

**U.S. dog and cat owners consumer perception of
insect proteins in companion animal feed**

by

Amanda Bimonte

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Major Professor
Aleksan Shanoyan

ABSTRACT

This research aims to provide insight on how to enhance consumer perception of insect-based pet products. Insect protein is a sustainable alternative to meat proteins that provides some nutritional components and is safe for dogs and cats. Feeding insects is a new concept for U.S. pet owners and many consumers are uncertain about the ingredients and their impact on pet health. There is a particular “ick-factor” for many people considering feeding their pets something they do not eat themselves. A consumer survey of 509 U.S. dog and cat owners was conducted in December of 2023, and the respondent’s data analyzed using logistic regression models. The paper utilized three main objectives to study consumer behavior when considering and purchasing pet products made with insect-based ingredients. The three objectives are to (i) quantify the attributes of current buyers of insect-based pet food products, (ii) determine which attributes insect pet foods would need to have for potential purchasers, (iii) and review which key facts about insect proteins would increase consumers comfortability feeding it to their pet.

The first objective is to establish statistically significant characteristics of current buyers of insect-based pet food products. Survey respondents who identified themselves as being a current or previous purchaser of insect-based pet food products were specified as a dependent variable. A binary logistic regression model was specified and estimated to examine hypothesized correlations between key attributes about respondents and their potential correlations with being current purchaser. The model results indicate a statistically significant relationship between a number of pet owner characteristics, pet food purchasing

habits and the likelihood of them being a current purchaser. Some notable factors include living in an urban community, seeking innovative pet products, having purchased plant-based pet food products, seeking sustainable pet food options, having purchased allergy pet food products, having purchased functional health pet products, having purchased insect-based food for themselves, and having purchased allergy specific food for themselves.

The second objective of the study is to shed light on the attributes that are important for pet owners when considering purchasing insect-based pet foods. Survey respondents were asked which product features they consider a “must have” in their potential insect-protein based pet food purchasing. After the question about which attributes were a “must have” for each consumer, they were asked “If a pet food made with insect protein met all of your “must haves”, would this change your likelihood of feeding it to your pet?”

Respondents reported if they were slightly more likely, very much more likely, or stayed the same. A logistic regression was modeled to test correlations between which “must haves” had a significant impact on increasing their likelihood to purchase insect products if their “must haves” were met. There were two “must haves” that had a statistically significant increase in likelihood of them reporting they are very much more likely to purchased insect-based pet foods. Two statistically significant variables were must have environmentally friendly and must have science-based .

The third objective is to gain insight on what facts about insect proteins made consumers more comfortable with the idea of feeding insects to their pet. In this section of the survey, several facts were shared about insect ingredients, and consumers were asked: “For each fact, would this make you more likely to feed pet food made with insect protein

to your pet?”. Consumers answered if they were slightly more likely, very much more likely, or if their likelihood stayed the same. After these series of facts, respondents were asked “Have these facts given you enough knowledge to feel comfortable with insect protein in pet food?” Respondents reported if they were fairly comfortable, slightly comfortable, comfortable, very comfortable, or not at all comfortable. A logistic regression was modeled to test several hypotheses between which facts that consumers reported made them very much more likely to purchase insect proteins, statistically correlated with them feeling comfortable or very comfortable feeding insect proteins to their pet. There were two statistically significant facts that increased consumers likelihood to purchase. These related education about aroma and flavor of insect protein and insects being a natural part of a wild cat’s diet.

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CHAPTER I: INTRODUCTION

1.1 Introduction to Insect Proteins in Pet Food

As the global pet population rises, the global supply of animal proteins needs to scale to meet demand (Alexander, et al., 2020). The heightened requirement of harmful land use, water consumption, and greenhouse gas emissions raises with the increasing pet population's consumption of animal proteins (Kepinska-Pacelik, et al., 2022). There is a need for sustainable protein options that can support global protein needs while preserving our planet.

In our modern society, consumers feed their companion animals like a part of their family. There is an increased humanization of pet food that challenges ingredient suppliers to compete with the human food chain for high quality materials like meat proteins (White, 2023).

Insects are a source of protein, fat, and vitamins (Rumpold, 2015). Insect proteins could be a viable solution to increasing protein production while limiting environmental impact. The biggest limitation of insect proteins in the current market is consumer perception. Consumers, especially from non-insect eating western cultures, may be skeptical to try novel insect proteins due to general neophobic tendencies. (Dobermann et al., 2017).

In this research, a survey will be conducted of 509 U.S. dog and cat owners to understand where consumer perception of insect proteins is now and how it can be influenced with education. This research will be utilized to suggest actionable insights on who the target consumer of insect proteins in pet food is and the best way to educate them into being a potential purchaser for their pets.

1.2 Problem Statement

There is a growing need to procure sustainable alternative proteins to feed the growing pet population. Research is available on the nutritional properties and the ability to process insect proteins as an alternative protein for companion animal food. However, there is a lack of literature that addresses the consumer perception of insect ingredients used in pet food. There is a need to understand how consumers currently perceive insect proteins and what education they may need to be able to feel comfortable purchasing insect-based pet foods for their pets.

1.3 Research Objectives

The goal of this research is to fill the literature gap on the consumer perception of insect-based ingredients in companion animal food manufacturing. This research will study a seventeen question self-reported survey from 509 U.S. dog and cat owners. An analysis of survey responses seeks to provide guidance to pet food brands on who their target market is, what attributes are important to a potential purchaser, and what key facts about insect proteins increase a consumer's comfortability with insect protein being used in pet food.

This research is divided into three main sections that address the main objectives of the analyzed survey responses. The three main objectives are (i) who is a potential buyer of insect-based pet foods, (ii) what market education on product attributes increases their likelihood of purchasing, and (iii) what facts about insect proteins make consumers more comfortable feeding their pet insect ingredients. The research analysis will include demographics of pet food buyers, what attributes of pet food are important to them, and what criteria must be met for them to become a potential buyer.

1.4 Overview of Methods

A self-reported consumer survey of seventeen questions was conducted using an Archer Daniel's Midland Outside Voice survey of 509 U.S. dog and cat owners in December of 2023. There were three main objectives of the survey (i) to determine which consumers had already tried purchasing insect-based pet food products, (ii) what attributes would be important to potential buyers when considering purchasing insect-based pet foods, and (iii) which facts about insect-based pet foods made consumers feel more comfortable feeding it to their pet. The research consists of a quantitative analysis of the consumer data survey using econometric logistic regression modeling to hypothesize the impact of independent variables on the dependent variable of being (i) a current purchaser of insect-based pet foods products, (ii) being more likely to purchase insect proteins in pet food if their "must have" product attributes were met, and (iii) feeling comfortable feeding their pet insect proteins. There is also analysis of the results, utilizing academic literature, to come to suggested conclusions on how to interpret the research for practical industry applications. Results of this research may be beneficial to pet food brands in identifying market strategies to grow the insect-based pet food market.

1.5 Overview of Key Results and Contributions

This research will provide key insights on how pet food consumers perceive insect-based ingredients in their dog and cat food. A review of current literature has limited data on how consumers perceive insect proteins in pet food and what key aspects of marketing education need to be realized to encourage them to be more likely to purchase these products. This research aims to provide insight into how to best understand where consumers mindset is and what marketing education could persuade consumers into trying

insect proteins in their pet food purchases. This research can be helpful for pet food brands that are trying to grow the insect ingredients and insect-based pet food markets.

Some key findings of this research were that consumers are statistically more likely to be a current buyer, if they are from an urban community, have purchased insect protein food product for themselves, seek out environmentally friendly pet food products, and seek innovative pet food products for their pet. Purchasing habits of consumers suggest that consumers are statistically more likely to be a current buyer, if they have previously purchased plant-based protein, functional, allergy specific, and diet pet foods for their pet. Additionally, when reviewing “must have” attributes for consumers considering purchasing insect ingredients, the research suggested that consumers are statistically more likely to be a potential purchaser if their insect-based pet food is environmentally friendly and based in science. Finally, we learned that several facts had a statistically significant impact on increasing a consumer’s likelihood of feeling comfortable feeding pet food made from insects. These facts included education on flavor and aroma, and that insects are a natural part of a wild cat’s diet.

CHAPTER II: BACKGROUND: INSECT PROTEINS IN PET FOOD

2.1 Problems Facing the Global Meat Supply

Global human populations are increasing and projected to reach nine billion by 2050 (Grafton et al., 2015; Park and Yun, 2018). This will require about double the amount of global food supply when reviewing human dietary requirements alone (Belluco et al., 2013). Meanwhile, land availability and crop output are decreasing with growing populations and declining environmental conditions (Dobermann et al., 2017). Environmental hardship competes with global access to nutritious foods.

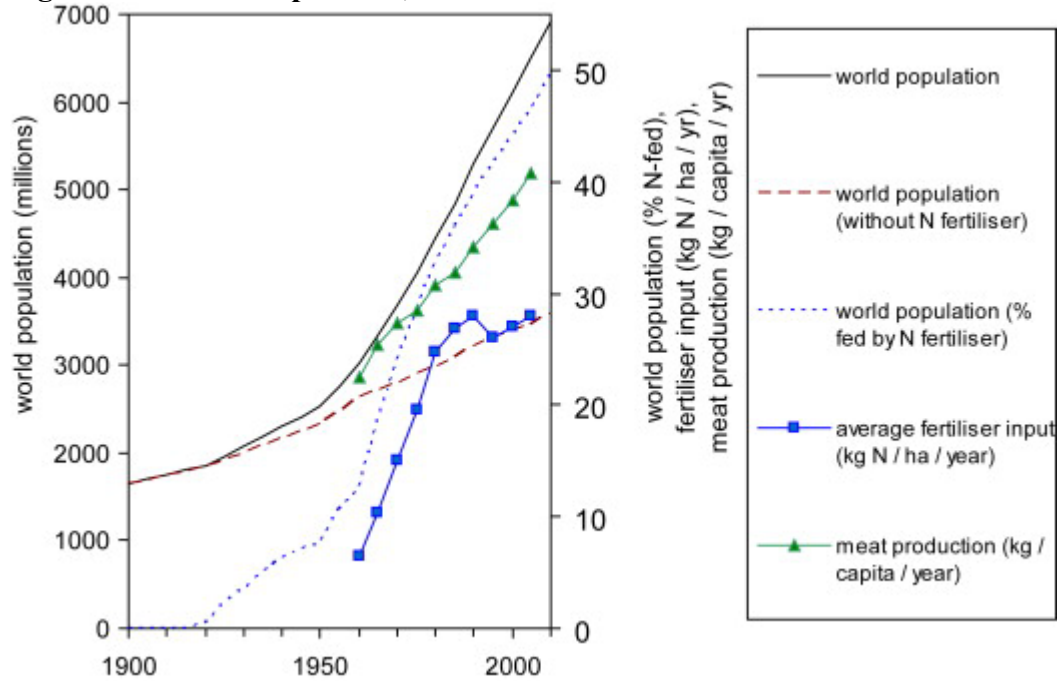
Developing countries consume one-third of meat products per capita compared to developed countries (Delgada, 2003). As developing countries advance, there is a shift in grain-based nutrition towards animal protein (Hawkes, et al., 2017). The per capita consumption of some meat proteins has grown by an average of 3% annually in emerging economies (Nigatu, Seeley, 2015). Because of population increase, and the advancement of developing countries, global meat consumption is expected to continue to increase (Delgada, 2003).

2.2 Global Meat Supply Impact on Pet Food

While animals are not typically slaughtered for immediate use in pet foods, meat rendering occurs before meat enters other industries like livestock and pet feed (Hill, 2022). One-half to one-third of referred animal production is used to feed humans (Meeker & Hamilton, 2006). The animal proteins used in pet food are typically byproducts from meat farmed and slaughtered for human consumption. Historically, as the global population increases, the global meat production increases (Aiking, 2011). Academic literature suggests that while meat production has historically increased fast enough to meet the

demands of pet food, that with increasing populations, that may not be possible in the future (Hill, 2022).

Figure 2.1. World Population, Meat Production and Fertilizers



Source: Erisman, et al., 2008

2.3 Problems Facing Protein Supply in Pet Food

2.3.1 Increasing Pet Population

Pet populations in the United States have tripled since the 1970s (Alexander, et al., 2020) increasing to 6.9 million dogs and 1.6 million cats between 2016 and 2020 (Larkin, 2021). The American Veterinary Medical Association's most recent data estimated there are between 83-88 million dogs and 60-61 million cats in the U.S. (AVMA, 2022). Additionally, 44.6% of U.S. households own a dog and 26% of households own a cat (AVMA, 2022).

There was a particularly steep growth in U.S. pet ownership during the COVID-19 pandemic. The American Pet Products Association (APPA) reported a 4.7% growth in U.S.

pet ownership in the decade prior to the pandemic, and a more than doubled growth of 9.77% between 2009-2019 (APPA, 2023). In APPA's Strategic Insights for the Pet Industry report, they identified 3 key drivers in increasing American pet ownership including (i) 48% of pet owners reported adding a new pet because they were spending more time at home with increased remote work, (ii) 47% reported that their family members wanted to add a pet, and (iii) 25% wanting more companionship due to increased isolation in the pandemic (APPA, 2023).

With the current forecast of pet population increase, there is concern that the demand for animal proteins needed for pet foods, may surpass the supply available by the U.S. agricultural industry (Wall, 2022). Dr Greg Aldrich, PhD, from Kansas State University's pet food program, advises that if growth rates of pet population increase as anticipated, the U.S. will reach a position of not having enough supply of animal proteins to support the nutritional needs of its pet population (Wall, 2022).

2.3.2 Environmental Impact

Pet food has a large global environmental footprint. The global dry pet food production industry emits an estimated 56-151 Mt CO₂ (equal to 1.1-2.9% of global agricultural emissions), 41–58 Mha agricultural land-use (equal to 0.8–1.2% of global agricultural land use), and 5–11 km³ of freshwater (0.2–0.4% of water extraction of global agriculture) (Alexander, et al., 2020). The global land required annually for dry pet food has the same land requirement of twice the size of the United Kingdom (Alexander, et al., 2020). In relative terms, if the global dry pet food production industry was a country, it would have the 60th highest emissions, with similar environmental impacts as countries Mozambique or the Philippines (Alexander, et al., 2020).

Right now, the protein requirements for companion animals are supplied primarily from the rendering of meats for human food. However, as population increases, in order to sustain the nutritional needs of our companion animals, pet populations may increase negative environmental impacts by consuming animal derived energy (Okin, 2017). A review of relative environmental impact of companion animals estimates that, when accounting for land, water, fossil fuel, phosphates, and biocides, a companion animal diet has an impact equal to 25-30% of human impact (Orkin, 2017). The United States has the largest amount of pet owners compared to other countries which means U.S. pets have the largest environmental impact (Orkin, 2017). There is a need for nutritionally adequate alternative proteins to be scaled to meet the nutritional demand of the pet population, while protecting the planet.

2.4 Insect Protein Solution

Insect proteins could be a sustainable solution to providing some of the nutritional requirements needed to feed the growing U.S. pet food population. There are also nutritional, functional health, and hypoallergenic benefits to feeding dogs and cats insect-based foods. Insects have a lower environmental impact than traditional meat proteins and a potential for scalable production. The insect production industry is at its beginning stages and the concept of feeding insect proteins to companion animals is in its infancy.

2.4.1 Nutritional Research on Insect Proteins

Insect proteins can help resolve the problem of animal protein availability by providing protein with less environmental impact than animal proteins. With an increase in demand of human-grade pet foods, proteins are being sourced from outside of the rendering process. This creates additional need for meat protein production. Insect proteins are an alternative to the meat supply that can support companion animal diets through high protein

content, high content of essential amino acids and fatty acids, including lauric acid (Kepinska-Pacelik, et al., 2022). Insect proteins have a good nutritional output, are easy to formulate with, and are palatable to companion animals (Kepinska-Pacelik, et al., 2022).

