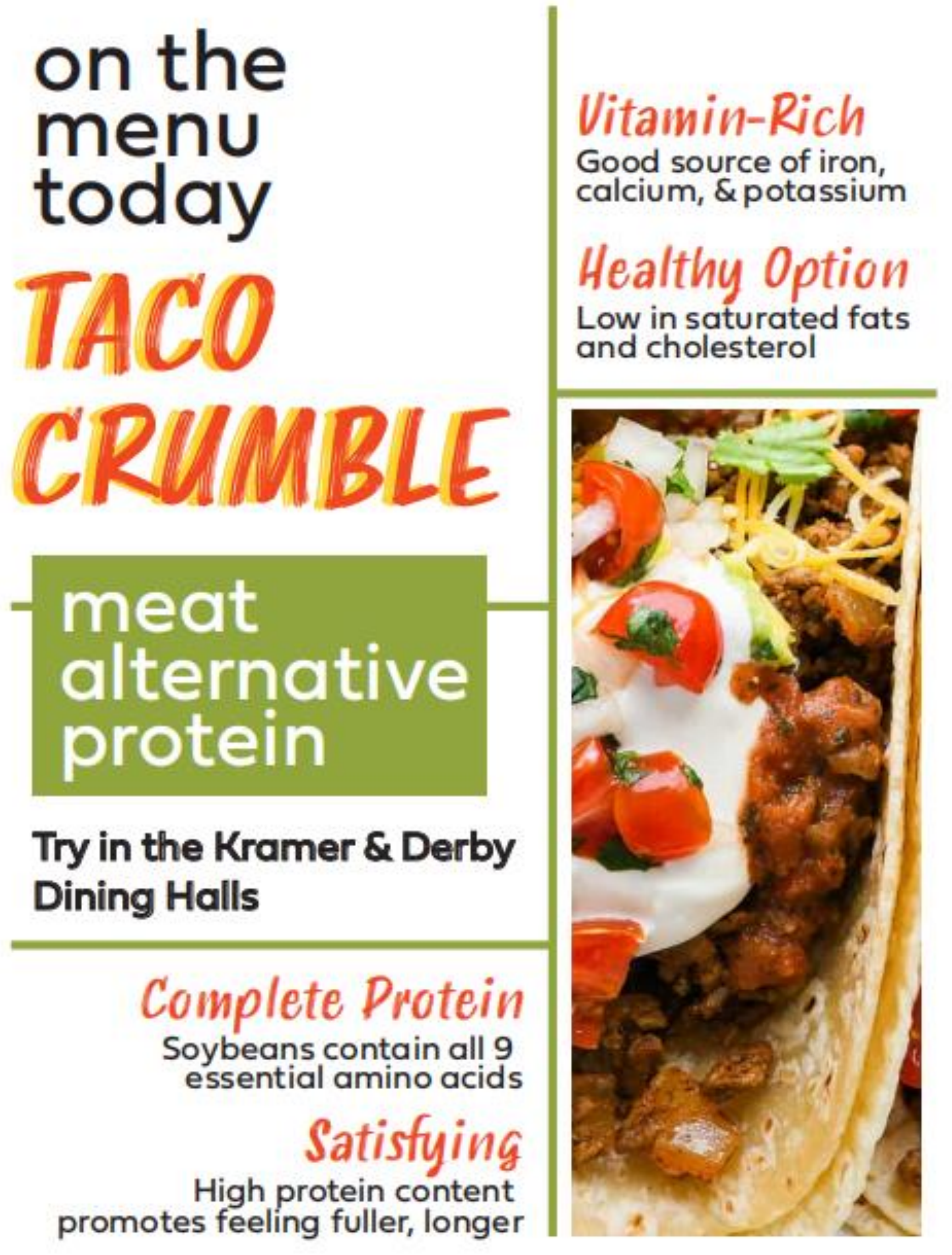


Figure 4.2 Meat-alternative protein infographic.

Figure 4.3 Soybean-based protein infographic.

Figure 4.4 Soy-based protein infographic.

Figure 4.5 Plant-based protein infographic.

4.4(3) Survey

A survey from previous studies was adopted (Pandey et al., 2021; Egan et al., 2021; Devraj et al., 2022; Van Hecke et al., 2020) and modified according to this research study's goals and based on the TPB model. The three original TPB constructs of intention were measured: attitude using six items, social norms using three items, and perceived behavioral control using three items. Respondents were asked to rate these items on a Likert scale from 1= “strongly disagree” to 5= “strongly agree.”

Attitude toward behavior refers to the emotional responses to a particular task or activity, indicating preference or aversion (Ajzen, 1977; Teo, 2010). In this study, the attitude was measured through respondents’ feelings towards soy-based food products by asking them questions about sustainability, health benefits, and the eco-friendly nature of soy.

Social norms reflect the individual’s belief that influential people in their life expect them to perform certain behaviors (Ajzen, 1991). This study positioned social norms as a key determinant in the intention to eat soy-based food products, influenced by expectations from significant others or groups. In this study, the social norms were measured by asking questions like do respondents' family, friends, and/or class fellows somehow affect their decisions to consume soy-based food products.

Perceived behavioral control (PBC) refers to an individual’s assessment of the ease or difficulty associated with performing a specific behavior (Ajzen, 1991). It impacts actual behavior when the individual does not have fully voluntary control over their actions (Guido et al., 2010). In this study, the perceived behavioral control (PBC) was measured by asking respondents if they think they can make their own decisions about consuming soy-based food products.

A pilot survey was conducted to assess the reliability of the survey, with a sample population size of 30 students (n=30) from the Fundamentals of Food Processing course. The data for the study was collected using Qualtrics, an online survey platform (Qualtrics, Provo, IT, USA). The results of Cronbach's alpha for the pilot survey yielded the following values: attitude (0.880), intention (0.618), social norms (0.917), and perceived behavioral control (0.609). These results indicated that the questions related to attitude and social norms are suitable for the final survey. However, the questions about perceived behavioral control and intention needed revision, as Cronbach's alpha values are below the acceptable threshold of 0.7. Consequently, certain questions from perceived behavioral control and intention were modified and updated for the final survey to improve reliability.

The target population for the final survey was university students who dine at the university's dining centers at Kansas State University. The data for the study was collected using Qualtrics, an online survey platform (Qualtrics, Provo, IT, USA), between 04th March and 15th April 2024.

The Qualtrics survey (**Appendix I)** consisted of five sections. In section one, respondents were informed about the study's purpose and assured of the confidentiality of their responses, after which they were provided informed consent to participate. The second part collected data on attitudes, social norms, and perceived behavioral control. In the third part, a participant was shown one of four randomly assigned infographics, each with a different heading: meat-alternative protein, plant-based protein, soy-based protein, or soybean-based protein. The participant was required to view the infographic for 30 seconds before answering a manipulation check question to confirm their engagement with the content. The fourth section gathered information on their intentions to consume soy-based food products, the appeal of the infographic, and demographic details such as age, gender, year, and college of study. The final section included a question on behavioral intent. Participants were incentivized with the chance to win one of two $100 Amazon gift cards, entered by providing their email upon survey completion.

4.4(4) Survey Recruitment Method

A survey statement with a QR code was distributed among the Kansas State University students using the dining centers monthly newsletter distributed via email. The same survey statement with a QR was distributed for 2 months in the newsletter to the students, first in March and again in April, to maximize response rates. The survey period was open from March 1, 2024, to April 16, 2024. Additionally, two flyers featuring QR codes were placed in both Kramer and Derby dining centers near the serving lines where the soy-based food product would be served, aiming to garner additional survey responses (Figure 4.6). These recruitment flyers were removed from the dining centers before the soy-based food product was served.

Figure 4.6 Survey recruitment flyer.

4.4(5) Infographic Effectiveness Testing

To test the effectiveness of the infographic, a soy-based food product (soy taco crumble) was served at Kansas State University's Kramer and Derby dining centers. The "plant-based protein" infographic, which received the most positive feedback, was displayed alongside the soy taco crumble at Kramer dining center for two hours on two different days at the southwestern serving line. The same food product was served without the infographic at Derby dining center for a similar duration. This setup allowed for the analysis of the infographic's effect on consumer consumption behavior.

4.5 Statistical Analysis

The internal consistency and reliability of each construct (attitude, social norms, perceived behavioral control, and intention) were measured by Cronbach's coefficient alpha. The acceptable value of Cronbach's alpha test is <0.70, the value less than 0.70 must be rejected (Bonett & Wright, 2015). The range of Cronbach's alpha is from zero to one, where values closer to 1 indicate high internal consistency, suggesting that the questions in the same 5-point Likert scale are highly correlated and measure the same underlying construct reliably. Since the endpoint was a 5-point scale Likert score, the Spearman rank-order correlation, a nonparametric measure of association based on the ranks of the data values was applied for relations between intention and other constructs (attitude, social norms, and perceived behavioral control). All statistical analyses were performed using the CORR, and FREQ procedures of SAS software, Version 9.4 (SAS Institute Inc., Cary, NC, USA).

4.6 Results

4.6(1) Survey Participants Demographics

Participants who dine at the Kansas State dining centers were recruited to participate in an online survey. Out of 82 respondents, 6 were disqualified for not completing the survey, resulting in a final sample of 76 validated participants. The average age of the participants was 25.41 years, comprising 18 males (23.68%), 54 females (71.05%), and four others (5.26%). The breakdown by academic year included 50 freshmen (65.79%), five juniors (6.58%), seven postgraduates (9.21%), nine seniors (11.84%), and five sophomores (6.58%). Regarding their majors, 11 were studying agriculture (14.47%), six in architecture, planning, and design (7.89%), 19 in arts and sciences (25.00%), nine in business administration (11.84%), five in education (6.58%), 12 in engineering (15.79%), and 14 in health and human sciences (18.42%) (Figures 4.7, 4.8, and 4.9).

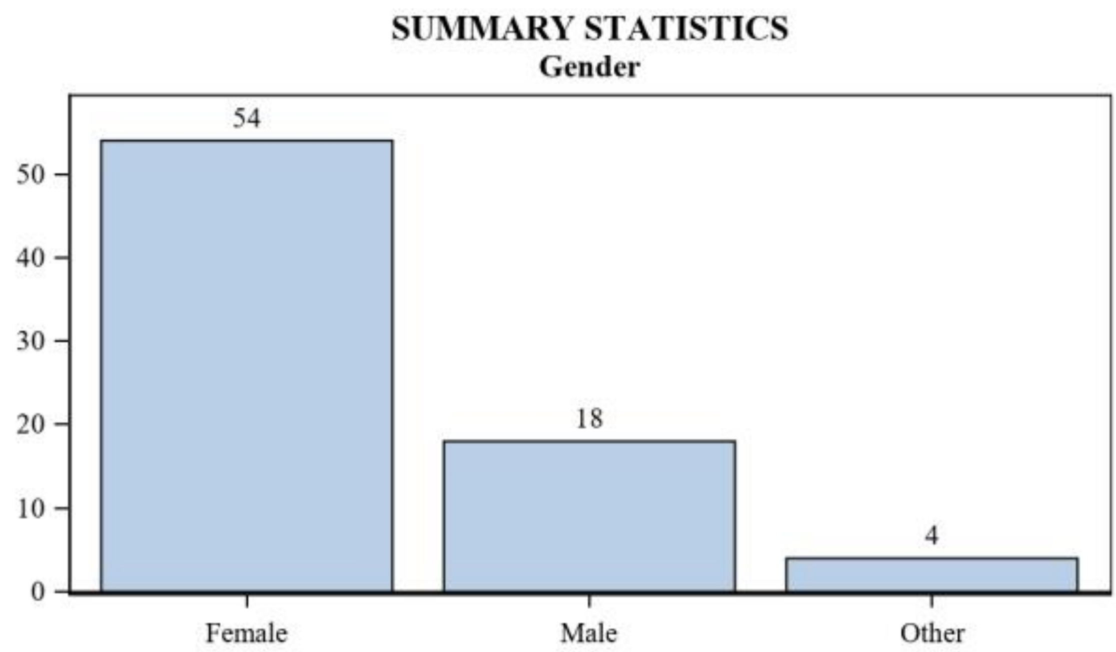


Figure 4.7 Respondents' gender responses.