One of the most nutritious insect protein species is black soldier fly larvae which have crude protein levels of 40-44% and crude fat of 36.2% (Kepinska-Pacelik, et al., 2022). Black soldier fly larvae have an amino acid profile compatible with traditional animal proteins used in dog and cat food (Kepinska-Pacelik, et al., 2022). Insect ingredients have a high level of vitamins and minerals, and some studies suggest that the body can absorb these vitamins and minerals at a faster rate than barley or wheat (Lani, 2022).

2.4.2 Safety of Insect Ingredients in Pet Food

Insect proteins have been studied and are considered safe to feed dogs and cats (Zou, et al., 2024). Insects have been a natural food source for wild canines and feral cats (Zou, et al., 2024). Feral cats and free-roaming wolves consume insects in their natural diet on average of 1% by weight (Beynen, et al., 2018). Insect ingredients are currently used to feed poultry, livestock, and aquaculture production animals (Zou, et al., 2024). In studies, there have been no documented adverse effects of feeding insect proteins to dog and cats (Zou, et al., 2024). There have been no reported health risks from the consumption of insects in pet diets thus far (Beynen, 2018). In a study by the European Food Safety Authority (EFSA), the currently permitted insect ingredients have a comparable microbial hazard as animal origin proteins and do not pose an additional hazard (Dobermann, et al., 2017).

2.4.3 Hypoallergenic Insect Proteins

Insects may also be a suitable alternative protein for pets with allergies or food sensitivities. Insect proteins are a novel protein, widely uneaten by domesticated

companion animals, which decreases their risk of producing an allergenic response, compared to traditional proteins (Beynen, 2018). In 2018 in Germany, 20 dogs with atopic dermatitis due to a previous veterinary diagnosis of adverse food reactions were studied (Bohm, et al., 2018). The dogs were fed commercially available insect diets for two weeks, and clinically reviewed using Canine Atopic Dermatitis Lesion Index (CADLI), Pruritus Visual Analogue Scale (PVAS) and coat quality score were used to review the hypo-allergenicity of insect-based dog foods (Bohm, et al., 2018). The CADLI score improved in 60% of participants and 42% of dogs who had eaten insect proteins, had improved coat quality with a respective $p=0.007$ and $p=0.01$ statistically significant improvement (Bohm, et al., 2018). The overall conclusion was that insect-based protein diets could be a successful alternative for dogs with food sensitivities (Bohm, et al., 2018).

2.4.4 Sustainability of Insect Ingredients

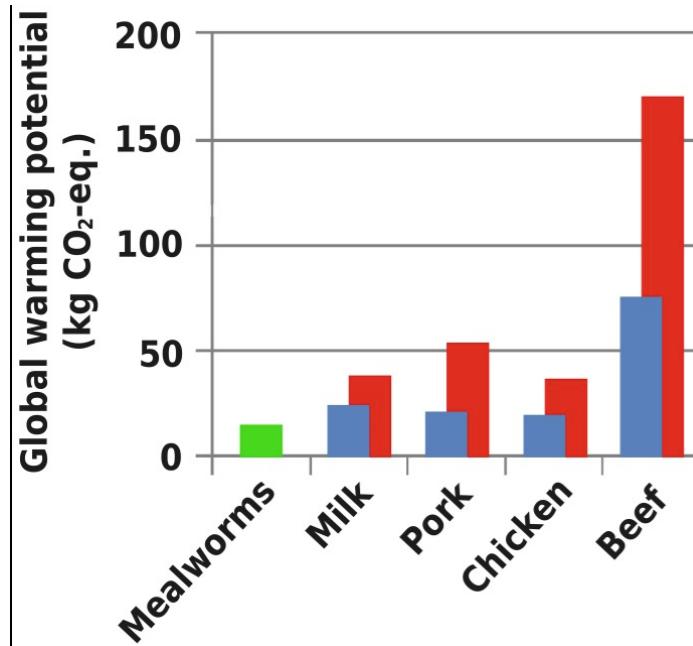
Insect proteins are shown to have less of an environmental impact than conventional animal proteins. Insects can convert their feedstock into protein at a more efficient rate than other animals (Lange, 2023). Insects allow low quality feed to convert to high value protein with less input than animal proteins. On average, crickets require less than 2kg of feed for every 1kg of bodyweight gain while chickens require 2.5kg, pork 5kg, and beef 10kg (Lange, 2023).

Insects also require less space and water to farm which equates to less greenhouse gas emissions (Lange, 2023). Yellow meal worm beetles and black soldier fly larvae emit less greenhouse gas per kg. live weight than chicken, pork, or beef (Beynen, 2018). When reviewing the lifecycle assessment of environmental impact of insect protein powder, whey powder used in dietary supplements has more than two times the impact (Smetana, 2016).

Chicken meat also has a 2-5 times higher environmental impact than insect protein (Smetana, 2016).

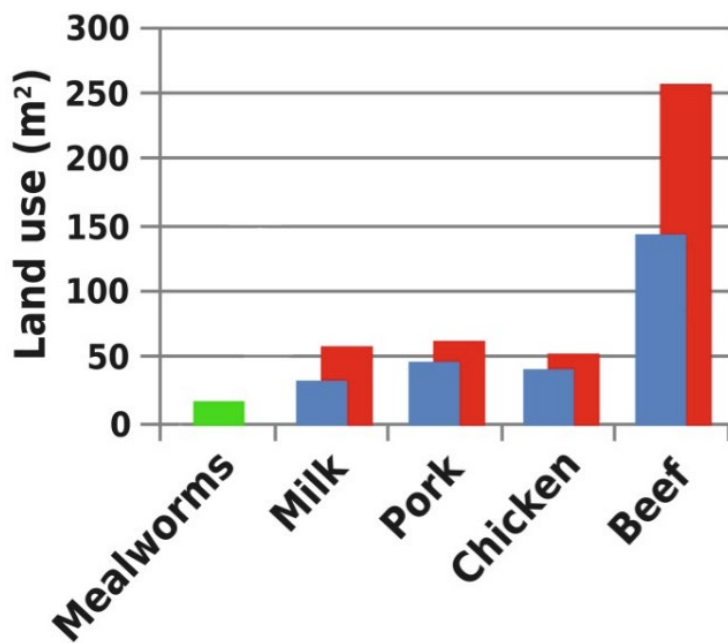
In a review lifecycle assessment of the impact of production mealworms used as a protein source has less global warming potential (Fig 2.2) and land use (Fig 2.3) than milk, pork, chicken, and beef (Oonincx, et al., 2012). This figure shows the potential due to the production of 1kg of edible protein with blue indicating the minimum and red the maximum from literature review (Oonincx, et al., 2012). It is important to note that current meat availability for pet food comes from the rendering industry and is more sustainable than farming human-grade meat supply for pets.

Figure 2.2: Global Warming Potential Impact of Mealworms Compared to Other Animal Products



Source: Oonincx, 2012

Figure 2.3: Land Use Impact of Mealworms Compared to Other Animal Products



Source: Oonincx, 2012

2.4.5 Functional Benefits of Insect Ingredients in Pet Food

Emerging studies on insect ingredients show there are additional attributes that may have functional health benefits to pets. Insect ingredients are high in antioxidants, which has a general immune health benefit in protecting the body from cell damage caused by free radicals (Lani, 2022). This supports reduction of oxidative stress that occurs naturally in metabolic reactions in the body during cellular growth (Zou, et al., 2024). In a previous study the anti-inflammatory and antioxidant capacity of black soldier fly larvae feed, results indicated a beneficial health impact in beagle dogs (Zou, et al., 2024).

Insect ingredients are also a source of essential fatty acids, needed in pet diets, and many species of insects have an ideal ratio of Omega 3:6 recommended for pet health (Lani, 2022). This supports improved coat quality and improvements of atopic dermatitis symptoms in companion animals (Zou, et al., 2024).

Insects have an exterior exoskeleton made of chitin, which has prebiotic tendencies to support digestive health (Lani, 2022). This provides diversity of gut microorganisms in companion animals (Zou, et al., 2024).

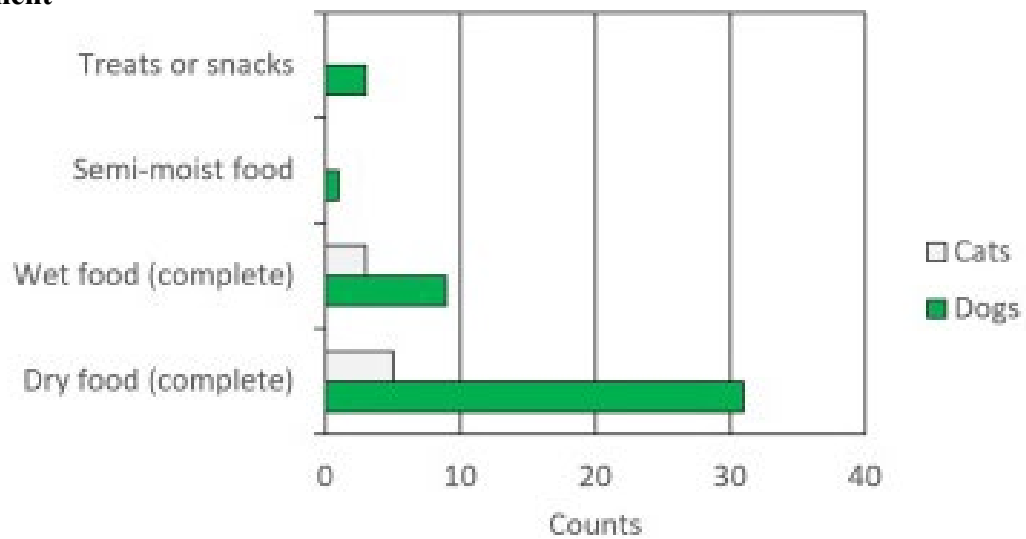
2.4.6 Current Insect Pet Food Market

The history of insect-based pet foods is relatively new and shows potential for growth. In 2015, the first insect-based dog food was launched in Europe (Beynen, 2018). In September of 2018, there were at least twelve brands marketing insect-based pet foods in Europe (Beynen, 2018). In 2015-2018, the primary goal of using insect proteins in pet diets was to promote a novel protein for its hypoallergenic benefits. All of the original twelve brands marketing insect-based pet foods specifically marketed for their hypoallergenic benefits (Beynen, 2018). The secondary marketing feature of insect-based pet foods was the decreased environmental impact. Eight out of the original twelve European brands marketed their products as being friendlier to the environment than meat proteins (Beynen, 2018). Today there are at least 43 brands actively selling insect-based pet foods globally (Siddiqui, et al., 2022). Although there is an ample amount of insect species, companion animal insect foods are primarily limited to mealworms, black soldier fly larvae, and crickets due to their nutritional benefit and production efficiencies (Zou et al., 2024).

Future Market Insights valued the insect pet food market at \$7.09 billion 2021 (Mridul, 2023). In a recent quantitative review of insect-based pet products, shown in Fig 4-6, the market penetration of product type, insect species, and region were analyzed (Siddiquie, 2022). The majority of the pet food products utilizing insect-based ingredients are dry complete food, followed by wet complete food, treats, and semi-moist foods (Fig. 4). Most insect-based pet foods utilize black soldier fly larvae (**Error! Reference source not found.**). Insect-based pet food brands are primarily sold in Europe, with the United

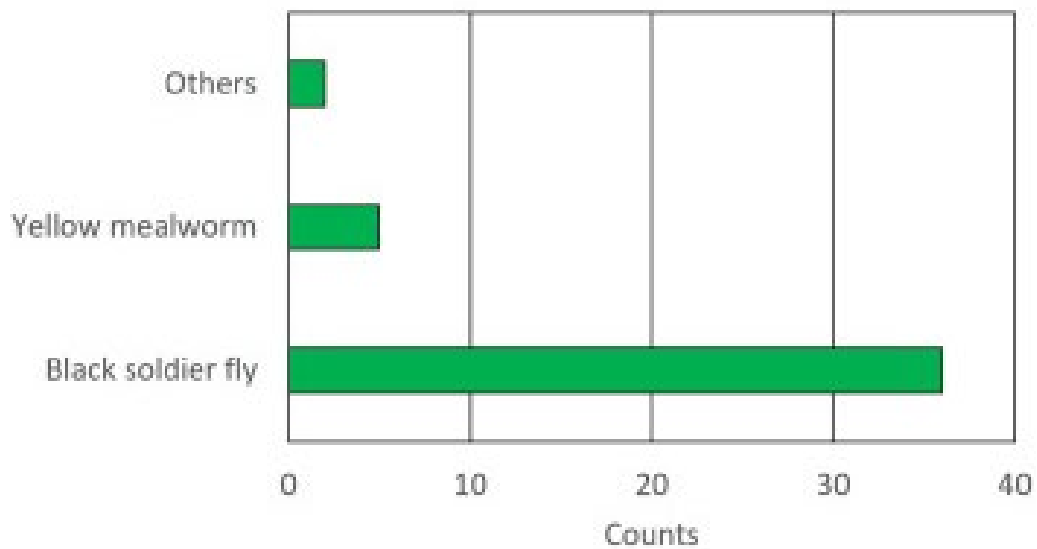
States following (**Error! Reference source not found.**). Since insect-based pet foods first had regulatory approval and product launches in Europe, the U.S. is following behind.

Figure 2.4: Overview of Insect-Based Pet food Brands Active in Individual Market Segment



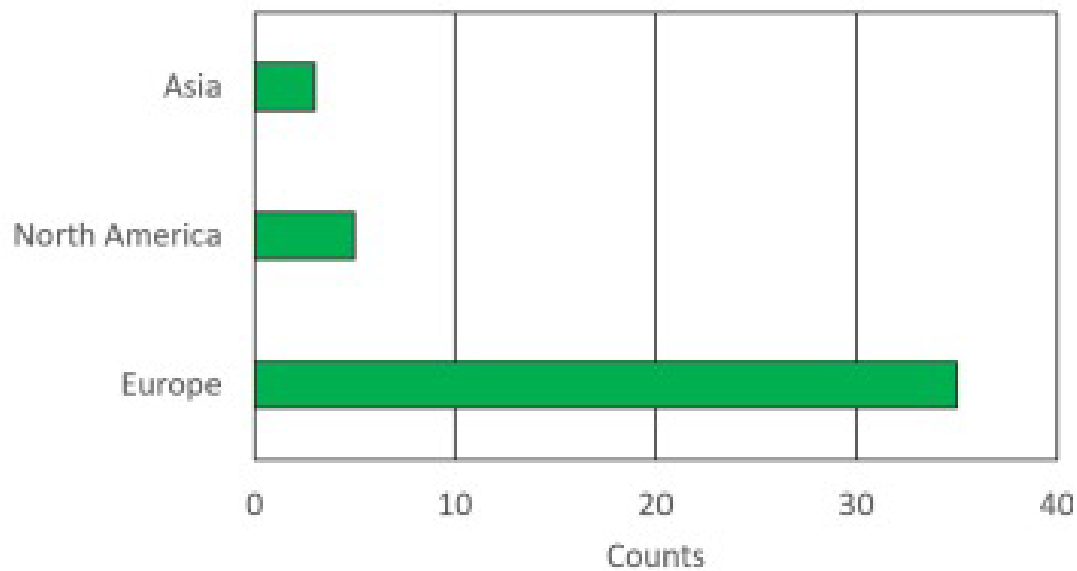
Source: Siddiqui, 2022

Figure 2.5: Overview of Insect-Based Pet Food Brands Active Per Insect Species



Source: Siddiqui, 2022

Figure 2.6: Insect-Based Pet Food Brands Active Per Geographical Segment



Source: Siddiqui, 2022

2.5 Current Restrictions on Insect Proteins in Pet Food

Insect protein production to support companion animal nutrition is a relatively new concept. There are several restrictions on the current market.