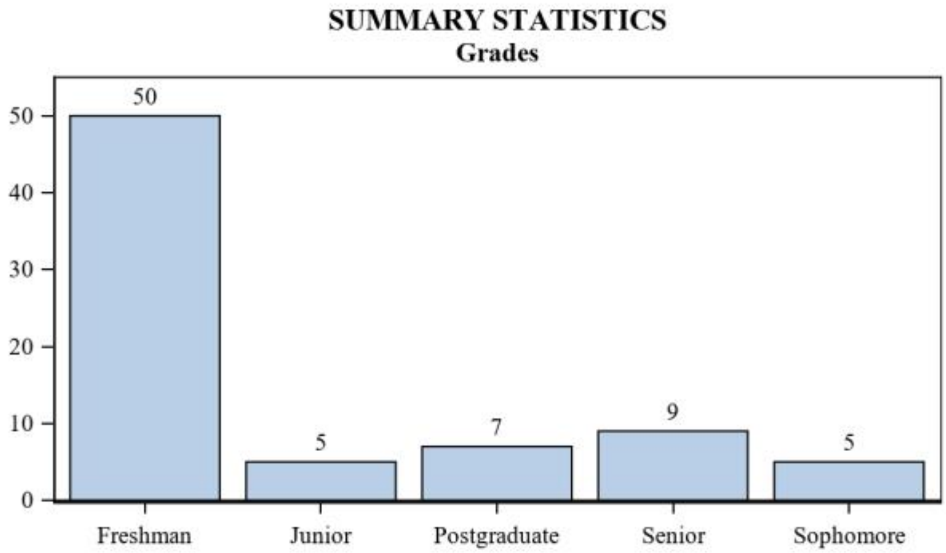


Figure 4.8 Respondents' academic year/grade.

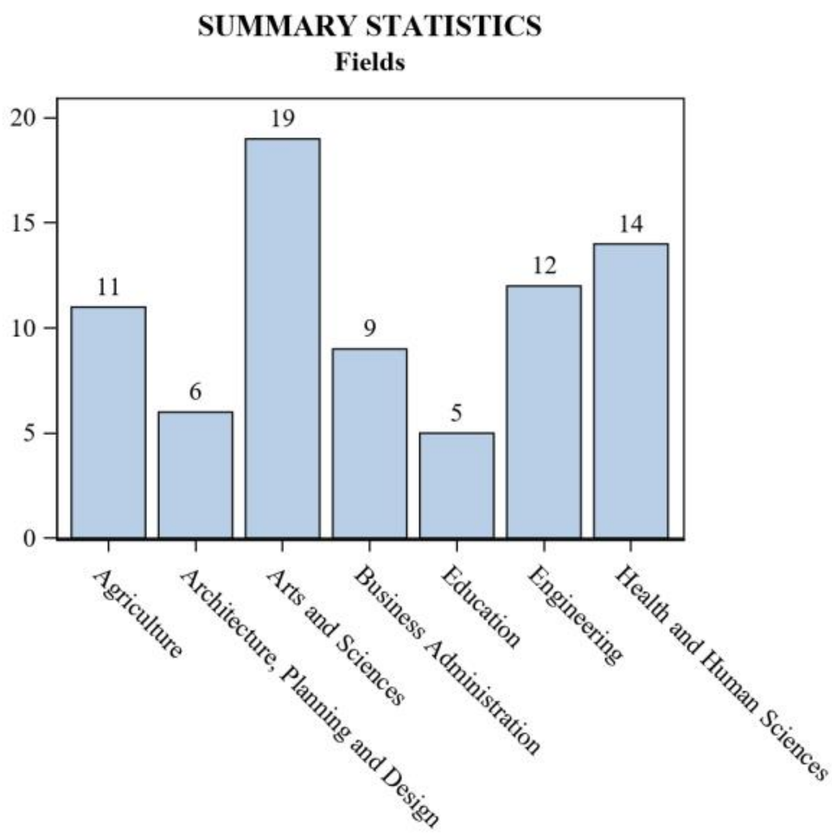


Figure 4.9 Respondents' major fields.

4.6(2) Survey Results

The constructs of intention within the Theory of Planned Behavior (TPB) model were evaluated to understand students' attitude, social norms, and perceived behavioral control regarding soy-based food products. The survey revealed that 69% of students agreed that consuming soy-based food products is an environmentally friendly choice (3.77±0.88), 57% of students agreed that consuming soy-based food products is a sustainable choice (3.52±1.01), Additionally, the majority of students recognized the health benefits associated with soy-based products. Over half of the respondents agreed that these products have digestive benefits (53%, 3.50±1.03) and are beneficial for their overall health (56%, 3.43±1.09). When considering animal welfare, students moderately agreed that consuming soy-based food products is better for animal welfare (3.32±1.12) and makes them feel good (2.89±1.20).

Social norms seemed to exert a moderate influence on students' attitudes towards soy-based food products. The responses indicated that students' friends (2.50±1.17), family (2.47±1.17), and colleagues/classmates (2.64±1.12) thought they should consume soy-based food products. These results indicate that family members, friends, and/or colleagues have a low impact on a students' decision to consume soy-based food products.

In terms of perceived behavioral control, 86% of students strongly agreed or agreed that the choice to include soy-based food products in their diet is entirely their own. Over 70% Talso expressed confidence in their ability to easily consume and find soy-based food products in the market.

Table 4.1 Constructs of intention in the TPB model with mean, [1]SD, and response range.

Construct	Questions	Mean±[1]SD	Response range
Attitude	Consuming soy-based food products is a sustainable choice.	3.52±1.01	Strongly disagree (1) to Strongly agree (5)
	Consuming soy-based food products is environmentally friendly.	3.77±0.88	
	Soy-based food products have digestive benefits.	3.50±1.03	
	Soy-based food products are beneficial for my health.	3.43±1.09	
	Consuming soy-based food products is better for animal welfare.	3.32±1.12	
	Consuming soy-based food products makes me feel good.	2.89±1.20	
Social Norms	My friends think I should consume soy-based food products.	2.50±1.17	Strongly disagree (1) to Strongly agree (5)
	My family thinks I should consume soy-based food products.	2.47±1.17	
	My colleagues/classmates think I should consume soy-based food products.	2.64±1.12	
Perceived Behavioral Control	The choice to include soy-based food products in my diet is entirely my own.	4.43±0.89	Strongly disagree (1) to Strongly agree (5)
	I am confident that, if I want to, I can easily consume soy-based food products.	3.89±1.11	
	I am confident that, if I want to, I can easily find soy-based food products in the market.	3.76±1.11	

[1]SD=Standard deviation; (n=76), Likert scale= “1=strongly disagree” to “5=strongly agree”.

After showing the randomized infographic the intention was measured using three items. Respondents were asked to rate these items on a 5-point Likert scale from 1= “strongly disagree” to 5= “strongly agree” (Table 4.2). Seven items also were measured on infographic appeal using a 5-point Likert scale (Table 4.2). The relationship between the demographic variable gender and intention was examined without having specific hypotheses. The relationship between the demographic variable gender and intention was examined without having specific hypotheses. No differences were found in attitude, social norms, and perceived behavioral control regarding the intention to consume soy-based food products among males, females, and others.

Table 4.2 Intention and infographic appeal items (n=76).

Construct	Questions	Mean±[1]SD	Response range
Intention	The likelihood that I will eat soy-based food products in the next two weeks is high.	2.88±1.43	Strongly disagree (1) to Strongly agree (5)
	I am planning to eat soy-based food products in the next two weeks.	2.65±1.41	
	I am willing to try soy-based food products.	4.07±1.12	
Infographic appeal	The infographic was easy to read.	4.52±0.80	Strongly disagree (1) to Strongly agree (5)
	The infographic was easy to follow.	4.44±0.80	
	The content used in the infographic was easy to understand.	4.56±0.69	
	How surprising do you find this information?	3.13±0.99	
	Is the information conveyed by the infographic new or novel to you?	3.17±1.23	
	Has this information changed your point of view on soybeans?	2.98±1.16	
	How useful did you find this infographic?	2.85±1.05	Not at all useful (1) to Extremely useful (5)

[1]SD=Standard deviation, Likert scale= “1=strongly disagree” to “5=strongly agree.”

Table 4.3 Behavior items (n=76).

Construct	Question	Percent response
Behavior	How often do you currently consume soy-based foods? (e.g., tofu, soy milk, edamame, soy sauce).	7% Very often (4 or more times a week 14% Often (2-3 times a week) 18% Occasionally (1-3 times a month) 37% Rarely (less than once a month)

4.6(3) Reliability of Questions

Cronbach’s alpha test was utilized to evaluate the construct's reliability (Santos, 1999). The acceptable value of Cronbach’s alpha test is <0.70, the value less than 0.70 must be rejected (Bonett & Wright, 2015). Combined responses to the intention items (Table 4.2) were in mid-to-high levels of their 5-point scale (3.206±1.468). Among the constructs of intention, respondents reported relatively high levels on a 5-point scale for combined perceived behavioral control (4.031±1.084), combined attitude (3.410±1.094), and combined social norms (2.539±1.155). Cronbach’s alpha ranged from 0.86 for attitude, 0.92 for social norms, and 0.87 for intention indicating an acceptable homogeneity limit of >0.70 among the items of a respective construct (Santos, 1999). All in all, the proposed theoretical model has adequate convergent and discriminant validity and reliability measures except perceived behavioral control construct with a Cronbach’s alpha of 0.52.

Table 4.3 Combined constructs (mean±SD) and Cronbach's alpha (n= 76).

Combined Constructs	[1]Combined Mean±SD 1=strongly agree and 5=strongly disagree	Cronbach's alpha
Attitude	3.41±1.09	0.86
Perceived behavioral control	4.03±1.08	0.52
Social norms	2.53±1.15	0.92
Intention	3.20±1.47	0.87

[1] Combined mean for each construct and SD=Standard deviation.

4.6(4) Relation Between the Constructs and Intention

Upon presentation of one of four distinct infographics to respondents, an analysis was conducted to examine the correlations between each infographic and the constructs related to respondents' intentions. The hypothesis was to determine which infographic (meat-alternative protein, plant-based protein, soy-based protein, or soybean-based protein) was most effective at influencing consumer intention to consume the soy-based food product (soy taco crumble). A sample size-to-item ratio of 10 participants per construct item is necessary for model precision, "the ability of the construct estimates to approximate true population value" (Kline, 2023). The results indicated that none of the three constructs (attitude, perceived behavioral control, and social norms) exhibited significant relationships with intention, as outlined in Table 4.6.

However, notably significant positive correlations were observed among respondents' attitudes and their intentions across all four infographics. The correlations were as follows: meat-alternative protein (r=0.728, $p<0.001$), plant-based protein (r=0.717, $p<0.001$), soy-based protein (r=0.623, $p<0.001$), and soybean-based protein (r=0.784, $p<0.001$).

In terms of perceived behavioral control, variability in the p-value was noted. The infographic depicting meat-alternative protein demonstrated a significant positive relationship with intention (r=0.556, $p<0.01$). However, the other infographics associated with plant-based protein (r=0.146, $p>.05$), soy-based protein (r=0.228, $p>.05$), and soybean-based protein (r=0.348, $p>.05$) did have positive correlations with the intention but these relations were not significant due to having p-values greater than .05. This variability might be due to not having the reliable perceived behavioral control Cronbach's alpha value ($\alpha = 0.52$).

Regarding the construct of social norms, the meat-alternative protein infographic did achieve a positive correlation with intention (r=0.377, $p>.05$), but the relation was not significant. Conversely, the infographics for plant-based protein (r=0.731, $p<0.001$), soy-based protein (r=0.558, $p<0.001$), and soybean-based protein (r=0.595, $p<0.01$) all demonstrated significant positive relationships with intention.

Table 4.4 Correlations among the constructs with intention after viewing infographics.

Infographics	n	Constructs	Correlation Coefficients (r)	*p*-values
Meat-alternative protein	14	Attitude	0.728	0.0031**
Meat-alternative protein	14	Perceived behavioral control	0.556	0.0386*
Meat-alternative protein	14	Social norms	0.377	0.1829
Plant-based protein	17	Attitude	0.717	0.0012**
Plant-based protein	17	Perceived behavioral control	0.146	0.5736
Plant-based protein	17	Social norms	0.731	0.0009**
Soy-based protein	28	Attitude	0.623	0.0004**
Soy-based protein	28	Perceived behavioral control	0.228	0.2432
Soy-based protein	28	Social norms	0.556	0.0020**
Soybean-based protein	17	Attitude	0.784	0.0002**
Soybean-based protein	17	Perceived behavioral control	0.348	0.1709
Soybean-based protein	17	Social norms	0.595	0.0117*

Note: * Significant at the 0.01 level; **Significant at the 0.001 level.

4.6(5) Infographic Appeal Results

The investigation into which infographics most effectively influenced intentions was complicated due to variations in the significant levels across the constructs of attitude, perceived behavioral control, and social norms. Cronbach's α values for the infographics were as follows:

meat-alternative protein (α=0.595), plant-based protein (α=0.808), soy-based protein (α=0.736), and soybean-based protein (α=0.634). Given that the acceptable homogeneity limit for Cronbach's alpha α is >0.70, the meat-alternative and soybean-based protein infographic α score values were below the acceptable value (Santos, 1999). So, the research team decided to use the plant-based protein infographic. This decision was based on its higher α-value than the soy-based protein infographic α-value, as shown in Table 4.7. Consequently, the plant-based protein infographic was selected for display alongside the soy-based food product (soy taco crumble) at the Kramer dining center.

Table 4.5 Infographics appeal testing.