2.5.1 No Established Supply Chain

There is a comprehensive farming process to raise and process insect ingredients. Large scale domestic rearing facilities are needed to scale insect protein production to feed U.S. pet populations. Industrial insect production for making silk has been nearly perfected from being around for over 7,000 years (Dobermann, et al., 2017). Farming insects for feed is different and a much newer concept. Over the years, the ideal species for production needs to be identified for attributes like high egg production, high egg hatch rate, short larval stage, and optimum nutrition weights for finished product (Dobermann, et al., 2017). While most research agrees that black soldier fly larvae (BSFL) meet this criterion, the

novelty of industrial production of BSFL means there has not been enough time for production optimization (Dobermann, et al., 2017).

Insect production for protein is in its infancy, with mostly start-up companies racing for scalability. There have been many venture capital investments for large companies to promote start-up insect producers. In 2022, Archer Daniels Midland, a leader in human and animal nutrition ingredients, invested in French insect producer Innovafeed and partnered on a joint U.S. production plant (Innovafeed, 2022). In 2023, Tyson Foods, a major producer of beef, pork, and chicken, invested in Protix, an insect ingredient maker out of Netherlands (Weiner-Bronner, 2023). Based on the newness of insect proteins in pet food, the demand for ingredients is low, but expected to grow, as production capacities and consumer perception improve.

2.5.2 Premium Costs

Much of insect production has not been automated and requires manual labor for feeding, collection, cleaning, and rehousing (Dobermann, et al., 2017). Additionally, maintaining the ideal environment for temperature, light, humidity, ventilation, rearing habitats, population density, oviposition sites, water and food access, feed nutritional composition, and quality controlling potential contaminants, can lead to a premium price point for insect proteins (Dobermann, et al., 2017).

Some companies are advancing production technologies to keep costs down, while limiting environmental impact. French black soldier fly larvae producer, Innovafeed, has developed a unique production model, called industrial symbiosis, that emits 80% less CO₂, and fossil fuel depletion by 83%, and 12,000 less truckers per year than a similar sized insect production facility (Phl, 2020).

2.5.3 Regulatory Status

The Association of American Feed Control Officials (AAFCO) is a 110-year-old independent organization that aims to set guidelines that state, federal, and international regulatory bodies can use to facilitate ingredient definitions, label standards, and laboratory standards to promote the health and safety of people and animals (AAFCO, 2024).

AAFCO helps to provide guidelines for the sale and distribution of animal feeds and drug remedies, including companion animals (AAFCO, 2024). In August of 2021, AAFCO voted on a tentative approval of black soldier fly larvae as an allowable ingredient in adult dog food (Tyler, 2021). At that time, it was the first insect ingredient to go through the ingredient definition process with AAFCO (Tyler, 2021). In January of 2024, after a six-month long scientific trial for safety and nutrition, AAFCO granted approval to insect producer Ynsect to use defatted mealworm protein in dog food products (Tyler, 2024).

There are many insect species that are currently not recognized by AAFCO for use in pet foods. There are also restrictions on current ingredients such as black soldier fly larvae only permitted for use in adult dog foods.

2.6 Additional Need for Consumer Perception Research

2.6.1 Current Perceptions of Insect Ingredients as Food

Consumer perception of edible insect acceptance is low, despite the benefits of being a very sustainable food that could support food insecurity (Alhujaili, et al., 2023).

With many positive sustainability and nutritional attributes, consumers are still skeptical to try novel insect proteins due to general neophobic tendencies. (Dobermann et al., 2017).

Because U.S. pet owners feed their pets like family, if they cannot foresee themselves consuming something, they may not want to feed it to their pet. Through regulatory

legislation and successful product development, the specific fear and disgust towards entomophagy may diminish over time (Ardoin, 2021).

In a recent study, 50% of participants reported they were willing to feed their dogs insect-based pet foods (Higa, Et al., 2021). Pet owners who were averse to eating insects themselves, were reluctant to feed them to their pets (Higa, Et al., 2021).

2.6.2 Opportunity for Further Research

This research will seek to understand where consumer perception is currently and how it can be utilized to promote the ingredient. Some published literature suggests that consumer acceptability of insect protein is low. This research aims to see what sort of marketing education about the many benefits to insect proteins may be helpful to persuade consumers into being potential purchasers. Additionally, there is limited research on consumers who have already tried insect ingredients in their pet foods. This research aims to understand those consumers who are the target market.

CHAPTER III: LITERATURE REVIEW

3.1 Academic Literature

3.1.1 Academic Literature on Nutrition, Efficacy, and Sustainability of Insect Proteins in Pet Food

There is plentiful academic literature on the nutritional benefits of insect proteins in the human, livestock, and companion animal diet. Studies have been done to review the nutritional efficacy of insect ingredients in a complete companion animal diet. This includes feeding trials with impact on skin health, hypo-allergenicity, fecal score, and functional health benefits (Lani, 2022). In journals that addressed the nutritional adequacy of insect ingredients for dogs and cats, articles focused on the nutritional research and had a short section on consumer perception. There is a lack of research that correlates the nutritional benefits of insect ingredients with consumer perception of feeding insects to their pets.

There has also been research done to review the lifecycle assessment of decreased environmental impact of insect ingredients compared to traditional meat proteins and alternative proteins like whey and soy. Several papers review the reduction in carbon emissions, global warming impact, and land and water use in insect protein production compared to other proteins. There is a lack of research that correlates the sustainability benefits of insect ingredients with consumer perception of feeding insects to their pets.

3.1.2 Academic Literature on Consumer Perception of Consuming Insects Themselves

The U.S. does not traditionally consume insects as part of their culture. Because of this, there is limited insect-based human food products and limited non-academic publications about consumer perception of U.S. citizens eating insects. The acceptability of people living in areas that have a cultural history of insect consumption, such as Asia,

Africa, and Central America, are more likely to consume insect food products (Valdes, et al., 2022). Conversely, cultures that do not practice entomophagy describe eating insects as “disgusting, unpleasant, malodorous, and dirty” (Valdes, et al., 2022). There is a lack of data to support the correlation of consumer negative perception in eating insects back to consumer behavior of feeding insects to their pets.

There are also papers that discuss the culture of humans eating insects and how sustainability impacts that trend. As the trends of eating more novel ingredients in the human diet, marketing promotions that emphasize the nutritional and environmental benefits of the novel ingredient have been successful in increasing consumer demand (Sun-Waterhouse et al., 2016). There is a lack of research on the perception of feeding pets sustainable insect ingredients.

3.1.3 Academic Literature on Consumer Perception of Feeding Insects to Pets

A review of academic literature in major journals related to food science shows a gap in literature specific to the consumer perception of insect ingredients in pet food. There are few published academic journals that address the human consumer perception of feeding their pets insect ingredients.

There is a published study that utilizes a consumer survey to review American consumer perception of eating black soldier fly larvae themselves and feeding it to their dogs (Higa, et al., 2021). In this study, the main objective was to investigate consumers attributes towards consuming or feeding insects as either (i) whole dried insects or (ii) non-visible insect meal inside of familiar food and treat products (Higa, et al., 2021). They found that American consumers were more willing to try food for themselves, or feed food products for their dog, made with insect flour than whole dried insects (Higa, et al., 2021). The study found that the closer a pet owner felt to their dog, the more resistant they were to feed their

dog food made with insects (Higa, et al., 2021). This research is helpful in understanding that consumers are averse to visible insects and correlate not wanting to eat insects themselves with not wanting to feed them to their pet. Further research is needed to understand which individuals are more likely to feed insect ingredients and what education may persuade them into trying the ingredient for their pet.

3.2 Non-Academic Literature

3.2.1 Non-Academic Literature on Nutrition, Palatability, and Safety of Insect Proteins in Pet Food

There are many insect farm producers who are promoting insect ingredients to the pet industry as this niche category develops. Multiple species of insects offer different benefits, so producers of insect ingredients are promoting the transparency of the insect type (Neitzel, 2022). Insect proteins could be a valuable solution to increasing nutritious protein production.

3.2.2 Non-Academic Literature on Consumer Perception of Consuming Insects Themselves

The U.S. has the least common history of eating insects and the most distrust towards the ingredient. Because of this, there are limited insect-based human food products and limited non-academic publications about consumer perception of eating insects. There is potential that due to the sustainability and functional health benefits of insect ingredients, that U.S. consumers may be willing to try eating insects as a niche wellness food product. Because the pet food industry follows human food trends, insect proteins are on-trend with “vegan, reducing meat production, [and] functional foods (Neitzel, 2022).” This trend is in the very early stages and seems to be a potential future trend that has not had its opportunity to infiltrate the general public yet.

3.2.3 Non-Academic Literature on Consumer Perception of Feeding Insects to Pets

There are multiple insect production companies that are promoting their ingredients within pet industry non-academic literature. That leads to podcasts, articles, and other published non-academic works discussing the opportunities of insect proteins for pet food. There are many discussions on the nutrition, sustainability, and production scalability of insect proteins. However, due to the conflict of interest, there is a lack of discussion on the hurdles and “ick-factor” associated with feeding pets insects. A more open dialogue on consumer’s hurdles to purchasing would assist these brands in promoting their ingredients to the right consumers with marketing education that helped them feel comfortable feeding insects to their pet.

3.3 Literature Gap

The literature suggests that there is hesitation from U.S. consumers to adapt insect proteins into a regular part of their pet’s diet. There is research that discusses the limitations of human entomophagy in western cultures. The what Neitzel coins as a “yuck-factor” may be less impactful on pet food than it is in human diets, which may support the acceptance of insects in pet food before human food (Netizel, 2022). Insect proteins in pet food is a new concept that there is not significant research to review the common opinion and relative sensitivity of U.S. dog and cat owners. There seems to be great potential in sustainability and nutrition, but a gap in consumer awareness. This research will aim to directly survey consumers to understand their opinions and knowledge on insect proteins in pet food.

CHAPTER IV: METHODOLOGY

4.1 Conceptual Framework

The survey was designed to mimic the marketing funnel of consumers' interest in the product from being an existing buyer or a potential buyer. Survey questions were grouped into three main objectives. The first part of the survey was designed to determine (i) who was an existing buyer or trier of insect protein pet foods. The second part of the survey aimed to determine (ii) what information consumers must have to increase their likelihood of being a potential buyer. The third part of the survey looked at particular facts about insect ingredients and assessed (iii) how comfortable consumers became after learning insect protein facts.

4.1.1 Objective One: Current Buyers

Goal: To determine if there are any statistically significant characteristics of current buyers of insect-based pet foods that can predict their likelihood of being a current buyer.

Data Needed: Consumer survey data on demographics of current purchasers of insect-based pet food products. Characteristics of consumers should include their general demographics and their purchasing habits when buying food for themselves and their pet.

4.1.2 Objective Two: Must Haves of Potential Buyers

Goal: To determine if there are any product attributes on insect pet food products that consumers must have to have a statistically significant increased probability in a consumer's likelihood to purchase.

Data Needed: Consumer survey data on what insect-based pet food products must have for them to consider purchasing. Product attributes should include key marketing features such as being environmentally friendly, science-backed, or endorsed by

veterinarians. Additionally, the designation of which consumers became very much more likely to purchase insect pet foods if their “must haves” were met.

4.1.3 Objective Three: Education Needed to Feel Comfortable

Goal: To determine if there are any facts about insect proteins that have a statistically significant increase in likelihood of a consumers feeling comfortable feeding their pet insects.

Data Needed: Consumer survey data on what facts made them feel more likely to purchase insect pet foods. Facts should include education on their nutrition, environmental impact, and flavor to pets. Additionally, a designation of which consumers became comfortable with feeding their pets insect proteins after learning these facts.

4.2 Estimation Approach

Logistic regression models are used as a statistical model to evaluate multiple variables on a binary dependent variable. Logistic regression, or logit, models can help analyze the probability of obtaining an outcome of interest (Onukwugha, et al., 2015). The independent variables are predictor variables that have a correlation on the probability of the dependent variable occurring (Onukwugha, et al., 2015). The program Stata was used to run a logistic regression model and provided coefficients, p-values, and marginal effect for each independent variable. There are several calculations used in this research from the logistic regression model.

4.2.1 Binary Variables Coefficient Calculations

In the survey, variables are a yes or no binary variables, meaning they either occur ($Y=1$) or do not occur ($Y=0$). Only one of the variables ($Y=1$) should be present in the model to prevent multicollinearity and the statistics of $Y=0$ can be calculated from the included variable. In logistic regression models, coefficients establish the criteria of change

within log odds. Therefore, the coefficient of $y=0$ is equal to negative the coefficient of $Y=1$.

$$\beta_{\text{not occurring}} = -\beta_{\text{occurring}}$$

Whereas, $\beta_{\text{occurring}}$ is the coefficient used in the logistical regression, and $\beta_{\text{not occurring}}$ is the calculated coefficient of that variable not occurring.

4.2.2 Marginal Effect

The marginal effect (ME) is used to measure the change that occurs on the consequence of a variable occurring (Onukwugha, et al., 2015). ME calculates the change in the probability of the dependent variable for a one-unit change in the binary independent variable, holding all other independent variables constant. Marginal effect will be referred to as ME throughout this research.

CHAPTER V: DATA

5.1 Survey Design

This research utilizes the quantitative data collected from a 17-question consumer survey administered to 509 U.S. dog and cat owners in December of 2023. The survey was distributed to a random sample of U.S. consumers who owned dogs and cats. Only respondents who reported they owned a dog or cat were utilized. The total survey population is intended to represent a collective variance in the U.S. population. The survey was broken up into 3 major sections to address the three main objectives.

The goal of the first section was to determine who were the current purchasers of insect-based pet foods. Consumers who reported they had purchased insect proteins for their pet were allocated to a purchaser sub-category. For these consumers, they are at least in the “trier” section of the marketing funnel. This is representative of the target market.

The first section of the survey reviewed the overall demographics of the survey respondents. They were asked how many dogs and cats they have, annual income, and education level. Next, they were asked what they seek out when purchasing pet food including if they sought out sustainable pet foods, hypoallergenic pet foods, and foods from larger pet food companies. Next, they were asked which types of products they had purchased for themselves or their pets such as diet foods and plant-based proteins. The responses to these questions were fitted into binary independent variables. Several hypotheses were tested to examine potential correlations between independent variables and the dependent variable of being a current purchaser.

The second section of the survey aimed to see what aspects of insect-based pet foods would be important for consumers to see on product packaging and marketing

materials. Next, respondents were asked to consider purchased pet food made with insect protein and select which attributes were “must haves”, “nice to have”, or “do[esn’t] matter”. This included attributes like environmentally sustainable and endorsed by veterinarians. Respondents were then asked if the pet food product met all their “must haves”, would it change their likelihood of feeding it to their pet. Independent variables of their “must haves” were tested for correlation with their likelihood to purchase if their must haves were met.

In the third section, we provided education to survey respondents on some facts about insect protein and asked if each fact made them more likely to purchase insect-based pet foods. Facts included education on the nutrition and sustainability of insect ingredients. After a series of facts, respondents were asked to share how comfortable they were feeding their pet insect protein. In this model, independent variables of the facts were tested for correlation on the dependent variable of reporting being comfortable purchasing insect ingredients for their pets after learning the facts.

Each survey question collected data from the respondent, which was compiled and catalogued into binary values. Questions were derived to address the three main research objectives.

5.2 Summary Statistics

5.2.1 Survey Demographic Distribution

The goal of the survey was to gain a wide variety of insights from U.S. pet owners from a wide background. Figure 5.1 shows the spread of total survey respondents in level of education. Figure 5.2 shows that survey respondents came from rural, suburban, and urban communities. In Figure 5.3, different annual incomes of survey respondents are

shown. Figures 5.4 and 5.5 show the number of cats and dogs, respectively, survey respondents own.

Figure 5.1: Highest Level of Education of Survey Respondents

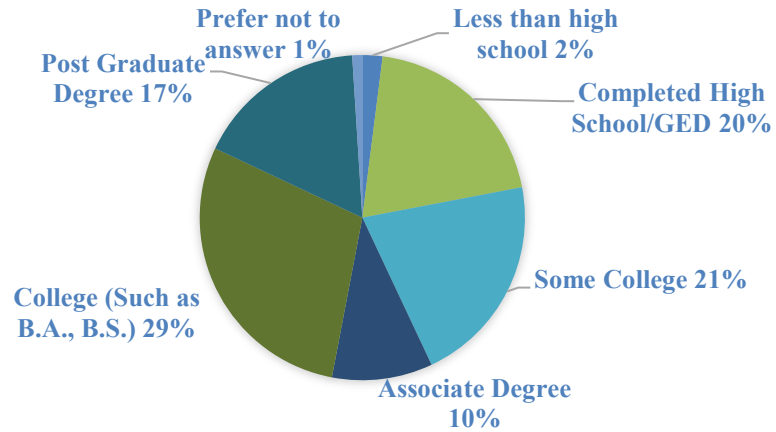


Figure 5.2: Community Type of Survey Respondents

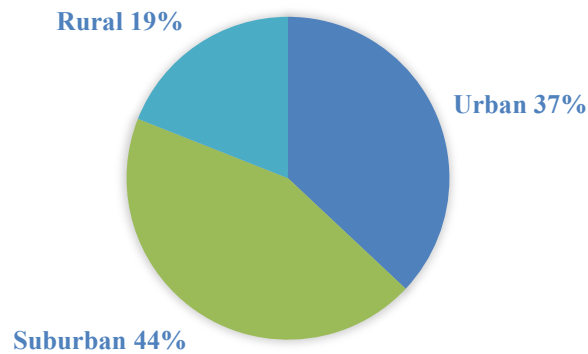


Figure 5.3: Annual Household Income of Survey Respondents

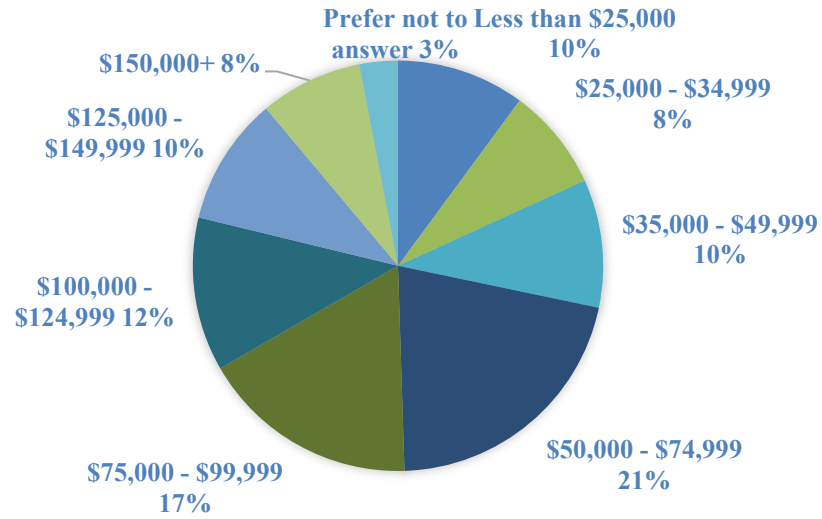


Figure 5.4: Number of Cats Owned by Survey Respondents

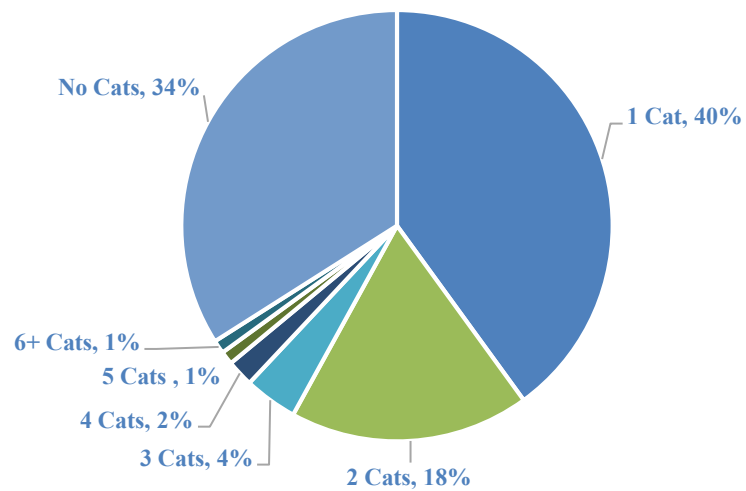
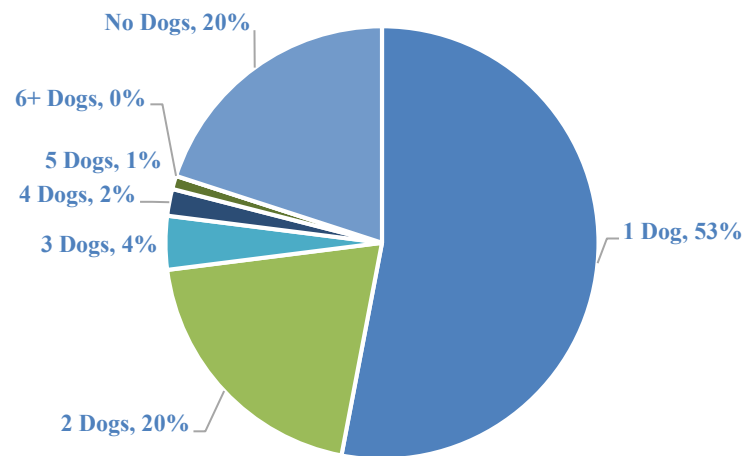


Figure 5.5: Number of Dogs Owned by Survey Respondents

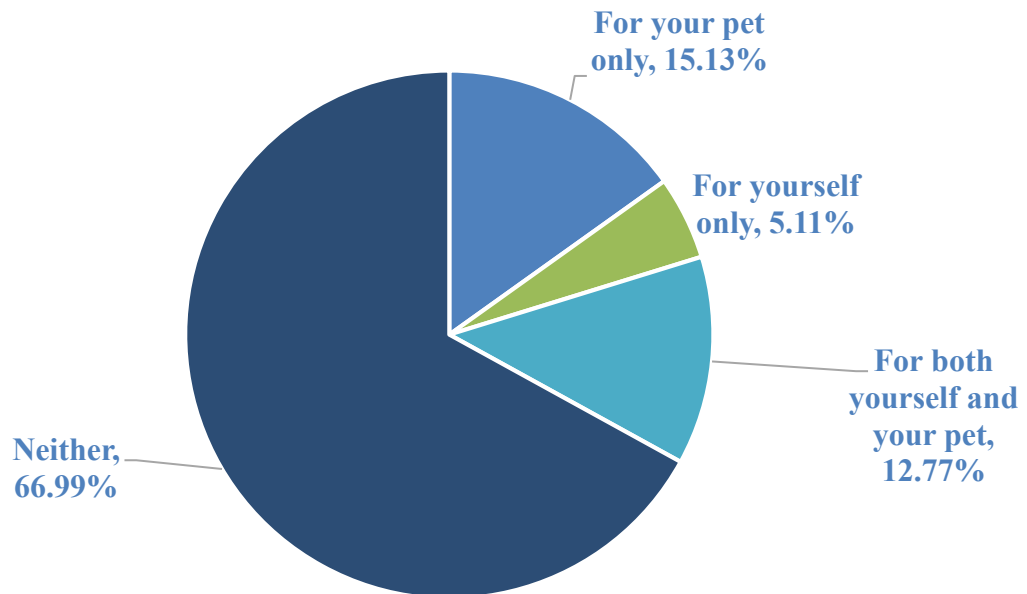


CHAPTER VI: ANALYSIS

6.1 Objective One: Understand Key Characteristics of Current Buyers of Insect-Based Pet Food Products

The first step in the research was to utilize survey results to see which consumers were already purchasing insect-based pet food products. In a survey, consumers were asked “Which of the following types of products or products made with the following ingredients have you purchased for you or your pet? Insect-Based Protein”. Those who responded, for their pet only or for themselves and their pet were given a binary value of $Y=1$ for the dependent variable “Purchaser”. 27.90% reported they had already purchased insect-based products for their pet.

Figure 6.1: Purchase History of Insect-Based Protein for all Respondents



6.1.1 Logit Modeling of Current Buyers

Each survey question was fit into a binary variable to be used in a logistic regression model. The model was used to test for correlation between hypothesized independent variables and the dependent variable of being an existing purchaser of insect-based pet products. A binary value of $Y=1$ one indicates when survey respondents were asked a question, they reported the response described in the below definition **(Error! Reference source not found.)**. The null hypothesis for all independent variables in this logit model is that the coefficient is equal to zero. Thus, there is no statistically significant relationship between the predictor variables and the dependent variable. If any of the independent variables have a p-value less than .05, we would reject the null hypothesis, thus suggesting that there is a statistically significant relationship between the independent variables and the dependent variable.

The independent variables for this model are in two groups. The first group is general pet owner demographics. The variable Cat Owner and Dog Owner shows which kind of pet they own. We also have a variable for owners who have multiple pets (whereas they have more than one dog, cat, or a combination of both). We are also testing independent variables of education level, income level, and community type (urban vs suburban and rural). We are testing if there are any statistically significant differences in main demographic groups on their likelihood of being a current buyer.

The second group is the consumers' buying habits when purchasing for themselves and their pet. We are testing to see if there is any correlation between what they seek when purchasing food for themselves and their pet in their likelihood of being a current buyer. The survey asked consumers if they sought sustainable, nutritious, and innovative pet foods. We also asked consumers if they preferred to purchase from small

well-known pet brands or large well-known companies. Then there were a series of food types, consumers were asked if they had purchased for themselves and/or their pet. These included plant proteins, insect proteins, functional health products, allergy specific foods, and/or diet specific foods. The survey aimed to see if any of these buying trends correlated with an increase in the likelihood of them being a purchaser.

This model had a pseudo R-squared value of 0.4705. This suggests that the model has an explanatory power of approximately 47.05% of the variance in the dependent variable. This suggests a moderate goodness of fit.

Table 6.1: Variables in Logit Model of Current Buyers

Variable	Definition Question	Y=1 Response	Y=0 Response
<i>Const</i>	Which of the following types of products or products made with the following ingredients have you purchased for you or your pet? Insect-based protein" reported	"for your pet only" or "for yourself and your pet"	"for yourself only" or "neither"
Cat Owner	How many dogs/cats do you currently have? If you do not have a dog or cat, select "I do not have this type of pet." Cat	"1,2,3,4,5 or 6+"	
Dog Owner	How many dogs/cats do you currently have? If you do not have a dog or cat, select "I do not have this type of pet"	"1,2,3,4,5 or 6+"	
Multiple Pets	How many dogs/cats do you currently have?	Sum of dogs + cats = 2 or more	Sum of dogs + cats = 1
Seeks Sustainable	Do you agree or disagree with the following statements? I seek out sustainable, environmentally-friendly pet food	"agree" or "strongly agree"	
PetLikes Innovative	Do you agree or disagree with the following statements? My pet likes to try new and innovative pet food options	"agree" or "strongly agree"	
Seeking Nutritious	Do you agree or disagree with the following statements? I'm looking for very nutritious pet food with the best sources of protein, healthy fats, vitamins, & minerals.	"agree" or "strongly agree"	
PetAllergies	Do you agree or disagree with the following statements? My pet has allergies or sensitivities to some protein sources like beef, chicken, or grains.	"agree" or "strongly agree"	
LargeWell Known	Do you prefer to buy pet food made by?"	"large well-known companies"	"doesn't matter" or

			"small to medium intendent companies"
Doesn't MatterSize	Do you prefer to buy pet food made by?	"doesn't matter"	"small to medium intendent companies" or "large well-known companies"
Purchased PlantSelf	Which of the following types of products or products made with the following ingredients have you purchased for you or your pet?	"for yourself only" or "for yourself and your pet."	"for your pet only" or "neither"
Purchased PlantPet	"Which of the following types of products or products made with the following ingredients have you purchased for you or your pet? 'Plant-based protein' reported "for your pet only" or "for both yourself and your pet."	"for your pet only" or "for yourself and your pet"	"for yourself only" or "neither"
Purchased InsectSelf	"Which of the following types of products or products made with the following ingredients have you purchased for you or your pet? Insect-based protein" reported "for yourself only" or "for yourself and your pet".	"for yourself only" or "for yourself and your pet."	"for your pet only" or "neither"
Purchased Functional Self	"Which of the following types of products or products made with the following ingredients have you purchased for you or your pet? Functional foods (with health benefits)" reported "for yourself only" or "for yourself and your pet."	"for yourself only" or "for yourself and your pet."	"for your pet only" or "neither"
Purchased Functional Pet	"Which of the following types of products or products made with the following ingredients have you purchased for you or your pet? Functional foods (with health benefits)" reported "for your pet only" or "for yourself and your pet."	"for your pet only" or "for yourself and your pet"	"for yourself only" or "neither"
Purchased Allergy Self	"Which of the following types of products or products made with the following ingredients have you purchased for you or your pet? Allergy specific foods (for example: gluten-free, soy-free)" reported "for yourself only" or "for yourself and your pet."	"for yourself only" or "for yourself and your pet."	"for your pet only" or "neither"
Purchased Allergy Pet	" Which of the following types of products or products made with the following ingredients have you purchased for you or your pet? Allergy specific foods (for example: gluten-free, soy-free)" reported "for your pet only" or "for yourself and your pet."	"for your pet only" or "for yourself and your pet"	"for yourself only" or "neither"
Purchased Diet Self	Which of the following types of products or products made with the following ingredients have you purchased for you or your pet? Diet specific	"for yourself only" or "for yourself and your pet."	"for your pet only" or "neither"

	foods (for example: weight management)" reported "for yourself only" or "for yourself and your pet."		
Purchased Diet Pet	"Which of the following types of products or products made with the following ingredients have you purchased for you or your pet? Diet specific foods (for example: weight management)" reported "for your pet only" or "for yourself and your pet."	"for your pet only" or "for yourself and your pet"	"for yourself only" or "neither"
High School or Less	What is the highest level of education you completed?	"completed high school/GED" or "less than high school/GED"	higher levels of education or "prefer not to say"
Some College Associates	What is the highest level of education you completed?	"some college" or "associates degree"	lower or higher levels of education or "prefer not to say"
Post Graduate	What is the highest level of education you completed?	"post graduate degree."	lower levels of education or "prefer not to say"
Under50k	Please indicate your annual household income before taxes	"less than \$25,000, \$25,000-\$34,999" or "\$35,000-\$49,999"	other income ranges
50kto100k	Please indicate your annual household income before taxes	"\$50,000-\$74,999" or "\$75,000-\$99,999."	other income ranges
150kand Above	Please indicate your annual household income before taxes	"\$150,000+"	other income ranges
Urban	Which of the following best describes the area where you live?	"urban"	"rural" or "suburban"

Note: For each definition question, the intended variable has a value of $Y=1$ or $Y=0$ for each corresponding response.