Infographic	**Cronbach's alpha**
Meat-alternative protein	0.595
Plant-based protein	0.808
Soy-based protein	0.736
Soybean-based protein	0.634

4.6(6) Infographic Influence

At Kramer dining center, soy taco crumble accompanied by a plant-based protein infographic was served on the southwestern line over two days, each serving session lasting a minimum of two hours (Figure 4.10). In contrast, the same food product was served at Derby dining center on the southwestern line without an infographic but displayed with a placard entitled "taco seasoned vegan protein *contains soy" during a similar timeframe (Figure 4.11). To evaluate the impact of the infographic on consumer consumption behavior, the author counted the number of people who took a serving of soy taco crumble during the serving times.

The Kramer dining center, which utilized the infographic, attracted 20 consumers who chose to consume soy taco crumble serving as their meal option because of the infographic. In contrast, the Derby dining center, which did not use the infographic, attracted only 9 consumers. This preliminary observation suggests that infographics might positively influence consumer consumption patterns.

However, it is essential to consider additional factors that could have affected these results. Notably, the seating capacity and style at each dining center differ; Kramer serves approximately 1,200 students, while Derby accommodates about 1,000. Furthermore, the presence of alternative food options such as beef and chicken available on the days the soy-based product (soy taco crumble) was served also could have influenced consumer choices. These variables underscore the need for a more controlled study to isolate the effect of the infographic on consumption behavior accurately.

Moreover, before viewing an infographic, 69% of respondents believed that consuming soy-based food products is an environmentally friendly choice whereas 56% believed soy-based food products are beneficial for their health and are a sustainable choice. Later on, after reading all the infographics, 38% of respondents indicated that the information provided through the infographics changed their point of view on soy-based food products. In addition, students viewing the infographic were more likely to try the product over just seeing the name of a soy-based food product in the dining center.

Figure 4.10 Serving line at Kramer dining center without the infographic.

Figure 4.11 Serving line at Derby dining center with the infographic.

4.7 Discussion and Implication

This research study investigated the impact of different infographics (meat-alternative protein, plant-based protein, soy-based protein, and soybean-based protein) on university students' willingness to consume soy-based food products, using the Theory of Planned Behavior (TPB) and its key constructs: attitude, social norms, and perceived behavioral control. The results generally showed that infographics positively influenced students' willingness to consume soy-based foods.

The study also revealed that the positive attitude towards soy-based and plant-based alternatives is a significant predictor of the intention to consume soy-based and plant-based food products. This aligns with the findings from previous research studies. As the study by Pandey et al. (2021) revealed that both attitude ($\beta = 0.216$, $p < 0.001$) and perceived behavioral control ($\beta = 0.229$, $p < 0.001$), had a positive and significant impact on consumers' intention to consume plant-based yogurt alternatives. Conversely, subjective norms ($\beta = 0.106$, $p = 0.087$) did not have a significant effect on consumers' intention to consume plant-based yogurt alternatives. (Pandey et al., 2021; Hoek et al., 2011).

In line with the TPB model and findings from other researchers (Zhang et al., 2019; (Rees et al., 2018; Krispenz & Bertrams, 2020; Huang et al., 2020; Croker et al., 2009; Gifford et al., 2024; Wheeler & Chapman-Novakofski, 2014; Li et al., 2010), social norms significantly correlated with the intention to consume soy-based and plant-based food products. Interestingly, in this study, social norms and intentions did not significantly influence the consumption of soy-based food products after viewing the meat-alternative infographic, but it was significantly related to intention for consuming soy-based food products after viewing other infographics (plant-based protein, soy-based protein, and soybean-based protein). A future hypothesis might be to explore whether individuals prefer to view themselves as independent from their social circles, regardless of whether this perception is accurate.

Lastly, perceived behavioral control showed no significant effect on the intention to consume soy-based food products in the aggregated sample for all four infographics. Previous research supports that perceived behavioral control is a less effective construct than attitude when it comes to adopting plant-based diets (Wang et al., 2016; Graça et al., 2015). Graça et al. (2015) lend support to the idea that holding a pattern of attachment towards meat consumption may hinder personal willingness and intentions to adopt a more plant-based diet. This attachment to meat can diminish the influence of perceived behavioral control, thereby emphasizing the stronger role of attitudes in shaping dietary intentions. Essentially, individuals with a strong attachment to meat are less likely to feel capable of changing their diet, making their attitude towards plant-based diets a more critical factor in their decision-making process.

4.8 Limitations and Conclusion

This research study employed the extended Theory of Planned Behavior (TPB) model to examine the willingness of university students to eat soy-based foods, focusing on those who dine at Kansas State University's dining centers. To conduct this study, a questionnaire was adopted from previous studies and modified according to the hypotheses of this study. Four infographics titled meat-alternative protein, plant-based protein, soy-based protein, or soybean-based protein were developed and utilized to analyze the impact of infographics on university students' consumption behavior. Plant-based infographic was displayed on the serving line with the soy taco crumble at Kramer dining center, which attracted more consumers and increased their willingness to consume soy-based food products.

There are several limitations to this research. The sample size used for data analysis was 76, barely meeting the threshold necessary for testing multiple hypotheses (Byrne, 2013). Additionally, the study was limited to individuals from a single university, possibly affecting the generalizability of the findings. The data was gathered through a structured questionnaire, which may have limited deeper insights into consumer behavior regarding soy-based foods. Limited previous studies on soy-based food products have restricted the comparison and contrasting of results. The study focused solely on attitudes, social norms, and perceived behavioral control, neglecting potentially influential factors such as health consciousness (Mäkinen et al., 2016) and environmental concerns (Hoek et al., 2011), which could have provided a better understanding of consumer decision-making.

In conclusion, this research successfully applied the TPB model focusing on three main constructs: attitude, social norms, and perceived behavioral control. Findings indicated that these factors significantly influenced Kansas State University students' intentions to consume soy-based foods. However, social norms and perceived behavioral control did not significantly affect consumption intentions.

Future research should involve larger and more diverse samples and extend over longer periods and across different nations to enhance representativeness and applicability. Additionally, incorporating a segmentation approach within the TPB model could offer deeper insights into the complexities of food choices, particularly concerning soy-based products.

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Chapter 5 - Development and Scale-up of Soy Taco Crumble for K-State Dining Services; Sensory and Cooking Properties of Texturized Soy Protein Taco Crumble

5.1 Abstract

With the global population expected to surpass nine billion by 2025, there is an urgent need for sustainable plant-based protein alternatives. The objective of this study was to develop and scale-up a texturized soy protein taco crumble for university dining services that serve approximately 2,200 students daily. This research optimized the formulation, evaluated physicochemical properties, and assessed consumer acceptance. Taco crumble recipe underwent formulation and scaling for dining service portions. Key physicochemical properties, including moisture content, pH, color, cooking loss, and water-holding capacity, were evaluated to ensure product stability and quality under typical dining center serving, storage, and reheating conditions. Sensory evaluations were conducted among students (n=208) and dining center staff using the nine-point Hedonic scale (1=dislike extremely, 9=like extremely).

Taco crumble ingredients included texturized soy protein, vegetable base, hot water, oil, and taco seasoning mix. Preparation involved rehydrating texturized soy protein in hot water with vegetable broth, cooking in oil and seasonings at 200-250°F using a tilt skillet, and holding at ≥140°F temperature during serving.

Moisture analyses at different storage and reheating conditions were performed to assess moisture impact on product quality, ensuring product remained within standards required for safe and enjoyable consumption in dining centers. Results indicated that freshly cooked product retained the same moisture ($p>0.05$) during holding for 60 minutes, while refrigerated samples for 3 and 7 days had reduced moisture content ($p<0.05$) throughout the 60-minute holding period and extended freezing for 14- and 21-days improved moisture retention upon holding ($p<0.05$).

Sensory results indicated high acceptability of taco crumble, particularly for aroma, flavor, and seasonings, with overall acceptability scores of 7.54±1.17, confirming the product’s potential success in dining services. Cooking loss averaged 13.22±3.07, and water-holding capacity was 96.44±1.14, demonstrating the product's ability to maintain moisture and a desired texture. For cooked taco crumble, pH was 6.47±0.12 and color was L*=39.63±4.26, a*=15.64±0.81, and b*=29.35±0.98. Nutritional analysis showed that one serving containing 2 ounces (67g) contained 11 grams of protein, 4 g of dietary fiber, and 100 calories, with a cost of $0.18 per serving.

In conclusion, this study successfully developed a scalable soy taco crumble that aligns with consumer preferences for taste, texture, and sustainability for university students. Over 82% of the students tasting the product were willing to consume the product again in the dining center. Regarding sensory properties, several students commented that “they could not tell the product was plant-based.”

Keywords: Soy-based food, Soy taco crumble, Plant-based meat alternative, Consumer acceptance, Food product development, Sustainable protein sources

5.2 Introduction

The global population is projected to reach at least nine billion by 2025 (Lee et al., 2020), necessitating a significant increase in meat or protein production, potentially doubling current levels. Plant-based meat alternatives offer a promising solution to this problem, proving a good source of protein that can match the color, nutrition, taste, and consistency of specific meats (Choudhury et al., 2020). Also, a massive demand for plant-based proteins has surged in consumers' perceptions (Bakhsh et al., 2021; Sha & Xiong, 2020).

Consumers are demanding healthier options, more sustainable, and more ethical foods to meet their protein needs. Plant-based food products are being developed to meet these growing consumer needs (Choudhury et al., 2020; Zhou et al., 2022). Plant-based meat alternatives are among the most accepted alternative proteins (Circus & Robison, 2019; Grasso et al., 2019; Iannuzzi et al., 2019). Plant-based proteins have also been extensively involved in meat products as partial extenders or full replacements to enhance the properties of meat products or to imitate the meat-like texture and taste (Bakhsh et al., 2021; Ball et al., 2021).

Texturized vegetable protein (TVP) is a processed plant product produced via texturization with fibrous textures, closely imitating animal muscle meat (Maningat et al., 2022). Texturized vegetable protein (TVP) has been derived from several grains, with soy protein and wheat gluten being two of the primary protein sources (Kyriakopoulou et al., 2021). Soy proteins are a cost-effective source of high-quality plant-based protein and have a highly similar appearance to meat (Fang et al., 2014). Incorporating soy-based ingredients in various food formulations enriches the food with higher protein content while reducing overall food costs compared to animal-based proteins like meat or dairy (Dias et al., 2024). Due to the functional properties of soy protein such as water-holding capacity, gelling, fat absorption, and emulsifying capacity, soy protein is extensively used in the development of meat alternatives and some meat products to improve texture (Ahmad et al., 2022). This comprehensive protein profile has led to its widespread use in the food industry, both as a primary ingredient in various food products (Kumar et al., 2022) and as a common functional additive like soy lecithin (Modgil et al., 2020; Rybowska, 2016).

Despite these benefits, many consumers are reluctant to change their eating habits (Onwezen et al., 2021). For plant-based food products to gain acceptance, they must be delicious, affordable, and convenient. As a result of these consumer demands, food product developers are continuously trying to closely mimic the desirable quality attributes of animal-based food products in plant-based food products, making them more appealing to consumers (Zhou et al., 2022).

Developing plant-based meat alternatives that consumers find acceptable hinges on replicating the texture and flavor of meat (Herz et al., 2021). Various techniques, including extrusion, freeze structuring, electrospinning, high-temperature induced shearing, mixing plant proteins and hydrocolloids, bioprinting (3D printing technology), and electrospinning, have been explored to match the texture of meat to meet consumer needs and demands (Elzerman et al., 2011; Hoek et al., 2011; Dekkers et al., 2018; Bhushani & Anandharamakrishnan, 2014; Krintiras et al., 2016).

Research indicated that 54% of consumers are willing to replace meat with alternative protein sources. The primary drivers for adopting alternative proteins are taste, convenience, environmental benefits, appearance, and healthiness (Onwezen et al., 2021). The increased demand for protein alternatives has also increased the demand for texturized vegetable proteins.

Texturized vegetable protein is a key component in many meat alternatives (Boukid & Gagaoua, 2022).

As demand for alternative proteins grows, advancements in food science and technology will be crucial in enhancing protein properties and developing products that meet consumer preferences. The food industry is responding by modifying product formulations and employing various food processing technologies to create sustainable meat protein alternative food products (IFT, 2023).

In this study, initially, a soy taco crumble was developed using a series of proposed tests to characterize the physicochemical and sensory attributes of taco crumble. Key attributes focused on color, cooking loss, pH, water-holding capacity, and moisture. While these attributes alone may not fully characterize texturized soy protein, they are useful for the initial screening of different formulations for further testing, including sensory analysis. The main objectives of this study were to develop a scalable recipe for soy taco crumble suitable for industrial-size kitchen production in the dining centers. Additional objectives included: 1) evaluate the proximate composition and physicochemical properties of the soy taco crumble; 2) to assess consumer acceptance of soy taco crumble among university students; and 3) to analyze the effect of different storage conditions (refrigeration and freezing) and durations on the moisture content of the soy taco crumble.