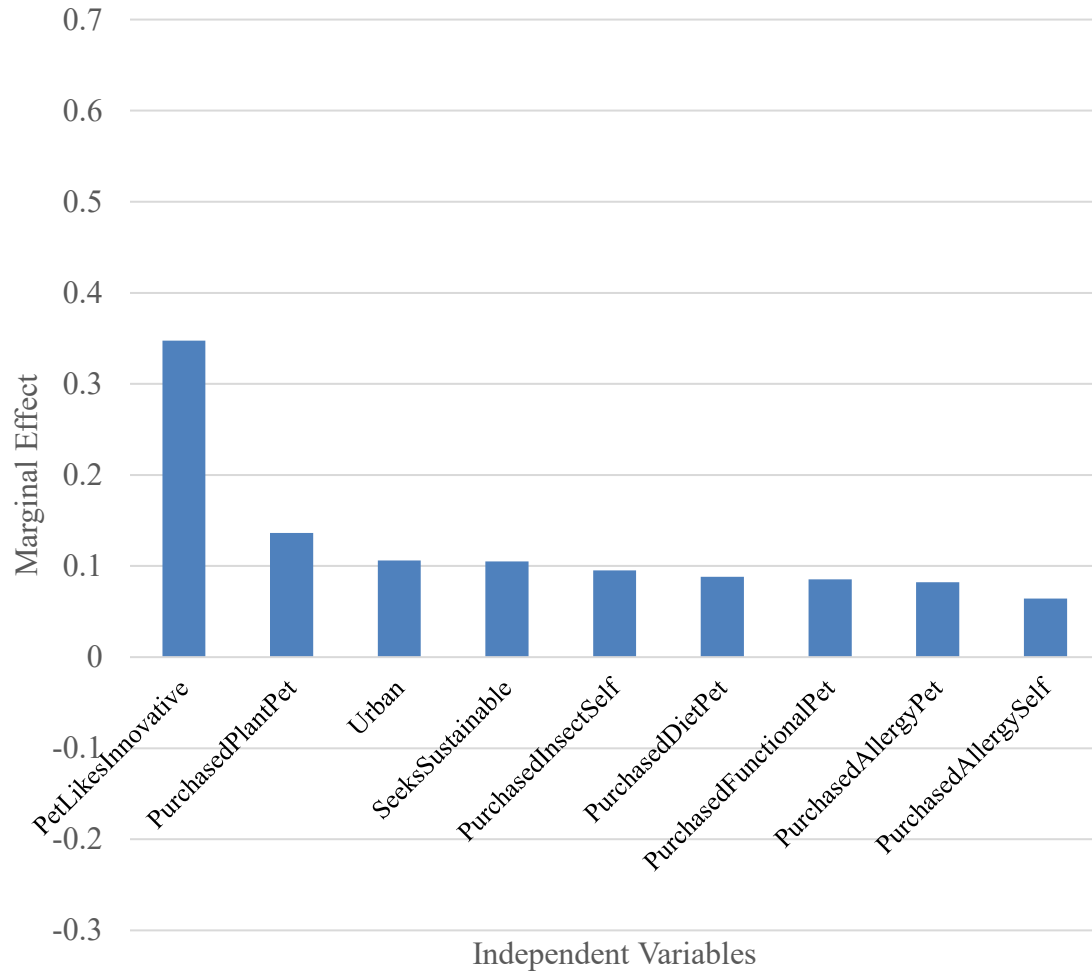
Table 6.2: Model Data from Logit Model of Current Buyers

Variable	β	P(Y=1)	ME	<i>p-value</i>	*
const	-3.8677			0.000	***
CatOwner	-0.8374	0.6601	-0.0817	0.091	*
DogOwner	-0.0965	0.7957	-0.0094	0.857	
MultiplePets	0.8455	0.6444	0.0824	0.080	*
SeeksSustainable	1.0783	0.5305	0.1051	0.002	***
PetLikesInnovative	1.3975	0.5206	0.1363	0.000	***
SeekingNutritious	-0.8859	0.8251	-0.0864	0.069	*
PetAllergies	0.0738	0.2829	0.0072	0.828	
LargeWellKnown	-0.2077	0.4047	-0.0203	0.570	
DoesntMatterSize	-0.4735	0.4008	-0.0462	0.238	
PurchasedPlantSelf	0.3507	0.4303	0.0342	0.282	
PurchasedPlantPet	1.2169	0.3497	0.1187	0.000	***
PurchasedInsectSelf	0.9751	0.1788	0.0951	0.010	**
PurchasedFunctionalSelf	-1.4217	0.7387	-0.1386	0.001	***
PurchasedFunctionalPet	0.8741	0.7564	0.0852	0.036	**
PurchasedAllergySelf	0.6580	0.7564	0.0642	0.038	**
PurchasedAllergyPet	0.8430	0.3438	0.0822	0.010	**
PurchasedDietSelf	0.6066	0.4637	0.0591	0.059	*
PurchasedDietPet	0.9042	0.4617	0.0882	0.004	***
HighSchoolorLess	-0.6750	0.2259	-0.0658	0.157	
SomeCollegeAssociates	-0.0771	0.3163	-0.0075	0.840	
PostGraduate	-0.5209	0.1650	-0.0508	0.231	
Under50k	0.6487	0.2829	0.0633	0.141	
50kto100k	-0.1555	0.3831	-0.0152	0.686	
150kandAbove	-0.4539	0.0786	-0.0443	0.436	
Urban	2.7086	0.3733	0.1060	0.001	***

Note: * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$

There were several independent variables that had a statistically significant correlation to the likelihood of being a current buyer. The magnitude of effect is a measure of the strength of the relationship between the independent and dependent variable. **Error! Reference source not found.** graphs the magnitude of effect of the statistically significant independent variables.

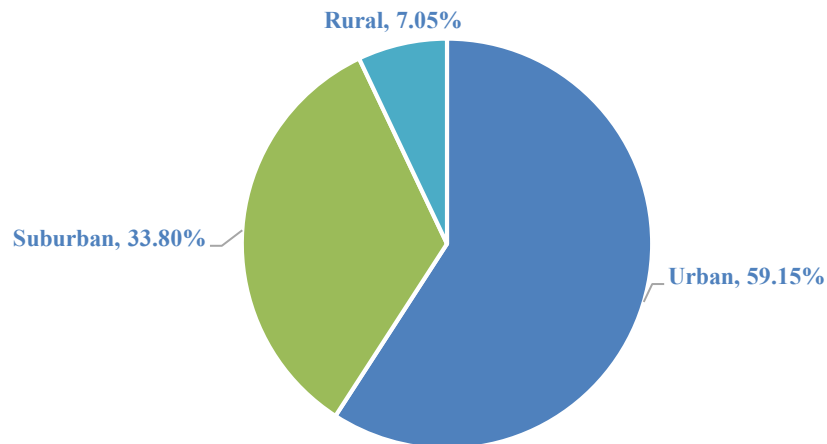
Figure 6.2: Magnitude of Effect for Statistically Significant Variables for Current Buyers



6.1.2 Urban Purchasers

59.15% of the subpopulation of survey respondents who have already purchased insect products for their pet, live in an urban community **Error! Reference source not found..**

Figure 6.3: Community Type of Insect-Based Pet Food Purchaser Subpopulation

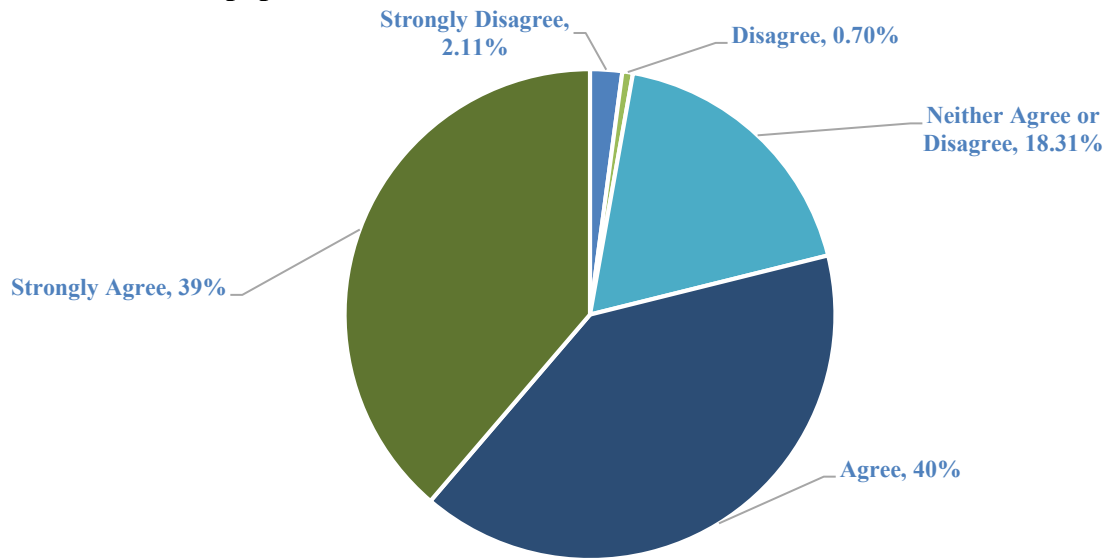


There is a statistically significant ($p\text{-value}_{\text{Urban}}=0.001$) positive correlation ($\beta_{\text{Urban}}=2.7086$) that consumers from urban communities are more likely to have previously purchased insect-based pet foods (Table). The data suggests that being from an urban community, is associated with an estimated 10.6 percentage point ($ME_{\text{Urban}}=0.1060$) increase in the probability of having purchased insect pet foods, compared being from rural or suburban communities, holding all other variables constant. This variable had the highest marginal effect and thus the largest magnitude of effect, shown in **Error! Reference source not found.**, suggesting the greatest impact on the probability of being a current buyer, compared to other independent variables reviewed. Thus, we reject the null hypothesis that there is no statistically significant relationship.

6.1.3 Environmental Seeking Purchasers

78.87% of the subpopulation of current purchasers reported that they agree (40.14%) or strongly agree (38.73%) that they seek out sustainable, environmentally friendly pet food (**Error! Reference source not found.**).

Figure 6.4: Responses to “I seek out sustainable, environmentally-friendly pet food” in Purchaser Subpopulation

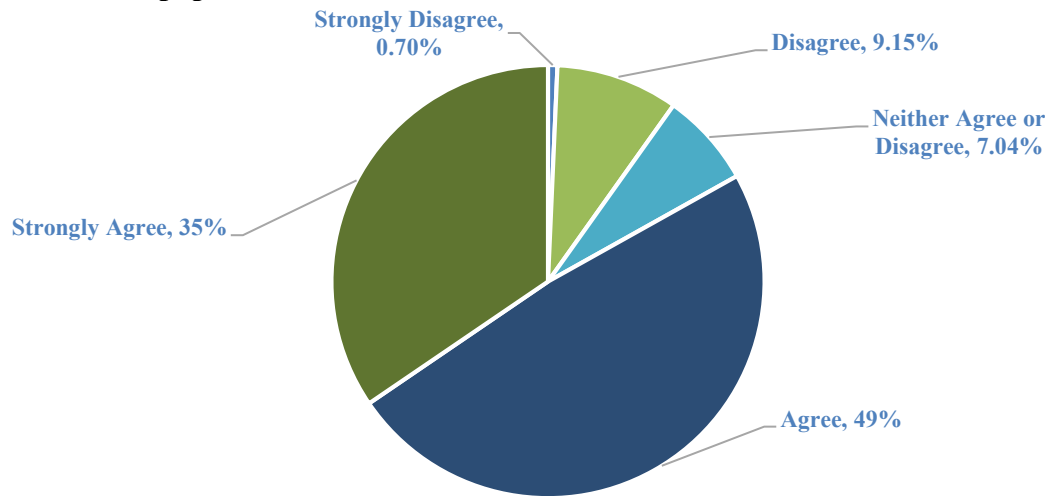


The logit model in Table suggests there is a statistically significant (p -value_{SeeksSustainable}=0.002) positive correlation (β _{SeeksSustainable}=1.0783) that consumers who seek out sustainable pet foods are more likely to have previously purchased insect-based pet foods. The data suggests that seeking sustainable pet foods, is associated with an estimated 10.51 percentage point increase (ME _{SeeksSustainable}=0.1051) in the probability of having purchased insect pet foods, compared to not seeking sustainable pet foods, holding all other variables constant. Thus, we reject the null hypothesis that there is no statistically significant relationship.

6.1.4 Innovation Seeking Purchasers

Upon reviewing the results of current buyers, 83.10% reported that they agree (48.59%) or strongly agree 34.51% that their pet likes innovative pet food products (**Error! Reference source not found.**).

Figure 6.5: Responses to “My pet likes to try new and innovative pet food options” for Purchaser Subpopulation

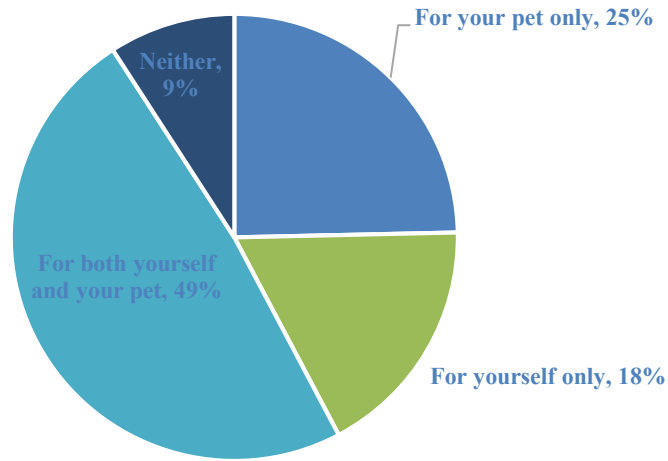


In the model, the independent variable “PetLikesInnovative” represents consumers who agree that their pet likes to try new and innovative pet food options. The logit model in Table , suggests a statistically significant ($p\text{-value}_{\text{PetLikeInnovative}}=0.000$) positive correlation ($\beta_{\text{PetLikeInnovative}}= 1.3975$) that consumers who believe their pet likes innovative products, will be a current purchaser of insect-based pet foods. The data suggests that believing your pet likes innovative pet foods, is associated with an estimated 13.63 percentage point increase ($ME_{\text{PetLikesInnovative}}=0.1363$) in the probability of having purchased insect pet foods, compared to disagreeing that your pet likes innovative products, holding all other variables constant. Thus, we reject the null hypothesis that there is no statistically significant relationship.

6.1.5 Plant Protein Purchasers

73.24% of current purchasers of insect protein reported they have purchased plant-based protein products for their pet only (25%) or for both themselves and their pet (49%).

Figure 6.6: Responses to "Which of the following types of products or products made with the following ingredients have you purchased for you or your pet? 'Plant-based protein" for Purchaser Subpopulation

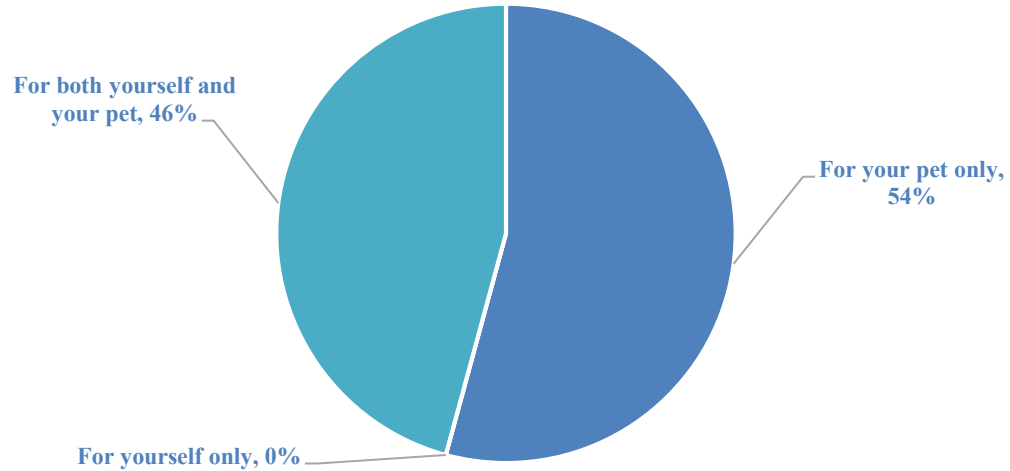


In the model, the independent variables “PurchasedPlantPet” represents the occurrence that pet owners have purchased plant protein products for their pet. The logit model in Table 6.2 suggests a statistically significant ($p\text{-value}_{\text{PurchasedPlantPet}} < 0.0001$) positive coefficient of ($\beta_{\text{PurchasedPlantPet}} = 1.2169$). The data suggests that having purchased plant-based food products for your pet, is associated with an estimated 11.87 percentage point increase ($ME_{\text{PurchasedPlantPet}} = 0.1187$) in the probability of having purchased insect pet foods, compared to having not purchased plant-based food products for their pet, holding all other variables constant. Thus, we reject the null hypothesis that there is no statistically significant relationship.

6.1.6 Human Insect Diet Purchasers

45.77% of current purchasers of insect protein reported they have purchased insect protein products for themselves and their pet. 0% of purchaser respondents reported that they had purchased insect protein for themselves only.

Figure 6.7: Responses to "Which of the following types of products or products made with the following ingredients have you purchased for you or your pet? Insect protein" for Purchaser Subpopulation

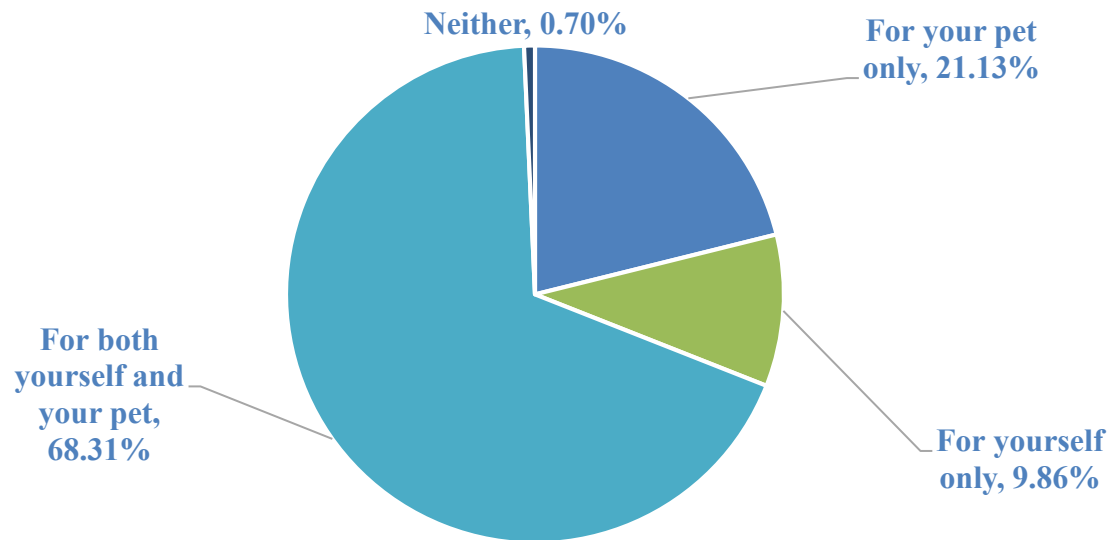


In the model, the independent variables “PurchasedInsectSelf” represents the occurrence that pet owners have purchased insect protein for themselves. The logit model in Table 6.2 suggests a statistically significant ($p\text{-value}_{\text{PurchasedInsectSelf}}=0.010$) positive coefficient of ($\beta_{\text{PurchasedInsectSelf}}=0.9751$). The data suggests that being having purchased insect food products for yourself is associated with an estimated 9.51 percentage point increase ($ME_{\text{PurchasedInsectSelf}}=0.0951$) in the probability of having purchased insect pet foods, compared to not having purchased insect-based food products for yourself, holding all other variables constant. Thus, we reject the null hypothesis that there is no statistically significant relationship.

6.1.7 Functional Health Purchasers

89.44% of current purchasers of insect protein reported they have purchased functional pet foods for their pet only (21.13%) or for themselves and their pet (68.31%) (Figure).

Figure 6.8: Responses to “Which of the following types of products or products made with the following ingredients have you purchased for you or your pet? Functional foods (with health benefits)” for Purchaser Subpopulation

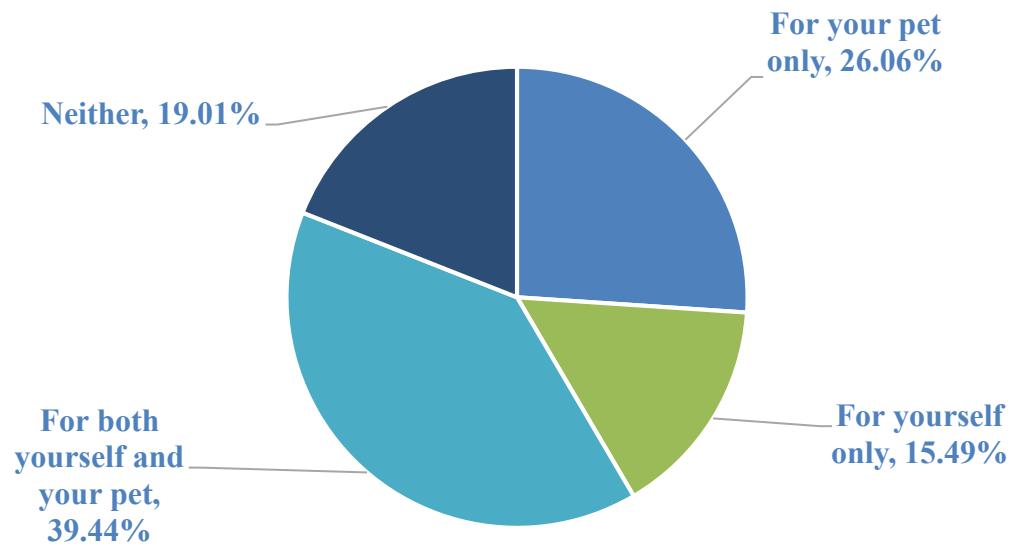


In the model, the independent variables “PurchasedFunctionalPet represents the occurrence that pet owners have purchased functional foods with health benefits for their pets. The logit model in Table 6.2 suggests a statistically significant (p -value_{PurchasedFunctionalPet}=0.036) positive correlation ($\beta_{\text{PurchasedFunctionalPet}}$ =0.8741) that consumers who have purchased functional pet food products are more likely to have previously purchased insect-based pet foods. The data suggests that being having purchased functional pet foods, is associated with an estimated 8.52 percentage point increase ($ME_{\text{PurchasedFunctionalPet}}$ =0.0852) in the probability of having purchased insect pet foods, compared to not having purchased functional pet foods, holding all other variables constant. Thus, we reject the null hypothesis that there is no statistically significant relationship.

6.1.8 Allergy Purchasers

65.49% of current purchasers of insect protein reported they have purchased allergy specific foods for their pet only (26.06%) or for themselves and their pet (39.44%). 54.93% of current purchasers reported they have purchased allergy specific foods for themselves only (15.49%) or themselves and their pet (39.44%).

Figure 6.9: Responses to “Which of the following types of products or products made with the following ingredients have you purchased for you or your pet? Allergy specific foods (for example: gluten-free, soy-free) for Purchaser Subpopulation



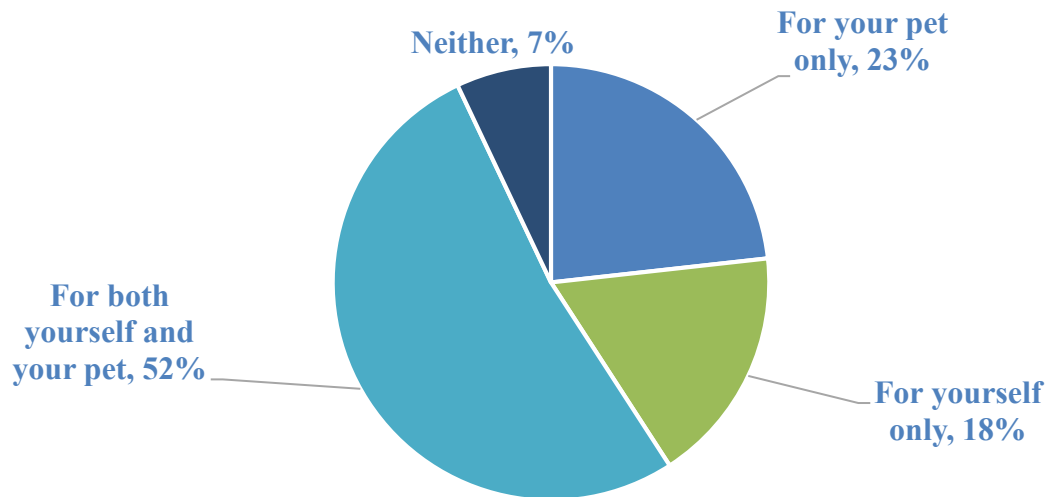
The logit model in Table 6.2 suggests a statistically significant (p -value_{PurchasedAllergySelf}=0.0038) positive correlation (β _{PurchasedAllergySelf}=0.6580) that consumers who have purchased allergy specific pet foods are more likely to have previously purchased insect-based pet foods. The data suggests having purchased allergy specific foods, is associated with an estimated 6.42 percentage point increase (ME _{PurchasedAllergySelf}=0.0642) in the probability of having purchased insect pet foods, compared to not having purchased allergy specific foods, holding all other variables constant. Thus, we reject the null hypothesis that there is no statistically significant relationship.

There is a statistically significant ($p\text{-value}_{\text{PurchasedAllergyPet}}=0.010$) positive correlation ($\beta_{\text{PurchasedAllergyPet}}=0.8430$) that consumers who have purchased allergy specific pet foods are more likely to have previously purchased insect-based pet foods. The data suggests having purchased hypoallergenic pet foods, is associated with an estimated 8.22 percentage point increase ($\text{ME}_{\text{PurchasedAllergyPet}}=0.0822$) in the probability of having purchased insect pet foods, compared to not having purchased hypoallergenic pet foods, holding all other variables constant. Thus, we reject the null hypothesis that there is no statistically significant relationship.

6.1.9 Purchasers of Diet Pet Foods

75.35% of current purchasers of insect protein reported they have purchased diet specific foods for their pet only (23.24%) or themselves and their pet (52.11%).

Figure 6.10: Responses to “Which of the following types of products or products made with the following ingredients have you purchased for you or your pet? Diet specific foods (for example: weight management)” for Purchaser Subpopulation



The logit model in Table 6.2 suggests there is a statistically significant ($p\text{-value}_{\text{OPurchasedDietPet}}=0.0054$) positive correlation ($\beta_{\text{PurchasedDietPet}}=0.2196$) that consumers who

have purchased diet-specific pet foods are more likely to have previously purchased insect-based pet foods. The data suggests that having purchased diet pet foods, is associated with an estimated 21.96 percentage point increase ($ME_{\text{PurchasedDietPet}}=0.2196$) in the probability of having purchased insect pet foods with a one-unit increase compared to not having purchased diet pet foods, holding all other variables constant. Thus, we reject the null hypothesis that there is no statistically significant relationship.

6.2 Objective Two: Must Haves for Insect Protein Marketing

The second main objective of this research is to understand which attributes of pet food marketing and consumer education will be most helpful in promoting products within the industry. Survey respondents were asked “If you were buying pet food made with insect protein, please sort the following into groups of those that are “must haves,” “nice to have,” and “don’t matter.” Categories consisted of various aspects that a pet food brand could market in the insect-based pet foods such as environmentally friendly, and nutritionally superior. Responses to these questions can help determine which key features are most important to U.S. dog and cat owners.

After the question about which attributes were a “must have” for each consumer, they were asked “If a pet food made with insect protein met all your “must haves”, would this change your likelihood of feeding it to your pet?” 17.88% claimed they were very much more likely to purchase insect pet food if their must haves were met. For the case of this research, those who reported that they were very much more likely to purchase insect-based pet foods if all their must haves were met are considered a subpopulation of potential buyers with must haves.

Figure 6.11: Responses to “If you were buying pet food made with insect protein, please sort the following into groups of those that are “must haves”, “nice to have”, and “don’t matter”

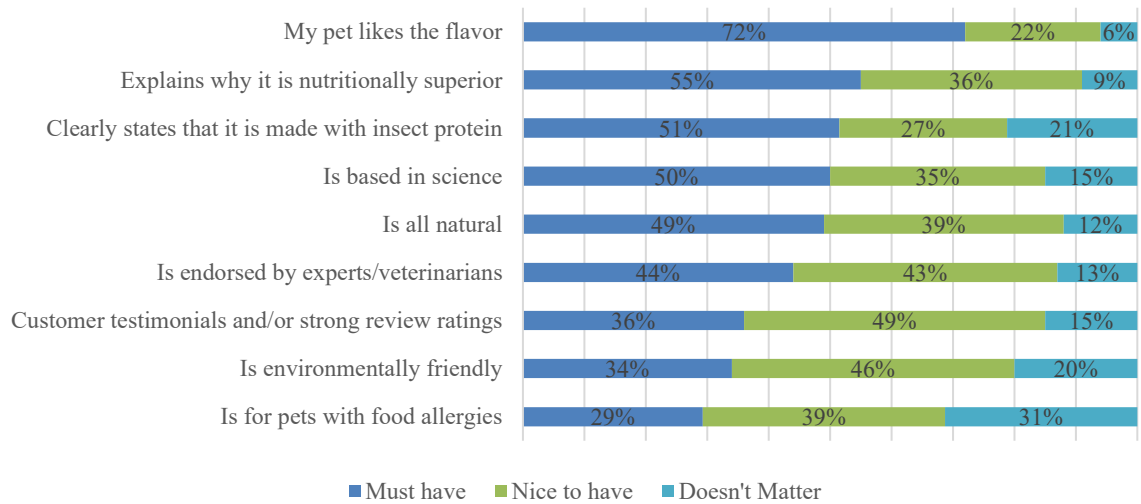
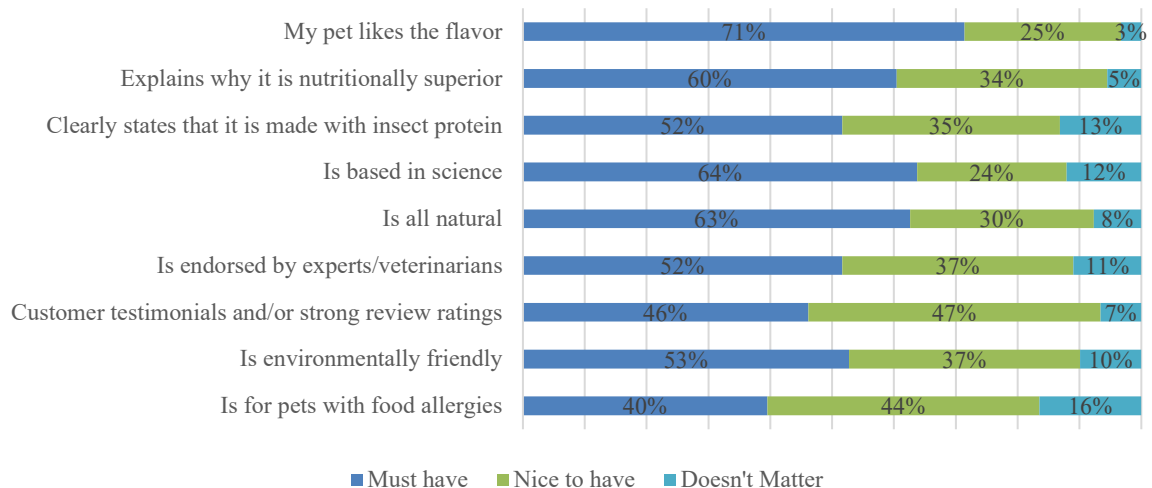


Figure 6.12: Responses to “If you were buying pet food made with insect protein, please sort the following into groups of those that are “must haves”, “nice to have”, and “don’t matter” For Potential Buyer Subpopulation



6.2.1 Potential Purchasers with Must Haves Subpopulation

Each attribute in the must-haves section of the survey was fit into a logistic regression model to analyze the potential correlation between their must haves being met and their likelihood to purchase insect proteins for their pet if their must haves were met.

Consumer responses for attributes that were a “must have” were correlated to a binary independent variable of $Y=1$ if it was a “must have” for them and $Y=0$ if it was not a must have. The goal is to analyze which “must haves” may increase the likelihood of a potential purchaser of to be very much more likely to consider insect-based pet foods. All 509 respondents were included.

The theory in this logistic regression model is to determine which attributes that consumers require on their insect pet food are statistically correlated to their likelihood of being very much more likely to purchase. This can determine what consumer requirements are important to them, if present in insect pet food, increase their likelihood of being a potential buyer.

The null hypothesis for all independent variables in this logit model is that the coefficient of each independent variable is equal to zero. If any of the independent variables have a p-value less than .05, we would reject the null hypothesis, thus suggesting that there is a statistically significant relationship between the independent variables and the dependent variable.