5.3 Materials and Methods

5.3(1) Basic Experimental Design

The soy taco crumble was developed and tested under various conditions, including different levels of spices, with and without oil, and different soaking times for texturized soy protein (TSP). The objective was to identify the optimal recipe that meets the cooking, holding, and storage requirements of Kansas State University dining centers (Kramer and Derby). The cooking methods and conditions were determined based on the study conducted by Heywood et al., 2002.

The soy taco crumble was made in both Kramer and Derby dining centers. The product was made four times (n=4 batches) at Kramer and three times (n=3 batches) at Derby for scale-up, final serving, and storage testing for both frozen and refrigerated conditions. The product was served freshly prepared once and refrigerated then reheated once on the southwestern serving lines at both dining centers. To assess moisture loss or gain after storage and reheating, the product was kept frozen for 14 and 21 days and refrigerated for 3 and 7 days.

For each storage condition, 30g samples were taken immediately after reheating, 30 minutes on the serving line, and 1 hour on the serving line. Additionally, the physiochemical attributes of the freshly cooked and refrigerated then reheated product, including color, pH, water-holding capacity, and cooking loss, were evaluated.

5.3(2) Preliminary Research

The initial soy taco crumble recipe used in this experimental study was developed by senior undergraduate food science students at Kansas State University as a part of the “Research & Development of Food Products” course. Over the course of this semester-long class, students formulated their recipes on a small scale and presented the soy taco crumble to a focus group for feedback and refinement. The recipe included a combination of hydrated texturized soy protein, taco seasonings, and oil. Then the product was pan-fried to develop a crispy texture. Responses from the focus group participants were positive especially when served as a “walking taco.”

5.3(3) Scale-up of Taco Crumble

The recipe was updated and scaled up for quantity production to meet the needs of Kansas State University's dining centers, which serve approximately 2,200 students. Azhar undertook the task of scaling up the recipe, making necessary modifications in the formulation according to consumer demand, and accommodating industrial-sized kitchen equipment and ingredients.

5.3(4) Testing in the Dining Centers

Once the final recipe was formulated, the soy taco crumble was subjected to evaluation of physiochemical properties, including moisture content, pH, color, cooking loss percentage, and water-holding capacity (WHC), as well as consumer acceptability testing. Furthermore, the soy taco crumble was stored under different conditions (refrigeration and freezing) over varying periods to analyze the impact of storage conditions on moisture content.

Approximately 30g samples of soaked TVP were collected both before and after cooking to evaluate color, pH, and cooking loss percentage. Additionally, 30g samples were taken after cooking to measure the water holding capacity (WHC). To assess moisture content, 30g samples of the freshly cooked product were collected at three different times: immediately after cooking, after being held on the serving line for 30 minutes, and after being held for 60 minutes. This approach allowed us to observe changes in moisture content over the holding period.

5.3(5) Testing Parameter Requirements for Dining Centers

The reason for conducting and evaluating the physiochemical properties, including moisture content, pH, color, cooking loss percentage, and water-holding capacity, stems from the requirements of the dining center to ensure the soy taco crumble suitability for storage, reheating, and serving. These parameters are crucial in determining the product's stability, quality, and shelf life under the storage conditions commonly used in the dining center, such as refrigeration and freezing. Ensuring that the soy taco crumble maintains its quality and safety over time is essential for the dining center's operations. Additionally, testing consumer acceptance is vital to ascertain whether the product will be well-received and enjoyed by the dining center's consumers.

5.3(6) Preparation/Cooking Protocol

Cooking methods and conditions were determined based on the study conducted by Heywood et al., 2002. In preparation of soy taco crumble, a systematic protocol was followed. Quantitative measurements of both dry and wet ingredients were obtained and are provided in section 5.4(1). The texturized soy protein (TSP) was soaked in a mixture of vegetable broth for 15-20 minutes to rehydrate (Figure 5.1). After rehydration, the TSP was thoroughly drained using a cone-shaped strainer (Figure 5.2). The weight of the TSP was recorded post-draining to assess cooking loss percentage.

The rehydrated TSP was then transferred to a tilt skillet (Figure 5.3) preheated to 250°F (121°C), containing oil. The TSP was cooked over a temperature range of 200°F (93°C) to 250°F (121°C) for 5 min to achieve an even texture. To enhance flavor, a blend of seasonings was folded into the TSP. Cooking continued for an additional 5 min to allow for flavor development. During this period, the TSP’s temperature was maintained between 135°F (57°C) to 145°F (63°C).

The internal temperature of the texturized soy taco crumble was measured using a thermometer (AquaTuff 352, Middlefield, CT, USA). This systematic approach ensured consistent quality and flavor development in the soy taco crumble, making the food suitable for large-scale production and consumption in university dining centers.

The leftovers from the serving line after two hours were refrigerated ≤40°F (4.4°C) to evaluate if leftovers from heating could be reheated. Leftover product was reheated and evaluated for sensory properties. It was determined by the Kramer staff that the product should be discarded after being held on the serving line and that small batches should be placed on the serving line to have optimal quality during the two hours of serving.

The reheating time for refrigerated soy taco crumble was 12-15 min in the steamer at ≥165°F (74°C). For frozen soy taco crumble, reheating took 35-40 minutes in the steamer at ≥165°F (74°C) without thawing. However, this time can be reduced if the product is thawed beforehand.

Figure 5.1 Soaked soy taco crumble.

Figure 5.2 Conned shape strainer.

Figure 5.3 Tilt skillet.

Figure 5.4 Final cooked product (soy taco crumble).

5.3(7) Cooking Loss (CL)

Cooking loss (CL) percentage was measured by modifying a method described previously (Wi et al., 2020). After cooking, the samples were cooled at room temperature. Cooking loss (CL) was calculated as the percentage weight difference between the raw rehydrated TSP before cooking and after cooking, using the following formula (Zhou et al., 2022):

CL percent = $(W_1-W_2)/W_1 \times 100$

W_1: weight of raw rehydrated TSP before cooking (g).

W_2: weight of cooked TSP after cooking (g).

5.3(8) Water Holding Capacity (WHC)

The method used to measure the water holding capacity (WHC) of cooked samples was based on a simple low-speed centrifugation method described previously by Wi et al. (2020) and Zhang et al. (1995). Initially, filter paper (7.0 cm diameter) and 15 ml conical centrifuge tubes were used for analysis. The filter paper was placed at the bottom of the centrifuge tube to absorb water released from the samples during centrifugation. A weighted mass of sample (5g) was then placed on top of the filter paper, the centrifuge tube was sealed, and the sample was centrifuged at speed 3 for 15 minutes. Water-holding capacity percentage was calculated by comparing the weight of the samples before and after centrifugation, using the following formula (Zhou et al., 2022):

WHC percent = $(W_2/W_1) \times 100$

W_1: weight of the sample before centrifugation (g)

W_2: weight of the sample after centrifugation (g)

5.3(9) Color Analysis

The color of rehydrated raw TSP and cooked texturized soy crumble was measured using a portable HunterLab MiniScan EZ colorimeter (Model No. 4500L, Reston, VA, USA). The apparatus was standardized through a black-and-white port, and lightness (L^*), redness (a^*), and yellowness (b^*) values were recorded.

5.3(10) pH Analysis

The pH values of rehydrated raw TSP and cooked texturized soy crumble were measured with a digital pH meter (Fisherbrand™, Accumet™, AP110, Pittsburgh, PA, USA) using 3 g of sample homogenized with 20 ml distilled water.

5.3(11) Moisture Analysis

Moisture contents were determined based on the standard AOAC (AOAC, 2005). Moisture content was quantified by the oven, drying 5g samples at 50°C for 24 hours. Moisture was calculated by comparing the weight of the samples before and after oven drying, using the following formula:

Moisture content = $W_1 – W_2$

W_1: weight of the sample before oven drying (g)

W_2: weight of the sample after oven drying (g)

The moisture percentage was calculated by using the moisture content/weight of sample before drying multiplied by 100.

5.3(12) Sensory Evaluation

Plant-based meat alternatives must be accepted by the public for the successful replacement of meat. Sensory evaluation plays a very important role in predicting consumer acceptance of plant-based meat alternatives. Consumer acceptance depends on many different factors like political values, ethical aspects, and ecological welfare (Fiorentini et al., 2020).

During the development process of soy taco crumble, food science, baking science, and animal science undergraduate students enrolled in the “Fundaments of Food Processing” course provided sensory feedback for two different percentages of seasoned soy taco crumbles by rating acceptance, flavor, texture, color, taste, seasoning, salt, and aroma on the 9-point Hedonic Scale (1=dislike extremely, 9=like extremely). A common way to assess acceptability is through hedonic scales where the participants indicate how much they like or dislike the sample in terms of a specific sensory property, such as appearance, flavor, taste, and texture, and can also include overall liking/acceptance. A commonly used scale is the 9-point hedonic scale that ranges from “like extremely” to “dislike extremely” (Lawless & Heymann, 2010). Half of the sensory panel students provided their feedback for less seasoned soy taco crumbles and half of the sensory panel students provided feedback for 125% increased seasoning soy taco crumbles. The soy taco crumbles were served to the sensory panel students with tortilla chips. This testing helped to analyze and change the flavor, color, seasoning, and other important factors of the soy taco crumble for the final scale-up in the dining center. A testing station was set up in the classroom to evaluate products. The data was analyzed using SAS (SAS Institute, Inc., Cary, NC, 1999). After this testing evaluation, the seasoning of soy taco crumble was increased by 125% to meet the consumers' demand.

The sensory evaluation was also conducted by the managing staff at Kramer dining center which provided valuable feedback on various sensory attributes of the product. The staff rated acceptance, flavor, texture, color, seasoning, and aroma on the 9-point Hedonic Scale (1=dislike extremely, 9=like extremely).

5.3(13) Consumer Acceptability

To assess final consumer acceptability, the product was prepared and tested at both dining centers. A testing table for the soy taco crumble was set up near the entrance of the Kramer dining center (Figure 5.5). Due to the smaller size of the Derby dining center, the soy taco crumble was tested directly on the serving line as there was no space to set up a separate testing table (Figure 5.6). The product was served for 2 hours at each dining center to evaluate consumer acceptability. At both dining centers, the soy taco crumble was served for testing with tortilla chips and the infographic on plant-based protein also was displayed at the stations for students to further read what they were tasting.

Figure 5.5 Kramer dining center consumer acceptance testing station.

Figure 5.6 Derby dining center consumer acceptance testing station (infographic not viewable in this picture but at the left of the serving line).

5.3(14) Statistical Analysis

The results of the texturized soy crumble are presented as the mean, standard deviation, and standard error of the mean (SEM). Furthermore, the mean, standard deviation, SEM, and analysis of variance (factorial ANOVA) with post hoc Tukey HSD test were performed using Statistical Analysis Software® (SAS®), version 9 (SAS Inc., Cary, N.C., U.S.A.).

5.4 Results and Discussion

5.4(1) Ingredients and Formulations

Texturized soy protein from Bob's Red Mill Natural Foods (Milwaukie, OR, USA) was used for the development of soy taco crumble. Soy protein is commonly used in meat alternatives due to its desirable functional properties, such as water-holding capacity, gelling, fat absorption, and emulsifying capacity, and it is also cost-effective (Ahmad et al., 2022).

To enhance the acceptability of the soy taco crumble, functional ingredients were incorporated. A vegetable base from Sysco (Houston, TX, USA) was used to prepare vegetable broth for hydrating the soy taco crumble. Vegetable oil from Crisco (Parsippany, NJ, USA) was added to improve flavor, moisture, and texture. The dining center's pre-prepared meat taco seasonings, including chopped dried onions, salt, chili powder, cornstarch, ground red cayenne pepper, garlic powder, dried oregano leaves, ground cumin, and dried cilantro, were used to provide flavor and color. The finalized ingredients and their respective weights are shown in Table 5.1. Various ratios of these functional ingredients were tested to produce an acceptable product. The soy taco crumble can be served either for lunch or dinner.

Table 5.1 Soy taco crumble ingredients and formulation.

Soy Taco Crumble -V		
Category: Vegan: Entree		**Yield: ≈ 30 servings**
Mater Ref: 0.1253 pounds		**Portion: 2 ounces**
Ingredient	**Amount**	**Method**
Protein, Vegetable, Textured for Research…………..	1.3736 lb	1. (1) In 12x20x4 pan, add water and base. Stir to combine. (2) Add TVP. Allow to soak for 15-20 minutes.
Base, Vegetarian, Refrig…………………	0.0554 lb	
Water, Hot………………	2.5688 Ib	
Oil, Salad, GAL……………….	0.1495 lb	2. (3) Heat tilt skillet to medium heat. (4) Add oil and allow to coat the surface of the pan. (5) Add hydrated TVP product and seasoning mix. (6) Sautee to heat, brown, and allow product to absorb seasonings. (7) Cover. Hold at or above 140°F for service.
Taco Seasoning Mix-Sub-V…………………	0.3008 lb	

(8) One portion is a #24 disher (0.1253 lb).

3. (9) Quality Standard: The soy crumble will resemble taco-seasoned beef in texture, moisture, flavor, and coloration. Serve with taco/nacho bar toppings.

4. (10) Refrigerate leftovers at or below 40°F.
(11) Cover, label, and date when cool.
(12) Reheat to a minimum of 165°F.

5. Equipment:
Tilt Skillet
12 x 20 x 4 inch pans
Rubber Spatula
12x20x2 inch pans
#24 Disher

6. Date Entered in Computrition:
4/16/2024 – for Food Science Institute Research Study.

The recipe was input into Computrition (a food service management system, Canoga Park, CA, USA). Computrition formats recipes for quantity use, procurement, pricing, and nutritional content (Table 5.2 and Figure 5.7).

Table 5.2 Soy taco crumble cost report.

Ingredients	Amount (AP)	Cost Per Person	Cost Per Recipe	Percentage (%)
Protein, Vegetable, Texturized for Research	1.37 lb	$ 0.11	$ 3.45	65
Base, Vegetarian, Refrigerated	0.05 lb	$ 0.01	$ 0.36	7
Water, Hot	2.57 lb	$ 0.00	$ 0.00	0
Oil, Salad, GAL	0.15 lb	$ 0.01	$ 0.19	4
Taco Seasoning Mix – Sub –V	0.3 lb	$ 0.04	$ 1.35	25
Total Costs		$ 0.18	$ 5.34	

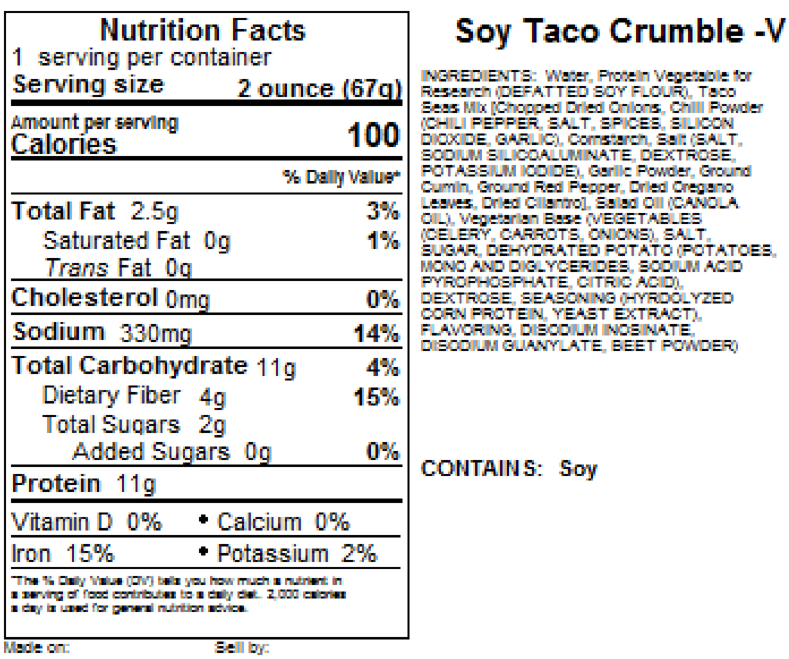

Figure 5.7 Soy taco crumble nutrition facts and ingredient statement.

5.4(2) Cooking Loss (CL) Results

After cooking, plant-based meat alternatives experience significant changes in their physicochemical properties due to various molecular and physical processes, such as protein denaturation, protein aggregation, water absorption, and water evaporation. These transformations can cause shrinkage, leading to a reduction in both the mass and volume of the cooked product (Kondjoyan et al., 2013). Therefore, it is essential to measure water-holding capacity and cooking loss (CL) to assess the quality of texturized vegetable proteins, like soy taco crumble. Cooking loss (CL) and water-holding capacity are crucial indicators of the degree of shrinkage during cooking, which directly affects the juiciness and yield of the final product (Aaslyng et al., 2003; Wi et al., 2020; Zhou et al., 2022).

The cooking loss (CL) of soy taco crumble was measured in four samples, yielding a mean cooking loss of 13.22% with a standard deviation of 3.067%. This result indicates that, on average, approximately 13.2% of the soy taco crumble weight is lost during cooking. This aligns with another past study where the cooking loss (CL) (%) for plant-based burgers were (10%) (Zhou et al., 2022). The similar cooking loss percentages between our soy taco crumble (13.22%) and the plant-based burgers (10%) from the referenced study suggest that both products share comparable structural and functional properties in terms of fluid retention and protein behavior during cooking. This consistency reinforces the reliability of soy texturized protein as a viable ingredient for developing plant-based meat alternatives with desirable cooking characteristics.

Table 5.3 Cooking loss (CL) percent of soy taco crumble.

Parameter	Percent Mean ± SD[1]	SEM
Cooking Loss Percent (n=4)	13.22 ± 3.067	1.533

[1]Data are expressed as means ± standard deviation (SD); SEM: standard error of the mean.

The soy taco crumble consistent cooking loss exhibits, aligning with the expected values for texturized vegetable proteins. This consistency is crucial for maintaining product quality, juiciness, and yield. Such similarities highlight the effectiveness of using texturized soy protein to create plant-based meat alternatives that perform well under typical cooking conditions, making them a practical and appealing option for consumers seeking healthier and more sustainable food choices.

5.4(3) Water Holding Capacity (WHC) Results

Water-holding capacity (WHC) is a crucial factor affecting the quality, juiciness, and yield of texturized vegetable protein (Aaslyng et al., 2003; Wang et al., 2015). In plant-based meat alternatives, water-holding capacity (WHC) represents the protein's ability to retain water and form a stable protein gel network. A higher water-holding capacity (WHC) in plant-based meat alternatives enhances juiciness, making the product more appealing to consumers (Wi et al., 2020). To understand the impact of heat on water-holding capacity (WHC), the water-holding capacity (WHC) of soy taco crumble was evaluated after cooking.

Our results indicate that the water-holding capacity (WHC) of the cooked soy taco crumble is 96.44%. This high retention rate is likely due to the initial soaking and final heating process, which enhances the gel network formation of texturized vegetable protein through hydrophobic interactions, thereby retaining more water (Wi et al., 2020). Numerous studies have reported that heating improves the gel network of soy-based proteins (Wang et al., 2015; Gómez et al., 2019; Huang et al., 2010). These findings demonstrate that soy taco crumble effectively retains moisture after cooking, essential for maintaining the desired texture and juiciness of the final product.

Studies also indicate that the addition of soy decreases free water availability for syneresis in gluten and soy protein mixtures, resulting in high water-holding capacity (WHC) (Wi et al., 2020). Additionally, previous studies have shown that adding oil to plant-based meat alternatives can increase water-holding capacity (WHC) under both cooked and uncooked conditions (Wi et al., 2020; Xia et al., 2018).

Table 5.4 Water-holding capacity (WHC) of soy taco crumble after cooking.

Water-holding capacity	Percent Mean ± SD	SEM
After Cooking (n=5)	96.44 ± 1.135	0.507

Data are expressed as means ± standard deviation (SD); SEM: standard error of the mean.

5.4(4) Color Results

Color coordinates are a crucial physical property in determining consumer acceptance of a product (Bakhsh et al., 2021). After cooking, the lightness (L*) of soy taco crumble significantly decreases. The red/green component (a*) increases noticeably, indicating a shift towards red, while the yellow/blue component (b*) also increases, indicating a shift towards yellow. These results are somewhat similar to previous studies where adding texturized soy protein to beef patties increased the L* value, but the a* values were not statistically different (Deliza et al., 2002). The variation in a* values in the present study compared to others could be due to the complete substitution of protein composition (100% substitution) in the formulation with spices. After cooking, the b* values of texturized soy crumble were higher than before cooking, with the yellowish coloration attributed to the inherent yellow color of soy protein (Bakhsh et al., 2021).

The t-test results indicate that changes in L*, a*, and b* values are statistically significant, with p-values (<0.05) showing that the differences observed before and after cooking are not due to random chance. These significant changes in color parameters (L*, a*, and b*) demonstrate that cooking has a substantial impact on the color of soy taco crumble. The decrease in lightness and shifts towards red and yellow hues can be attributed to the Maillard reaction, caramelization, and seasonings commonly found in cooked foods. These findings are essential for understanding the visual and possibly sensory changes in soy-based products during cooking, which can influence consumer acceptance and product development.

Table 5.5 Means, standard deviations, and ΔE of soy taco crumble color.

Condition (n=5)	**Color**			
	L*	**a***	**b***	**ΔE**
Before Cooking	55.07 ± 0.61^{a}	10.91 ± 0.29^{a}	25.82 ± 0.68^{a}	16.53
After Cooking	39.63 ± 4.26^{b}	15.64 ± 0.81^{b}	29.35 ± 0.98^{b}	
Difference	**Δ L***	**Δ a***	**Δ b***	
	-15.44	4.73	3.53	

L*, lightness; a*, redness; b*, yellowness; Data are expressed as means ± standard deviations (SD). $^{a-b}$ indicates significant differences within a column at p<0.05.

5.4(5) pH Results

The pH of the soy taco crumble decreased from 6.80 before cooking to 6.47 after cooking (n=5). This indicates that cooking significantly reduced the pH level of the soy taco crumble, suggesting an increase in acidity. A pH above 6 indicates that the texturized soy protein is slightly alkaline (pH 7.42-7.43) (Anjum et al., 2011). Previous studies have shown that minced meat containing soy has a higher pH compared to control (meat without soy) and that soy protein isolates at 25% significantly increased the pH of meat sausage (6.7 ± 0.05) (Bell & Shelef, 1978; Ahmad et al., 2010).

The t-test yielded a p-value of <0.01, which is less than the typical significance level of 0.05, indicating that the difference in pH before and after cooking is statistically significant. The significant decrease in pH after cooking implies that the cooking process has a measurable effect on the acidity of soy taco crumble. This change in pH might be due to the seasonings added during cooking. Understanding this chemical change is crucial for comprehending the effects of cooking on soy-based products.

Table 5.6 pH before cooking and after cooking results.

pH (n=5)	**(Mean ± SD[1])**	**SEM**
Before Cooking	6.80 ± 0.056[a]	0.025
After Cooking	6.47 ± 0.116[b]	0.051

[1]Data are expressed as means ± standard deviation (SD). [a-b] indicates significant differences at $p < 0.05$.

5.4(6) Moisture Results

Texture parameters of plant-based meat alternatives are highly correlated with moisture content (Bakhsh et al. 2021). The analysis of moisture content under various storage and reheating conditions reveals significant insights into how storage time and temperature affect food quality.

For freshly cooked samples, the moisture content percent showed no significant variability across different holding times on the serving line. Specifically, the mean moisture content percent for freshly cooked samples was 41.7, whereas the 30 min and 60 min moisture content percent were similar at 41.0 and 41.67, respectively. The lack of difference could be due to the cooking equipment and the amount of product in the steaming server.

Table 5.7 Moisture percentage means, standard deviations, SEM, and p-value of freshly cooked soy taco crumble.

Storage Conditions (n=5)	Percent Mean ± SD[1]	SEM	p-value
Freshly Cooked	41.70 ± 7.60[a]	4.389	0.89
Freshly Cooked 30 min	41.00 ± 2.00[a]	1.154	
Freshly Cooked 60 min	41.67 ± 4.83[a]	2.786	

[1]Data are expressed as means ± standard deviation (SD); SEM: standard error of mean;
[a-b]Superscripts within a column that share the same letter are not significantly different (>0.05).

In contrast, samples stored under refrigerated conditions showed more variability than freshly cooked samples. For samples refrigerated for 3 days and then reheated, there was no significant difference in moisture percentage between the freshly reheated 3-day samples (36.46 ± 0.503) and the freshly reheated 3-day samples on the serving line for 30 minutes (36.00 ± 0.529). A significant difference was observed for samples on the serving line for 60 minutes (39.00 ± 1.400), suggesting that longer reheating times may mitigate moisture loss.

Table 5.8 Moisture percentage means, standard deviations, SEM, and p-value of refrigerated for 3 days soy taco crumble moisture.

Storage Conditions (n=3)	Percent Mean ± SD	SEM	p-value
Refrigerated 3 days, Freshly Reheated	36.46 ± 0.503[a]	0.290	0.01
Refrigerated 3 days, Reheated 30 min	36.00 ± 0.529[a]	0.305	
Refrigerated 3 days, Reheated 60 min	39.00 ± 1.400[b]	0.808	

Data are expressed as means ± standard deviation (SD); SEM: standard error of the mean;
[a-c]Superscripts within a column that share the same letter are not significantly different (>0.05).

Similarly, samples refrigerated for 7 days and then reheated showed a significant change in moisture content. Freshly reheated samples (39.46 ± 0.416) were significantly different from the samples reheated and held on the line for 30 and 60 min.

Table 5.9 Percent moisture means, standard deviations, SEM, and p-value of refrigerated for 7 days soy taco crumble moisture.

Storage Conditions (n=3)	Percent Mean ± SD	SEM	p-value
Refrigerated 7 days, Freshly Reheated	39.46 ± 0.416[a]	0.240	0.002
Refrigerated 7 days, Reheated 30 min	41.53 ± 0.702[b]	0.405	
Refrigerated 7 days, Reheated 60 min	42.53 ± 0.642[b]	0.371	

Data are expressed as means ± standard deviations (SD); SEM: standard error of the mean; p-values within column that share a letter are not significantly different (>0.05).