This model had a pseudo R-squared value of 0.058. This suggests that the model has an explanatory power of approximately 5.8% of the variance in the dependent variable. This suggests a relatively weak ability to predict the outcome of the dependent variable.

Table 6.3: Variables in Logit Model of Potential Buyers

Variable	Definition
<i>const</i>	Binary value of Y=1 for survey respondents who when asked "If a pet food made with insect protein met all of your "must haves", would this change your likelihood of feeding it to your pet? "reported "very much more likely,"
MustHave AllNatural	Is all natural
MustHaveEnviro	Is environmentally friendly
MustHaveNutritionally Superior	Explains why it is nutritionally superior
MustHaveForAllergies	Is for pets with food allergies
MustHaveTestimonials	Customer testimonials and/or strong review ratings
MustHaveVetEndorsement	Is endorsed by experts/veterinarians
MustHave Science	Is based in science
MustHave ClearInsect	Clearly states that it is made with insect protein
MustHavePetLikesFlavor	My pet likes the flavor

**Note: All independent variables have a binary value of Y=1 for survey respondents who when asked "If you were buying pet food made with insect protein, please sort the following into groups of those that are "must haves", "nice to have", and "don't matter" reported "must have" for the definition attribute. Each variable has a value of Y=0 is responded "nice to have" or "doesn't matter".*

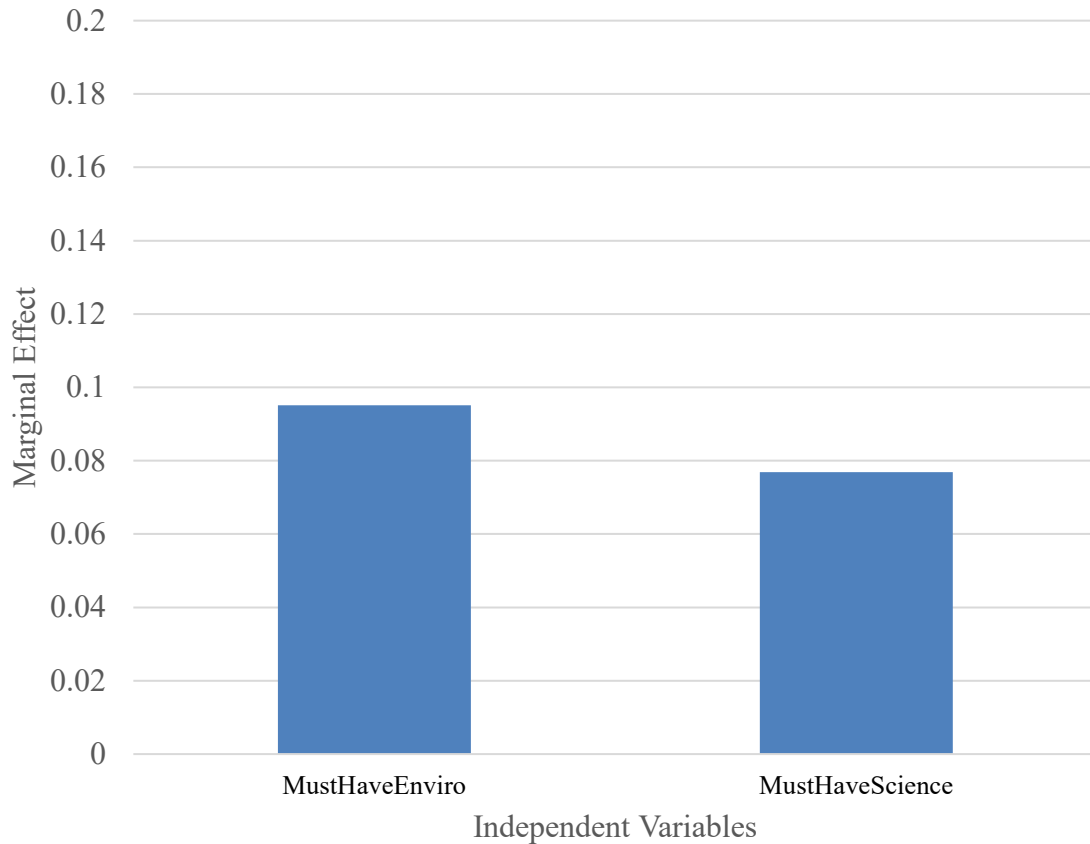
Table 6.4: Data from Logit Model of Potential Buyers

Variable	β	P(Y=1)	ME	<i>p-value</i>	*
<i>const</i>	-2.1855			0.0000	***
MustHaveAllNatural	0.3545	0.4912	0.0491	0.1820	
MustHaveEnviro	0.6873	0.3360	0.0951	0.0100	***
MustHaveNutritionallySuperior	-0.0439	0.5481	-0.0061	0.8750	
MustHaveForAllergies	0.3135	0.2927	0.0434	0.2310	
MustHaveTestimonials	0.3039	0.3615	0.0421	0.2570	
MustHaveVetEndorsement	-0.0986	0.4361	-0.0137	0.7240	
MustHaveScience	0.5555	0.5029	0.0769	0.0460	**
MustHaveClearInsect	-0.3224	0.5147	-0.0446	0.2100	
MustHavePetLikesFlavor	-0.1509	0.7230	-0.0209	0.5940	

Note: * $p < 0.10$, **= $p < .05$, and *= $p < .01$*

The magnitude of effect is illustrated for the two statistically significant variable's marginal effects.

Figure 6.13: Magnitude of Effect for Statistically Significant Variables of Potential Buyers



6.2.2 Environmentally Friendly Potential Buyer

52.75% of the potential buyer subpopulation reported that insect protein that “is environmentally friendly” is a “must have” for them when considering purchasing insect-based pet food.

There is a statistically significant ($p\text{-value}_{\text{MustHaveEnviro}}=0.0097$) positive correlation ($\beta_{\text{MustHaveEnviro}}=0.6873$) that consumers who consider environmentally friendly a must have for insect pet foods are more likely to be a potential buyer. The model suggests that on average, there is a 15.33 ($\text{ME}_{\text{MustHaveEnviro}}=0.1533$) percentage point increase in the probability of being a potential buyer occurring per one unit change in responding being environmentally friendly a must have for insect pet foods. Thus, we reject the null hypothesis that there is no statistically significant relationship.

6.2.3 Science-Based Potential Buyer

63.74% of the potential buyer subpopulation reported that insect protein that “is based in science” is a “must have” for them when considering purchasing insect-based pet food.

In the Table 6.3 model, the independent variables “MustHaveScience” represents the occurrence respondents reported they must have science-based insect-based pet foods. The model shows a statistically significant ($p\text{-value}_{\text{MustHaveScience}}=0.0457$) positive coefficient of ($\beta_{\text{MustHaveScience}}=.5555$). The model suggests that on average, there is a 13.89 ($ME_{\text{MustHaveScience}}=0.1389$) percentage point increase in the probability of being a potential buyer occurring per one unit change in responding that science-based is a must have for insect pet foods. Thus, we reject the null hypothesis that there is no statistically significant relationship.

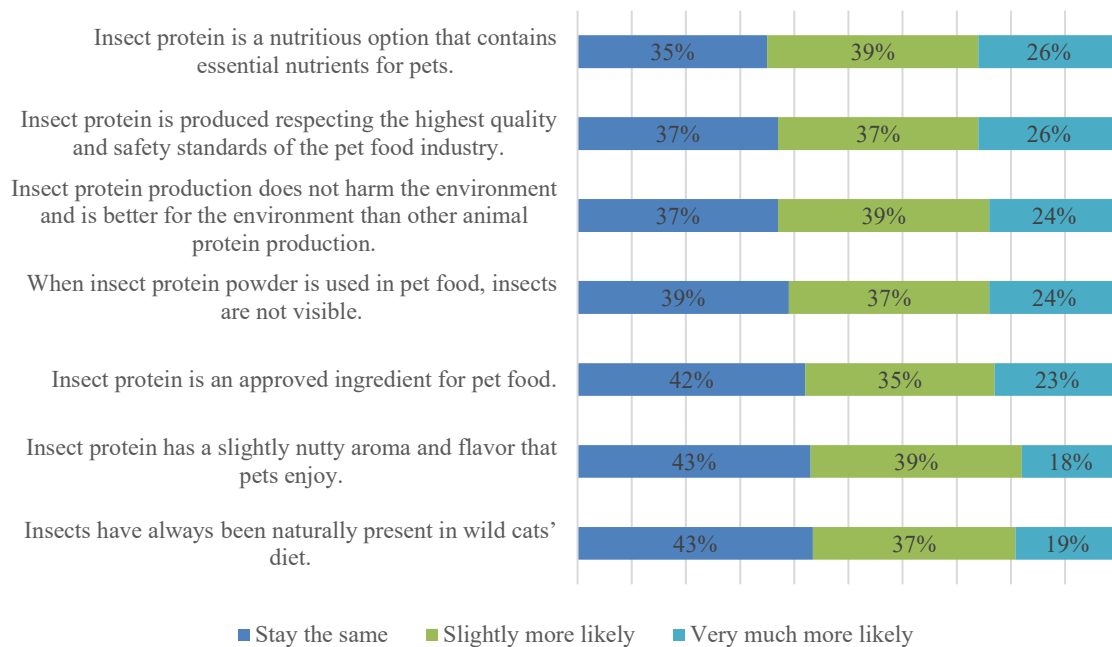
6.3 Objective Three: Which Facts Increase Comfortability

There appears to be an existing “ick-factor” when consumers are considering feeding insect proteins to their pets. A lack of eating insects in the human diet of U.S. culture leads to uncertainty of several key facts about insect proteins. The third and final objective of this research was to determine if consumers could be persuaded into being more comfortable purchasing insect-based pet foods with education on insect protein facts.

In this portion of the survey, consumers were given several facts about insect protein and asked if learning this made them slightly more likely or very much more likely to purchase insect pet foods or if they stayed the same. Facts included positive education about insects such as being nutritious, approved for use in pet foods, and having a pleasant flavor for pets. The goal is to review which facts made consumers very much more likely to purchase insect proteins.

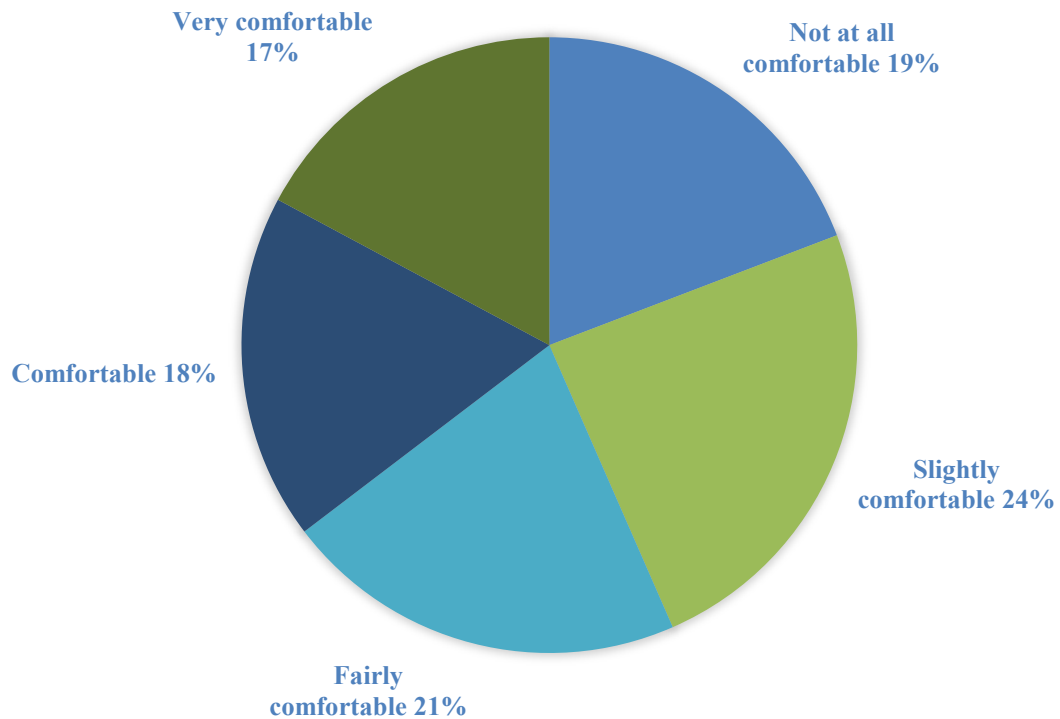
In Figure 6.14, the total survey populations responses to which facts made them more likely to purchase pet foods is graphed. The highest percentage of respondents (26%) reported that they were very much more likely to purchase, after learning about insect nutrition and production quality.

Figure 6.14: Responses to “For each fact, would this make you more likely to feed pet food made with insect protein to your pet?” For Total Survey Population



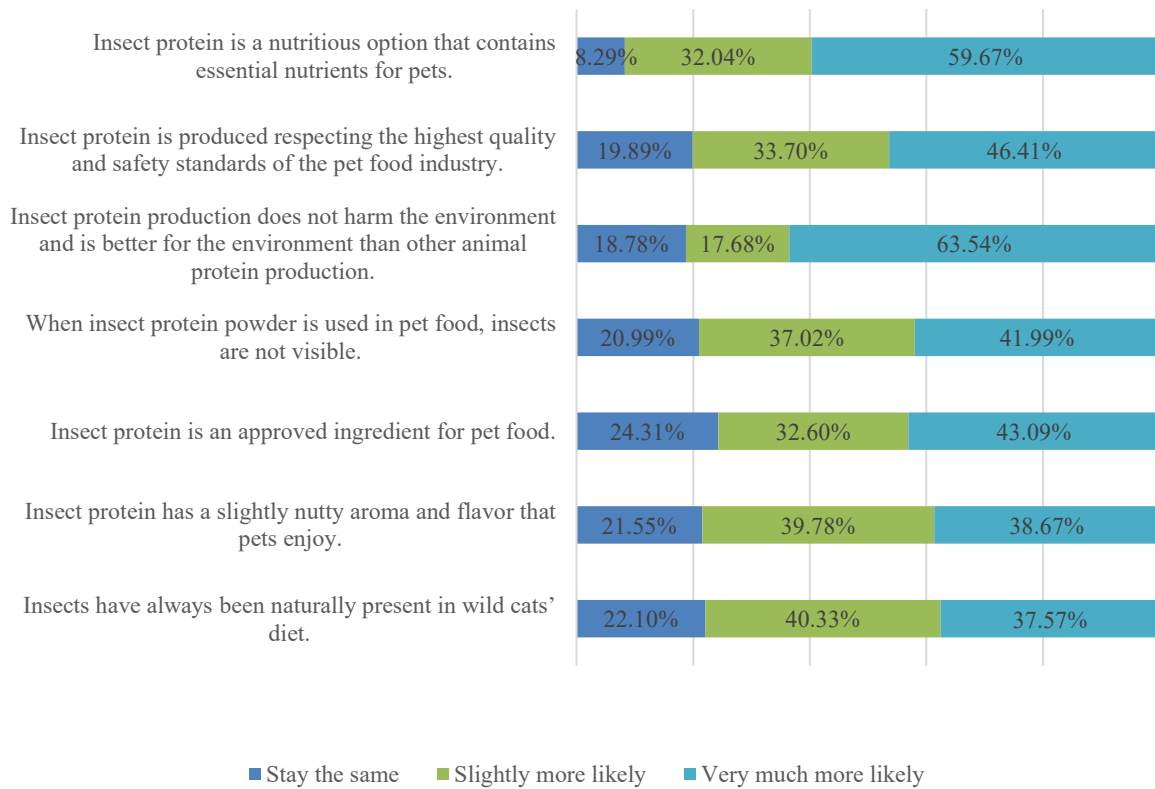
After a series of facts were given, respondents were asked if “these facts given [them] enough knowledge to feel comfortable with insect protein in pet food?” and given a categorical response of “not at all comfortable” to “very comfortable”. 35% of respondents became comfortable (18%) or very comfortable (17%) after education. This subpopulation is coined “Comfortable” for future references.