Frozen storage conditions had a distinct impact on moisture content. Samples frozen for 14 days and then reheated showed a significant reduction in moisture content (31.00 ± 0.529). This reduction was consistent for samples on the serving line for 30 min (25.46 ± 11.66).

However, the moisture percentage at 60 min (43.33 ± 0.305) was similar to the refrigerated product at 7 days, reheated for 60 min on the serving line.

Table 5.10 Moisture percentage means, standard deviations, SEM, and p-value of frozen for 14 days soy taco crumble moisture.

Storage Conditions (n=3)	Percent Mean ± SD	SEM	p-value
Frozen 14 days, Freshly Reheated	31.00 ± 0.529[a]	0.307	<0.002
Frozen 14 days, Reheated 30 min	25.46 ± 11.66[b]	6.737	
Frozen 14 days, Reheated 60 min	43.33 ± 0.305[c]	0.176	

Data are expressed as means ± standard deviation (SD); SEM: standard error of the mean; [a-c] indicates significant differences at $p < 0.05$.

Conversely, samples frozen for 21 days exhibited an increase in moisture percentage as compared to freshly cooked and refrigerated samples when reheated (44.26 ± 1.026) as well as after 30 min (44.13 ± 0.702) and 60 min (44.13 ± 0.757) of serving on the line. However, there is no significant difference among all three time periods of frozen for 14 days and reheated. These results suggest that prolonged freezing might influence moisture dynamics differently compared to shorter freezing periods. This increase in the moisture content over freezing might be due to the formation of ice crystals. Therefore, freezing as a storage method for plant-based meat alternatives is not recommended (Bakhsh et al., 2021).

Table 5.11 Means, standard deviations, SEM, and p-value of frozen for 21 days soy taco crumble moisture.

Storage Conditions (n=3)	Percent Mean ± SD	SEM	p-value
Frozen 21 days, Freshly Reheated	44.26 ± 1.026[a]	0.592	0.975
Frozen 21 days, Reheated 30 min	44.13 ± 0.702[a]	0.405	
Frozen 21 days, Reheated 60 min	44.13 ± 0.757[a]	0.437	

Data are expressed as means ± standard deviation (SD); SEM: standard error of the mean; [a] indicates no significant differences at $p < 0.05$.

Overall, these findings indicate that storage and reheating conditions significantly affect the moisture percentage of the soy taco crumble. Freshly cooked soy taco crumble samples retain consistent moisture content irrespective of serving line holding time. In contrast, refrigeration generally reduces moisture content, particularly with shorter reheating times, whereas longer reheating can partially restore it. Freezing, especially for shorter durations, leads to significant moisture loss, but longer freezing periods followed by reheating can increase moisture retention. These observations provide critical insights for optimizing food storage and reheating protocols to maintain quality.

All these parameters are crucial for serving soy taco crumble in dining centers. The storage and reheating conditions affect the quality attributes of the product and help determine the appropriate storage time to ensure the product meets the dining center's serving standards after a certain period. By analyzing these factors, we can ensure that the soy taco crumble remains up to the quality standards required for safe and enjoyable consumption by the dining center consumers.

5.4(7) Sensory Evaluation Results

5.4(7.1) Sensory Evaluation (Before Increasing the Seasoning)

Sensory studies are essential for improving product characteristics, understanding consumer expectations, and increasing consumer acceptance (Aschemann-Witzel et al., 2019). Sensory evaluation was carried out to analyze the flavor, texture, color, aroma, seasoning, and overall acceptability of the soy taco crumble, conducted by food science, baking science, and animal science undergraduate students enrolled in the "Fundamentals of Food Processing" course revealed a generally positive reception for various sensory attributes.

Based on the sensory analysis data with less seasoning, the mean and standard deviation for each attribute were calculated. On the hedonic scale, a mean liking score of 7 or higher on a nine-point scale is usually indicative of highly acceptable sensory quality. Most scores for aroma exceeded a mean of 7, suggesting high acceptability. Other attributes, while below 7, still showed promising acceptability with scores around 6. This indicates that the soy taco crumble is generally well-received, although there is room for improvement in certain areas like color and texture.

Table 5.12 Sensory analysis with less seasoning.

Attribute (n=13)	Mean ± SD
Overall Acceptability	6.54 ± 1.82
Flavor	6.31 ± 1.81
Color	4.77 ± 2.04
Texture	5.69 ± 1.77
Aroma	7.00 ± 1.88
Seasonings	6.00 ± 2.32

Data are expressed as means ± standard deviation (SD).

5.4(7.2) Sensory Evaluation (with 125% Increase in Seasoning)

Based on the previous sensory analysis data a 125% increase in seasoning was analyzed by another section of students in "Fundamentals of Food Processing." The mean and standard deviation for each attribute were calculated. The results indicate varying levels of acceptability for different attributes. On the hedonic scale, a mean liking score of 7 or higher on a nine-point scale is usually indicative of highly acceptable sensory quality. None of the attributes met this threshold, but some showed promising results with a mean of around 6.

These results suggest that the soy taco crumble with increased seasoning has potential but may require further adjustments to enhance its acceptability. Attributes such as overall acceptability, flavor, and color are close to the acceptable range, indicating that the product is relatively well-received but could benefit from additional optimization. This change in the feedback might be due to adding water mixed with seasoning to increase the seasoning and reheating the product again in the pan on the stove. As cooking method affects the quality of the final product. Changes were made as per consumer demand for the final cooking of the product like adjusting the seasoning and cooking the product on a tilt skillet instead of cooking on the stove in a pan.

Table 5.13 Sensory analysis with 125% increased seasoning.

Attribute (n=13)	Mean ± SD
Overall Acceptability	6.08 ± 1.77
Flavor	6.08 ± 1.73
Color	6.46 ± 1.91
Texture	5.77 ± 1.93
Aroma	5.92 ± 1.69
Seasonings	5.00 ± 2.22

Data are expressed as means ± standard deviation (SD).

5.4(7.3) Sensory Evaluation (Kramer Dining Center Staff)

The sensory evaluation conducted by the managing staff at Kramer dining center for less seasoned soy taco crumble provided valuable feedback on various sensory attributes of the product. The staff rated acceptance, flavor, texture, color, seasoning, and aroma on the 9-point Hedonic Scale (1=dislike extremely, 9=like extremely). The results suggest that the soy taco crumble has high acceptability among the Kramer Managing Staff, particularly in terms of color and seasonings, which both scored around 8 or higher. Attributes such as flavor, aroma, and overall acceptability also showed favorable ratings close to or above the threshold of 7, indicating good sensory quality. Texture, while slightly lower, still demonstrated acceptable levels of satisfaction.

Overall, the managing staff at Kramer dining center provided generally positive feedback across most sensory attributes, particularly for color, aroma, and seasonings. While flavor also received favorable responses, texture had mixed reviews, indicating a potential area for improvement. The strong positive feedback in key sensory areas highlights the product's potential success and overall acceptability among the staff.

Table 5.14 Sensory analysis Kramer dining center managing staff.

Attribute (n=8)	Mean ± SD
Overall Acceptability	6.88 ± 0.60
Flavor	8.00 ± 1.41
Color	6.38 ± 1.80
Texture	7.00 ± 1.22
Aroma	6.88 ± 0.93
Seasonings	8.88 ± 2.30

Data are expressed as means ± standard deviation (SD).

5.4(8) Consumer Acceptability Results

The consumer acceptance of soy taco crumble at Kramer dining center indicates a strong positive reception across multiple sensory attributes with the 141 respondents. Based on the collected data from the Kramer Students Consumer Acceptance study, the mean and standard deviation for each attribute were calculated. The results suggest that the soy taco crumble has high acceptability among student consumers, with all attributes scoring above 7 on the nine-point hedonic scale. This indicates that the product is highly acceptable in terms of overall acceptability, flavor, aroma, and seasonings. While color and texture also received positive ratings, they are slightly lower but still within the acceptable range. Overall, these findings support the conclusion that soy taco crumble is well-received and suitable for serving in dining centers.

Finally, the willingness to try the product in the dining center was high, with 118 respondents expressing a definite interest, 15 respondents unsure, and only eight respondents not interested. This overall positive consumer acceptance highlights the product's potential success in the Kramer dining center setting, reflecting favorable responses in flavor, texture, aroma, and seasonings, and a significant willingness to try among the respondents.

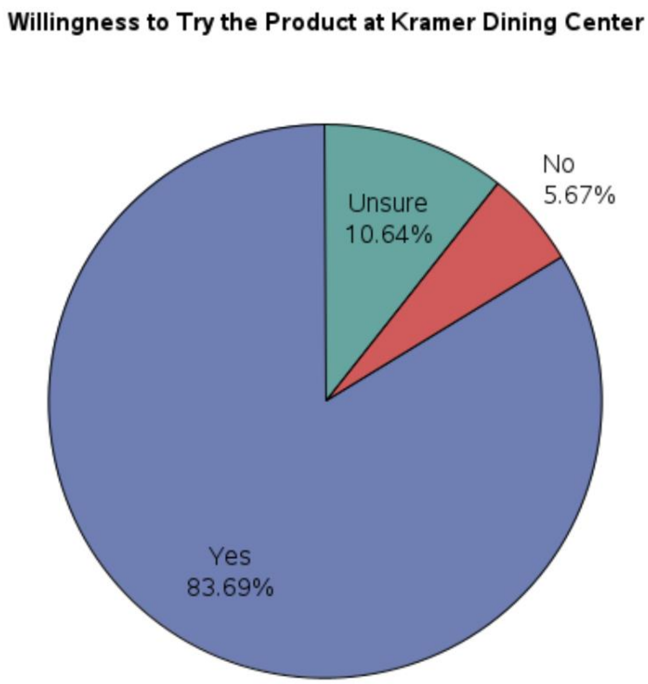

Figure 5.1 Consumer willingness to try the product at Kramer dining center.

The consumer acceptance of soy taco crumble at Derby dining center indicates a strong positive reception across multiple sensory attributes with the 67 respondents. Based on the sensory analysis data from the Derby Students Consumer Acceptance study, the mean and standard deviation for each attribute were calculated. The results suggest that the soy taco crumble has high acceptability among Derby student consumers, with most attributes scoring around 7 on the nine-point hedonic scale. This indicates that the product is generally well-received in terms of overall acceptability, flavor, aroma, and seasonings. Color and texture received slightly lower ratings but still fell within an acceptable range.

Finally, the willingness to try the product was high, with 55 respondents expressing a definite interest ("Yes"), 8 respondents unsure, and only 4 respondents not interested ("No"). This overall positive consumer acceptance among Derby students highlights the product's potential success, reflecting favorable responses across all sensory attributes and a significant willingness to try the product.

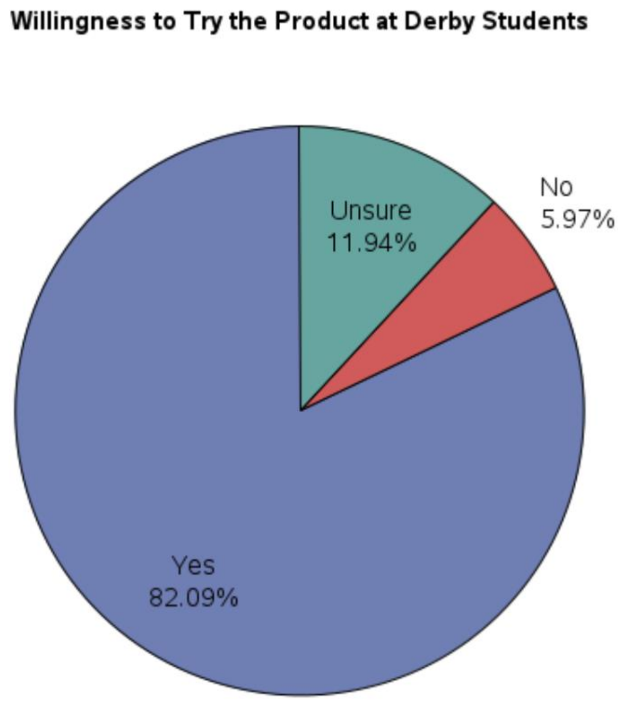

Figure 5.2 Consumer willingness to try the product at Derby dining center.

Table 5.15 Hedonic scale (1=extremely dislike and 9=extremely like) consumer acceptance.

Attribute	Kramer (n=141)	Derby(n=67)	Kramer + Derby (n=208)
Overall Acceptability	7.60 ± 1.25	7.48 ± 1.06	7.54 ± 1.17
Flavor	7.55 ± 1.23	7.12 ± 1.53	7.41 ± 1.35
Color	7.11 ± 1.51	6.99 ± 1.31	7.07 ± 1.45
Texture	7.21 ± 1.73	6.96 ± 1.59	7.13 ± 1.69
Aroma	7.26 ± 1.55	7.06 ± 1.53	7.19 ± 1.51
Seasonings	7.65 ± 1.43	7.49 ± 1.32	7.60 ± 1.40

Data are expressed as means ± standard deviation (SD).

Overall, these combined findings reinforce the conclusion that soy taco crumble is well-received and suitable for serving in dining centers or other locations. The high acceptability scores across various attributes demonstrate that the product meets the sensory quality standards desired by the consumers.

5.5 Conclusions

This research study on the development and scale-up of soy taco crumble for Kansas State University dining centers presents a comprehensive approach to addressing the increasing consumer demand for sustainable, ethical, and health-conscious protein sources. With the global population projected to reach at least nine billion by 2025, the necessity for alternative protein sources has become more pressing. The study underscores the potential of soy protein due to its cost-effectiveness and functional properties, such as water-holding capacity, gelling, and emulsifying capacity, making it an ideal candidate for plant-based meat alternatives.

The study focused on the physicochemical properties of soy taco crumble, which exhibited consistent cooking loss and high water-holding capacity, critical factors for maintaining product quality and consumer appeal. The cooking process resulted in significant changes in the product's color and pH, which are essential for texture and flavor development. Furthermore, the study examined the impact of storage and reheating on moisture content, revealing that freshly cooked samples retained moisture well, while refrigerated samples showed reduced moisture content. Interestingly, extended freezing followed by reheating increased moisture retention, offering valuable insights into optimal storage practices.

Sensory evaluations conducted with students and dining center staff yielded generally positive feedback, particularly regarding flavor, aroma, and seasoning, though texture received mixed reviews, indicating an area for potential improvement. Notably, an increase in seasoning led to more varied feedback, highlighting the need for balanced seasoning in product development. Consumer acceptance tests at both Kramer and Derby dining centers confirmed a strong positive reception, with the majority of respondents rating the product favorably across various sensory attributes and expressing a high willingness to try the product again.

In conclusion, the study successfully developed a scalable soy taco crumble recipe that aligns with consumer demands for taste, texture, and sustainability. These findings underscore the importance of continuous product testing and refinement to enhance acceptability and ensure successful integration of plant-based products like soy taco crumble into dining services.

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Chapter 6 - Summary and Implications

6.1 Summary

6.1(1) Summary of Findings

This study explored university students' perceptions and acceptance of soybeans and soy-based food products, focusing on a specific demographic at Kansas State University. Utilizing focus groups and surveys, the research examined students' awareness, nutritional knowledge, and the influence of educational infographics on their consumption behavior. Additionally, a soy taco crumble was developed, scaled, and evaluated for sensory and physiochemical properties to evaluate its potential integration into university dining services.

6.1(2) Qualitative Findings from Focus Groups

The focus group discussions revealed several key themes regarding students' perceptions of soy-based foods. Participants' awareness of soybeans largely stemmed from past experiences and geographical exposure, with many students recognizing soy as a source of protein but having limited knowledge about its broader nutritional benefits. There was a clear preference for familiar foods, though participants were open to innovative soy-based food products, particularly in savory dishes.

Participants expressed a desire for soy-based food products to have a distinct identity beyond being mere meat alternatives, highlighting concerns about soy-related stigma. The infographics used in the focus groups were well-received, particularly those that effectively combined engaging aesthetics with clear, informative content.

6.1(3) Qualitative Survey Results

An online survey leveraging the Theory of Planned Behavior (TPB) framework provided quantitative insights into students' attitude, social norms, and perceived behavioral control regarding intention to consume soy-based food products. The survey revealed a positive attitude towards soy-based food products and significant correlations between social norms and intention to consume soy-based food products. Infographics positively influenced students' intentions, with the "plant-based protein" infographic showing the highest reliability (α=0.808).

6.1(4) Sensory and Nutritional Evaluation of Soy Taco Crumble

The soy taco crumble was developed and evaluated for its physiochemical and sensory properties. The product demonstrated high acceptability, with an overall sensory score averaging 7.54 out of 9. Key physiochemical properties such as pH (6.47±0.12), color (L*=39.63±4.26, a*=15.64±0.81, b*=29.35±0.98), cooking loss (13.22±3.07), water-holding capacity (96.44±1.14) and moisture content were optimized to maintain quality and consumer appeal. Sensory evaluations indicated high scores for aroma, flavor, and seasonings, with over 82% of students willing to consume the product again. Nutritional analysis showed that one serving containing 2 ounces (67g) contained 11 grams of protein, 4 g of dietary fiber, and 100 calories, with a cost of $0.18 per serving.

6.2 Implications

6.2(1) Enhancing Nutritional Awareness and Education

The findings underscore the need for educational initiatives to enhance students' understanding of soy's nutritional benefits. Given the limited knowledge about the comprehensive health advantages of soy, universities could implement targeted educational campaigns. These could include interactive workshops, informative posters in dining centers, and integration of soy education into nutrition courses.

6.2(2) Product Development and Marketing Strategies

The positive reception of innovative soy-based products like the soy taco crumble highlights the potential for expanding plant-based options in university dining services. Developing a variety of soy-based dishes that cater to diverse tastes and preferences can encourage greater acceptance and regular consumption. Marketing strategies should emphasize the unique identity of soy products, moving beyond the "meat-alternative" label to highlight their intrinsic qualities and benefits.

6.2(3) Leveraging Infographics for Behavior Change

The effectiveness of infographics in influencing consumption behavior suggests that visually appealing and informative materials can play a crucial role in dietary interventions. Universities should consider deploying well-designed infographics in dining areas to promote healthy eating habits. Future studies could explore the long-term impact of these educational tools on students' dietary choices.

6.2(4) Addressing Social Norms and Behavioral Control

The study's application of the TBP model revealed that social norms significantly influence students' intentions to consume soy-based foods. Peer influence and social acceptance are critical factors that can be leveraged in promotional campaigns. Creating a supportive community environment that encourages plant-based eating can enhance the effectiveness of these interventions. Additionally addressing perceived behavioral control by making soy-based food products more accessible and convenient could further boost consumption.

6.2(5) Future Research Directions

To build on these findings, future research should involve larger and more diverse samples across different universities and cultural contexts. Longitudinal studies could provide insights into the long-term effects of educational interventions and product innovations on dietary behaviors. Additionally, incorporating factors such as health consciousness and environmental concerns into the TPB model could offer a more comprehensive understanding of consumer decision-making regarding soy-based foods.

In conclusion, this research highlights the promising potential of soy-based products in university dining services and underscores the importance of educational initiatives, innovative product development, and strategic marketing to foster a more sustainable and health-conscious food ecosystem. Through continued efforts in these areas, soy-based foods can become stable in the diets of university students, contributing to their overall well-being and environmental sustainability.

Appendix A - Focus Group Moderator Guide

Development of infographics and soy-based products based on college student's perceptions of soy-based products

Focus group moderator guide:

Introduction:

Welcome and thank you for being here today. We appreciate you taking the time to participate in this research project. My name is -------- and I will be the moderator of the discussion. Today we will be discussing soybeans.

Rules:

1. This conversation is being taped so that we don't have to take notes while you are all giving your opinions. One ground rule: you must talk, and you must talk loud enough so we can all hear you.
2. This conversation will remain completely confidential. Your full names will never be used. We just want to hear your opinions. This is not a classroom. There are no right and wrong answers.
3. If you have any questions or additional comments, please go ahead at any time. We have a good deal of material to cover in a short time; feel free to ask questions, but we will need to keep the conversation moving.
4. There will be a free ice cream coupon upon completion of the session.

We are fortunate to have some help today.

Purpose:

I think everybody knows why we are here but let me go over it just in case. We are part of a research team. The main thing we are interested in today is hearing from you, about your ideas, opinions, and concerns about soybeans and their consumption. Your participation in today's focus group will help us gain valuable insight into how individuals make decisions about soybeans.

Now let's go ahead with questions:

1. **How many of you know anything about soybeans? If so, from where have you heard about it.?**

Note: Soybeans and soy foods are rich in nutrients and beneficial plant compounds. Diets rich in minimally processed soy foods may offer various health benefits, including improved heart health, and a lower risk of certain cancers.

2. **How many of you have heard that soybeans are or can be consumed as human food? If so, from where you have heard about it?**
3. **Is anyone of you growing soybeans in your home right now or maybe in the past?**
4. **Do any of you consume any soybean-based products? If yes, what is that product's name and where did you buy it?**

Note: Fermented and Unfermented soybean-based products (Unfermented include- tofu, soy milk, edamame, soy nuts, and sprouts.

5. **Do any of you read the ingredients label before eating the product? If yes, then have you seen soybean or soybean extract used in any food product.? If yes, do you remember the product name and where you bought it?**

Note: Soy and soy extract are present in mini chips (cookies), fig bars, and Bischoff (Cookies), etc.

6. **Do you have a favorite snack with soybean/soybean extract? If yes, then please give the name of that product.**
7. **Have any of you heard about soybean milk? If yes, then can you compare it with cow milk? What will be the difference?**
8. **In your opinion what is the best source of protein?**
9. **Do you have any idea what plant-based protein is?**

Note: Plant protein is simply a meaningful food source of protein which is from plants. This group can include pulses, tofu, soya, tempeh, nuts, seeds, certain grains, and even peas.

10. **What is the difference between plant-based and animal-based protein?**

Note: Soy protein is a complete plant-based protein. Similar to animal protein, it provides our bodies with a full range of essential amino acids. Soy protein is a high-quality protein isolated from soybeans. Most of the fat and carbohydrates of the soybean have been removed, leaving a nutrient-rich and satiating protein that offers several benefits from heart health to weight management.

11. How do you feel about eating soybean-based products?

12. Do you want to try new innovative soybean-based products?

Like, Muffins, Donuts, Pizza dough, or biscuits made with soy flour or soy protein.

13. How many of you are health conscious while buying food products from supermarkets? If so, then what are your concerns?

14. How many of you want to cut meat-based products? And what is the main reason behind it?

15. What does the term healthy food mean to you? And do you think that plant-based products are healthy food?

16. Does any one of you have concerns about soybean-based products? If yes, then what concerns do you have?

17. If you had to put soybeans in a box, which box would you choose? Box for human consumption or box for animal consumption.

18. How many of you consider soy-based products healthy? And what is the reason behind it?

Thank you so much for your help and participation.!

Appendix B - Registration Flyer for Focus Group with QR Code

Appendix C - Focus Group Registration Informed Consent

KANSAS STATE UNIVERSITY

Consent for participation in pre-survey/registration survey for focus group soy-based foods:
Thank you for your willingness to participate in our Qualtrics Survey for registration in a focus group. This research is being carried out by a team of Dr. Kelly Getty, Dept. Animal Sciences & Industry, Dr. Nellie Hill, Dept. Communications and Agricultural Education, Dr. Jacqueline Aenlle, Dept. Communications and Agricultural Education, Kelly Whitehair, Housing and Dining Services, with the goal of understanding consumers' perceptions of soy-based foods. Your participation is voluntary. There will be no penalty if you want to quit later. This study has been approved for human subject participation by the Kansas State University Institutional Review Board (KSU IRB), Proposal number # IRB-11516.
You are eligible to participate in the study if you eat in the dining centers(Derby & Kremer) at least 12-14 meals per week. You will be asked some demographic questions and questions regarding soy-based foods to register yourself to participate in the focus group. This pre-survey/registration survey is expected to take approximately 2-3 minutes to complete. There is no direct benefit to you from being part of this study. After filling out and submitting this registration survey and after attending the focus group you will get one Call Hall ice cream coupon. Your response in this survey and in the focus group will be confidential, only the research team will be able to see your response and your name will not be declared to anyone. If you have questions about this study or the information in this form, please contact the principal investigator of the project, Dr. Kelly Getty, at kgetty@ksu.edu. Agreeing to continue means: you understand the information given to you in this form. If you agree to the terms, please type your name and continue to the registration survey. We sincerely thank you for your time.

First Name:

Last Name:

Email:

Phone:

Do you eat food in the dinning centers (Derby & Kramer)?

Yes

No

→

Appendix D - Focus Group Registration Survey Questions

KANSAS STATE
UNIVERSITY

Do you eat at least 12 to 14 meals in the dinning Centers per week?

Yes

No

Do you have any type of soybean allergy?

Yes

No

Can you speak and understand the English language?

Yes

No

Where did you hear about us?

Flyer

A friend

Other

Please select a suitable date for you to join the Focus Group.

04-18-2023, 4:05-5:20 pm

04-20-2023, 4:05-5:20 pm

Focus Groups will be held in the Kramer Dining Hall, Mezzanine Rooms 241B and 242.

→

We thank you for your time spent taking this survey.
Your response has been recorded.
Please note the Focus Groups Location:
Focus Groups will be held in the Kramer Dining Hall, Mezzanine Rooms 241B and 242.
Thank you.

Appendix E - IRB Exempt

KANSAS STATE UNIVERSITY | University Research Compliance Office

TO: Kelly Getty
Animal Sciences and Industry
Manhattan, KS 66506

Proposal Number: IRB-11516

FROM: Lisa Rubin, Chair
Committee on Research Involving Human Subjects

DATE: 03/09/2023

RE: Proposal Entitled, "Development of infographics and soy-based products based on college student's perceptions of soy-based products."

The Committee on Research Involving Human Subjects / Institutional Review Board (IRB) for Kansas State University has reviewed the proposal identified above and has determined that it is EXEMPT from further IRB review. This exemption applies only to the proposal - as written – and currently on file with the IRB. Any change potentially affecting human subjects must be approved by the IRB prior to implementation and may disqualify the proposal from exemption.

Based upon information provided to the IRB, this activity is exempt under the criteria set forth in the Federal Policy for the Protection of Human Subjects, **45 CFR §104(d), category:Exempt Category 2 Subsection ii.**

Certain research is exempt from the requirements of HHS/OHRP regulations. A determination that research is exempt does not imply that investigators have no ethical responsibilities to subjects in such research; it means only that the regulatory requirements related to IRB review, informed consent, and assurance of compliance do not apply to the research.

Any unanticipated problems involving risk to subjects or to others must be reported immediately to the Chair of the Committee on Research Involving Human Subjects, the University Research Compliance Office, and if the subjects are KSU students, to the Director of the Student Health Center.

Electronically signed by Lisa Rubin on 03/09/2023 6:52 PM ET

Appendix F - IRB Informed Consent for Focus Groups

Kansas State University
University Research Compliance Office

Institutional Review Board (IRB)
Informed Consent Template Form
comply@k-state.edu | 785-532-3224

PROJECT TITLE:

Development of infographics and soy-based products based on college student's perceptions of soy-based products (Focus Groups)

PROJECT APPROVAL DATE:	July 1, 2022	**PROJECT EXPIRATION DATE:**	June 30, 2024	**LENGTH OF STUDY:**	2 years

PRINCIPAL INVESTIGATOR:	Kelly Getty
CO-INVESTIGATOR(S):	Nellie Hill, Kelly Whitehair, Jacqueline Aenlle, Sadaf Azhar
CONTACT DETAILS FOR PROBLEMS/QUESTIONS:	Kelly Getty, Dept. Animal Sciences & Industry, Kansas State University, Manhattan, KS 66506, (785) 341-2819
IRB CHAIR CONTACT INFORMATION:	Lisa Rubin, Chair, Committee on Research Involving Human Subjects, 203 Fairchild Hall, Kansas State University, Manhattan, KS 66506, (785) 532-3224; Brad Woods, Associate Vice President for Research Compliance, 203 Fairchild Hall, Kansas State University, Manhattan, KS 66506, (785) 532-3224.
PROJECT SPONSOR:	Kansas Soybean Commission, 1000 SW Red Oaks Place, Topeka, KS, 66506-1103

PURPOSE OF THE RESEARCH:

1. To gather preliminary qualitative data on consumer perceptions of soy-based foods.
2. To develop infographics communicating the benefits of consuming soy products.
3. Gather quantitative data on consumer perceptions of soy foods and infographics via surveys.
4. To develop and evaluate a soy product based on consumer preferences

PROCEDURES OR METHODS TO BE USED:

We will ask you to participate and answer the questions related to soybeans. Remember there is no right or wrong answer.

We need qualitative research data for this project. We need to audio record this conversation to record your answers without missing any points and without any interruption. We promise to keep your names and your information confidential.

RISKS OR DISCOMFORTS ANTICIPATED:

We do not anticipate any risks from participating in this research. The research team believes that there will be no significant risks to you that will result from your participation in the research. But if you feel uncomfortable or upset at any time during a survey interview, the trained interviewer will stop the interview immediately and you may leave at this time.

BENEFITS ANTICIPATED:

You will not receive any benefits from participating in this study. We expect that the results of the research will help develop soy-based high-protein products in the future, but this will not impact you personally. By completing the focus group, you will receive a Call Hall ice cream to thank you for your time.

EXTENT OF CONFIDENTIALITY:

The answers that you give will be used only for this research project. Your information will be anonymized, meaning that it will not be linked to your name or any identifying information about you. We will not share your answers with any other organization, or with any of your family members, friends, or community leaders. To help keep track of study participants, we have assigned you a unique identification number. We will not put your name on your research documents; we will use this number instead. Only members of the research team will see your responses to the survey questions.

The information or biospecimens that will be collected as part of this research will not be shared with any other investigators.

Terms of participation: I understand this project is research, and that my participation is voluntary. I also understand that if I decide to participate in this study, I may withdraw my consent at any time, and stop participating at any time without explanation, penalty, loss of benefits, or academic standing to which I may otherwise be entitled.

I verify that my signature below indicates that I have read and understand this consent form, and willingly agree to participate in this study under the terms described and that my signature acknowledges that I have received a signed and dated copy of this consent form.

(Remember that it is a requirement for the P.I. to maintain a signed and dated copy of the same consent form signed and kept by the participant).

PARTICIPANT NAME:			
PARTICIPANT SIGNATURE:		**DATE:**	
WITNESS TO SIGNATURE: (PROJECT STAFF)		**DATE:**	

Appendix G - Survey Recruitment Flyer

Appendix H - Online Survey Informed Consent

KANSAS STATE UNIVERSITY

Dear Participant,

My name is Sadaf Azhar and I am a master's student in Food Science at Kansas State University. I am working on a project with my advisor, Dr. Kelly Getty, to determine university students' perceptions about soy-based food products. We would like to invite you to participate in this research by taking a short survey and we greatly appreciate your valuable input.

PURPOSE OF THE RESEARCH: To gather preliminary quantitative data on consumer perceptions of newly developed infographics related to soybeans. As part of this research, you will be presented with an infographic that contains information about soybeans.

WHAT YOU WILL BE ASKED TO DO: During the survey, we will ask you to share your prior familiarity and perceptions of soy-based food products and your thoughts on the information presented in an infographic. Additionally, we are interested in understanding how likely you are to try soy-based foods after viewing the infographic. The survey should take approximately 8-10 minutes to complete.

RISKS OR DISCOMFORTS ANTICIPATED: We do not anticipate any risks from participating in this research. You may quit the survey at any time if you feel uncomfortable or upset.

BENEFITS ANTICIPATED: You will not receive direct benefits from participating in this study. However, as a token of appreciation for your time, upon completing the survey, you will be entered into a drawing for a $100 Amazon gift card.

HOW WE WILL PROTECT YOUR PRIVACY: Your answers will be used solely for this research study. You will not be required to put your name on the survey. Your information will be anonymized, and your identity will be kept confidential. All results will be kept in an online password-protected database and will never be shared with anyone. Only the research team will have access to your survey responses.

YOUR OPTIONS TO QUIT THE STUDY: We do not anticipate any risks from participating in this study. You may quit the survey at any time if you feel uncomfortable or upset.

CONTACT INFORMATION: If you have any questions regarding this study, please contact Sadaf Azhar or Dr. Kelly Getty with the provided contact information below. You can also contact the KSU Institutional Review Board for the Protection of Human Subjects at the office of Research Services, Kansas State University, Manhattan, KS 66502, (785) 532-3224.
We would like to thank you for your consideration for participation.

Sincerely,
Sadaf Azhar (785) 370 9777 sadafa@ksu.edu
Dr. Kelly Getty (785) 341 2819 kgetty@ksu.edu

By selecting "I agree" you give consent to participate in the Study.

○ Agree

○ Disagree

→

Appendix I - Online Survey Questions

Which of the following dining centers do you dine in most often?

- ◯ Derby
- ◯ Kramer
- ◯ I don't usually dine in either dining center

→

Please rate your agreement with the following statements.

Consuming soy-based food products is a sustainable choice.

- ◯ Strongly agree
- ◯ Somewhat agree
- ◯ Neither agree nor disagree
- ◯ Somewhat disagree
- ◯ Strongly disagree

Consuming soy-based food products is environmentally friendly.

- ◯ Strongly agree
- ◯ Somewhat agree
- ◯ Neither agree nor disagree
- ◯ Somewhat disagree

○ Strongly disagree

Soy-based food products have digestive benefits.

○ Strongly agree

○ Somewhat agree

○ Neither agree nor disagree

○ Somewhat disagree

○ Strongly disagree

Soy-based food products are beneficial for my health.

○ Strongly agree

○ Somewhat agree

○ Neither agree nor disagree

○ Somewhat disagree

○ Strongly disagree

Consuming soy-based food products is better for animal welfare.

○ Strongly agree

○ Somewhat agree

○ Neither agree nor disagree

○ Somewhat disagree

○ Strongly disagree

Consuming soy-based food products makes me feel good.

- ◯ Strongly agree
- ◯ Somewhat agree
- ◯ Neither agree nor disagree
- ◯ Somewhat disagree
- ◯ Strongly disagree

My friends think I should consume soy-based food products.

- ◯ Strongly agree
- ◯ Somewhat agree
- ◯ Neither agree nor disagree
- ◯ Somewhat disagree
- ◯ Strongly disagree

My family thinks I should consume soy-based food products.

- ◯ Strongly agree
- ◯ Somewhat agree
- ◯ Neither agree nor disagree
- ◯ Somewhat disagree
- ◯ Strongly disagree

My colleagues/classmates think I should consume soy-based food products.

- ◯ Strongly agree
- ◯ Somewhat agree
- ◯ Neither agree nor disagree
- ◯ Somewhat disagree
- ◯ Strongly disagree

The choice to include soy-based food products in my diet is entirely my own.

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

I am confident that, if I want to, I can easily consume soy-based food products.

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

I am confident that, if I want to, I can easily find soy-based food products in the market.

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

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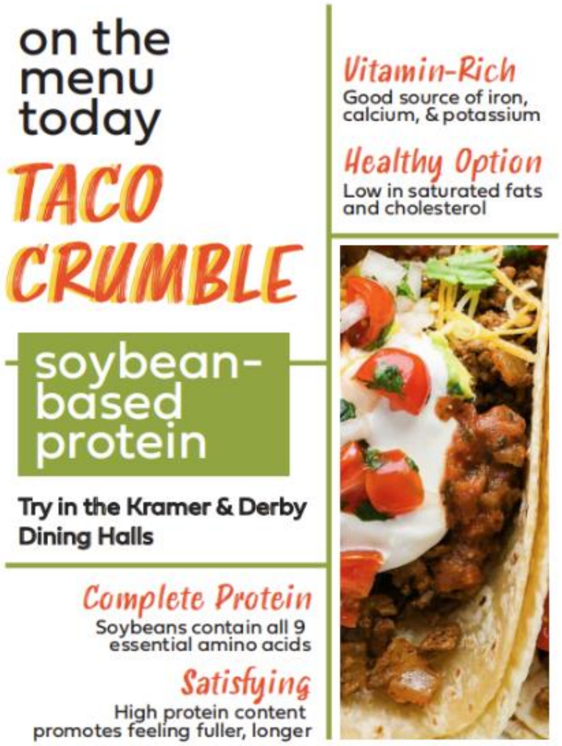
You are about to view an infographic about a soy-based food product. Please read the infographic for at least 10 seconds. There will be questions about it afterward.

→



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In the material you just viewed, which of the following terms was used to describe the taco crumble?

- ◯ Soybean-based protein
- ◯ Soy-based protein
- ◯ Plant-based protein
- ◯ Meat-alternative protein
- ◯ Other

→

The likelihood that I will eat soy-based food products in the next two weeks is high.

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

I am planning to eat soy-based food products in the next two weeks.

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

I am willing to try soy-based food products.

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Please rate your agreement in the following statements.

The infographic was easy to read.

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

The infographic was easy to follow.

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

The content used in the infographic was easy to understand.

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

How surprising do you find this information?

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

Is the information conveyed by the infographic new or novel to you?

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

Has this information changed your point of view on soybeans?

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

How useful did you find this infographic?

- Not at all useful
- Slightly useful
- Moderately useful
- Very useful
- Extremely useful

Please select your gender.

- ○ Male
- ○ Female
- ○ Other
- ○ Prefer not to say

What is your age in years?

Which academic grade are you currently in?

- ○ Freshman
- ○ Sophomore
- ○ Junior
- ○ Senior
- ○ Postgraduate

Please specify the college you are affiliated with.

- ○ Agriculture
- ○ Architecture, Planning and Design
- ○ Arts and Sciences
- ○ Business Administration
- ○ Education
- ○ Health and Human Sciences
- ○ Veterinary Medicine
- ○ Engineering
- ○ Leadership

How often do you currently consume soy-based foods? (e.g., tofu, soy milk, edamame, soy sauce).

- Very often (4 or more times a week)
- Often (2-3 times a week)
- Regularly (once a week)
- Occasionally (1-3 times a month)
- Rarely (less than once a month)

→

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Thank you for completing our survey!
After the survey period, there will be a random drawing for 2 participants to win a $100 Amazon gift card. If you're interested in entering the drawing, please click on the link below. You'll be directed to a separate window to submit your KSU email address, ensuring your entry into the lucky draw.
Submit Your KSU Email
Please note: The draw is random, and winners will be notified via their KSU email.