Figure 6.15: Comfortability after Facts



The Comfortable subpopulation had higher percentage responses to facts that made them very much more likely to feed their pet food made with insect protein. From highest percentage, 63.54% of comfortable consumers were very much more likely to purchase after learning insect protein was better for the environment than animal proteins (compared to 24% of total survey population). 59.67% were more likely after learning about the nutrition of insect protein (compared to 26% of the total population).

Figure 6.16: Responses to “For each fact, would this make you more likely to feed pet food made with insect protein to your pet?” For Comfortable Subpopulation



6.3.1 Logit Modeling of Comfortable Subpopulation

The occurrence of being in the subpopulation “comfortable” was used as the dependent variable for the binary a categorical logistic regression model. The independent variables of the model are the facts given to the survey takers that they reported made them very much more likely to purchase insect pet foods. The goal is to determine which facts about insect proteins that consumers reported made them very much more likely to purchase, makes consumers statistically more likely to become comfortable with feeding insect proteins for their pets. Only non-purchasers were included in this model.

The theory behind this model is that consumers were educated through the survey questions about insect proteins. The facts that consumers reported made them very much more likely to purchase insect proteins are the facts that had the most impact on the

consumer. After this section of the survey, those who reported they were comfortable were educated by the independent variables. If the consumer was persuaded to being very much more likely to purchase from a fact, and then became comfortable with purchasing, the magnitude of correlation between that positive response to the fact and their decision to be comfortable. The null hypothesis for all independent variables in this logit model is that the coefficient of each independent variable is equal to zero. Thus, there is no statistically significant relationship between the predictor independent variables and the dependent variable.

This model had a pseudo R-squared value of 0.1747. This suggests that the model has an explanatory power of approximately 17.47% of the variance in the dependent. This indicated a moderate goodness of fit and ability to predict the dependent variable.

Table 6.5: Variables in Logit Model of Comfortable Consumers

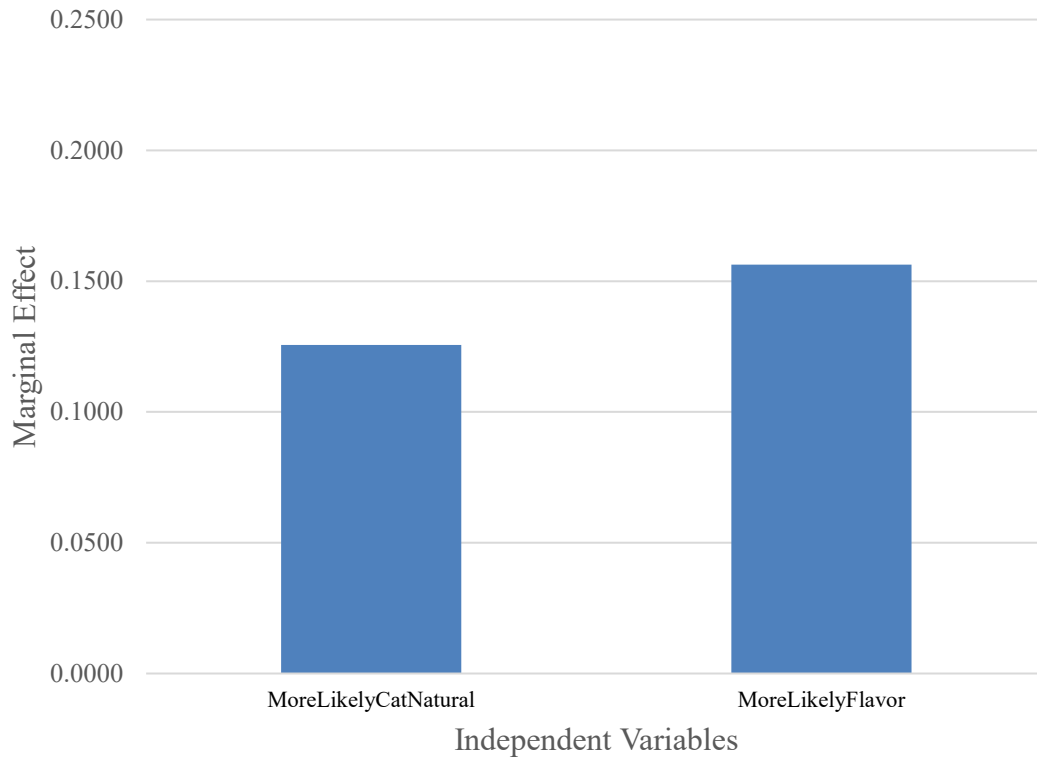
Variable	Definition Group
const	Binary value of Y=1 when survey respondents were asked "Have these facts given you enough knowledge to feel comfortable with insect protein in pet food?"
MoreLikelyNotVisable	When insect protein powder is used in pet food, insects are not visible.
MoreLikelyFlavor	When insect protein powder is used in pet food, insects are not visible.
MoreLikelyCatNatural	Insects have always been naturally present in wild cats' diet.
MoreLikelyQuality	Insect protein is produced respecting the highest quality and safety standards of the pet food industry.
MoreLikelyBetterforEnv	Insect protein production does not harm the environment and is better for the environment than other animal protein production.
MoreLikelyApproved	Insect protein is an approved ingredient for pet food.
MoreLikelyNutritious	Insect protein is a nutritious option that contains essential nutrients for pets.

Note: Independent variables have a binary value of Y=1 when they responded "very much more likely" when asked the definition question and a binary value of Y=0 if they reported "slightly more likely" or "stay the same."

Table 1.6: Data from Logit Model of Comfortable Consumers

Variable	β	P(Y=1)	ME	<i>p-value</i>	*
const	-3.1222			<0.0001	***
MoreLikelyNotVisable	0.3196	0.6071	0.0494	0.379	
MoreLikelyFlavor	1.0105	0.5737	0.1563	0.007	***
MoreLikelyCatNatural	0.8121	0.5658	0.1256	0.011	***
MoreLikelyQuality	-0.5098	0.6306	-0.0789	0.204	
MoreLikelyBetterforEnv	0.4794	0.6287	0.0742	0.247	
MoreLikelyApproved	0.5312	0.5835	0.0822	0.169	
MoreLikelyNutritious	0.4753	0.6503	0.0735	0.236	*

Note: * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$

Figure 6.17: Magnitude of Effect for Statistically Significant Variables on Comfortable Consumers

6.3.2 Flavor Education Increases Comfortability

The model in Table 1 suggests there is a statistically significant (p -value_{MoreLikelyFlavor}=0.007) positive correlation (β _{MoreLikelyFlavorFlavor}=1.0105) that consumers who were persuaded by aroma and flavor education are more likely to be comfortable with feeding insect ingredients. The model suggests that on average, there is a 15.63

($ME_{MoreLikelyFlavor}=0.1563$) percentage point increase in the probability of feeling comfortable when reporting flavor education made them very more likely to purchase.

Thus, we reject the null hypothesis that there is no statistically significant relationship.

6.3.3 Wild Cat Education Increases Comfortability

The model in Table 1 suggests there is a statistically significant (p -value $_{MoreLikelyCatNatural}=0.011$) positive correlation ($\beta_{MoreLikelyCatNatural}=0.8121$) that consumers who are very likely to be pursued with wild cat diet education are more likely to be comfortable. The model suggests that on average, there is a 12.56

($ME_{MoreLikelyCatNatural}=0.1256$) percentage point increase in the probability of feeling comfortable per one unit change in responding that learning about insects in wild cat diets would make the consumer very much more likely to consider purchasing insect pet foods. Thus, we reject the null hypothesis that there is no statistically significant relationship.

CHAPTER VII: RESULTS & DISCUSSION

7.1 Discussion of Swayed Population

In this consumer survey, the main goal was to see what information could educate consumers who were hesitant to purchase insect-based pet foods into being potential buyers. The goal of this portion of the survey was to identify what hurdles consumers need to be educated to overcome, to be more likely to purchase insect-based pet foods. Questions were designed to help understand what is important to potential consumers of insect-based pet foods to clarify the best characteristics to market on product packaging and marketing content.

In order to study this, respondents were asked early in the survey “How likely are you to feed your pet food made with insect protein?” Then, after several survey questions that included educational information on the safety, quality, and sustainability of insect ingredients, respondents were asked “Based on all that you've learned from this survey, how likely are you now to feed your pet food made with insect protein?”

Figure 7.1: Responses to Question 5. “How likely are you to feed your pet food made with insect protein?”

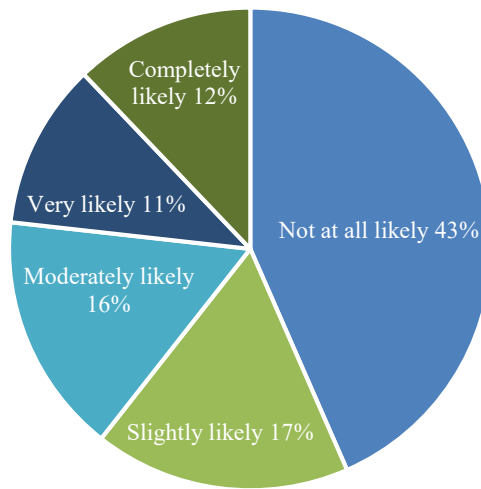
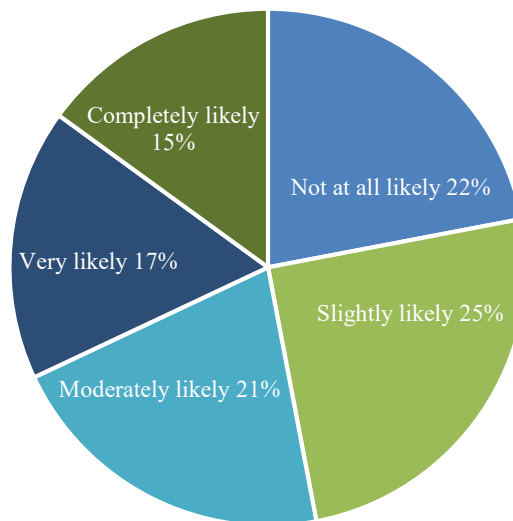


Figure 7.2: Responses to Question 12. “Based on all that you've learned from this survey, how likely are you now to feed your pet food made with insect protein?”

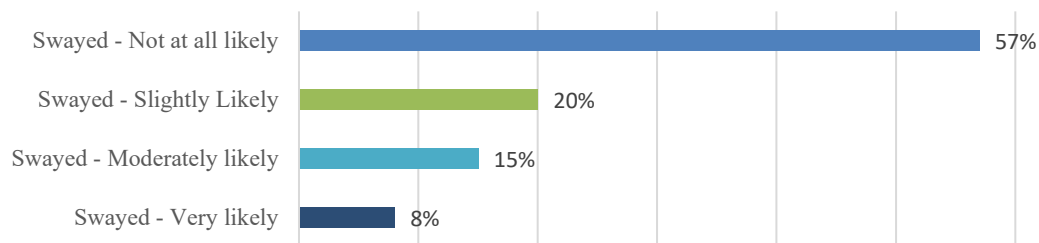


42% of respondents originally answered “Not likely at all” in question 5, while that dropped to 22% of respondents in question 12. People who increased their likelihood to purchase after the education in the survey are coined a subpopulation called “swayed”.

Table 2.1: Swayed Subpopulation Summary

	Total 100%	Swayed- Subpopulation 100%	How likely are you to feed your pet food made with insect protein? - How likely are you to feed your pet food made with insect protein?				
			Not at all likely 100% A	Slightly likely 100% *B	Moderately likely 100% *C	Very likely 100% *D	Completely likely 100% *E
Not at all likely	22%	0%	45% B, C, D, E	9% C, D	1%	0%	3%
Slightly likely	25%	33%	32% C, D, E	41% C, D, E	20% E	9% E	0%
Moderately likely	21%	31%	16% E	34% A, D, E	40% A, D, E	12%	5%
Very likely	17%	20%	5%	11% A	28% A, B	47% A, B, C, E	23% A
Completely likely	15%	16%	2%	3%	11% A	32% A, B, C	69% A, B, C, D

In *Table 2* the green boxes represent the “Swayed” subpopulation. 32% of those who originally answered they were not at all likely to purchase pet food made with insects, become slightly likely after education. Among those who improved their likelihood to purchase pet food made from insects, 57% of the “swayed” subpopulation began by saying they are not at all likely and by the end of the survey were at least slightly likely.

Figure 7.3: Original Likelihood to Purchase Insect Pet Food of “Swayed” Subpopulation

Overall, a review of the swayed subpopulation suggests that consumers can be educated into being potential purchasers. Now that we understand this, we can review which factors encourage potential purchasing to determine the best marketing strategies to grow this market share. In this research, we review factors about who the consumers are themselves, what they seek in an insect pet food, and what facts educate them enough to feel comfortable to purchase insect pet foods.

7.2 Environmental Sustainability

One of the most interesting aspects of insect proteins is the ability to sustainably produce it. Academic literature showed insect proteins could be a sustainable solution to feeding companion animals while limiting environmental impact.

In objective one, there is a statistically significant increase in the probability of being a current purchaser, compared to not seeking sustainable pet foods. 78.87% of the subpopulation of current purchasers reported that they agree or strongly agree that they seek out sustainable, environmentally friendly pet food. In objective two, there is a statistically significant increase in the probability of being a potential buyer, compared to not considering environmentally friendly a must have. 52.75% of the potential buyer subpopulation reported that insect protein that “is environmentally friendly” is a “must have” for them when considering purchasing insect-based pet food.

Data from this research suggests that marketing a pet food for its environmental sustainability is imperative to the success of products in the market. The target population of current product triers and potential purchasing consumers is seeking out sustainable pet foods. This suggests that marketing that focuses on the sustainability of insect-based pet foods may be extra effective in influencing the target audience.

7.3 Urban Target Market

Urban consumers are more likely to be current purchase of insect pet foods. In objective one, there is a statistically significant increase in the probability of having purchased insect pet foods, compared being from rural or suburban. In academic literature, those living in urban communities or more densely populated regions, were more likely to be accepting of entomophagy (Kroger, et al. 2022). With the humanization of pets in Western culture, the survey aimed to see if the increased likelihood of eating insects would translate to feeding insects to pets. The target market of insect-based pet foods may be from urban communities. Focused physical marketing (like billboards) and targeted social media campaigns towards urban communities may be more successful than marketing to suburban and rural consumers. Additionally, advertisements that center pets living in urban spaces may resonate more with the target audience.

7.4 Innovation Advantage

Insect proteins are just starting to be used in pet foods within the past ten years. To defend against consumer skepticism, marketing that focuses on the innovation of insect ingredients may be effective. Insect proteins are a relatively new novel protein to the pet food market with the first pet food product launching in 2015 (Beynen, 2018). Consumers who are more likely to try new and innovative pet foods, may be early to the adopters and have already tried insect-based pet foods. Insect production is a very innovative practice, with innovative production models like Innovafeed's Industrial Symbiosis model (Phl, 2020). In objective one, there is a statistically significant increase in the probability of having purchased insect pet foods, compared to disagreeing. Since consumers who sought out innovative products were more likely to be current purchasers, marketing the

innovation of pet food products and insect proteins themselves may be effective in marketing campaigns.

7.5 Alternative Protein Focus

Insect proteins fall into a category of alternative proteins meaning they are not conventional meat proteins. Plant proteins are also considered an alternative protein. In objective one, there is a statistically significant increase in the probability of having purchased insect pet foods.

In the human food industry, there is an increasing trend of eating more sustainable proteins (Aschemann-Witzel, et al., 2020). This includes a growing diet trend of flexitarian and semi-vegetarian. Insect proteins, while not vegan, are an alternative to traditional proteins. Many people who are vegan, vegetarian, or flexitarian are motivated by wanting to decrease their environmental impact. Because insect proteins are such a sustainable alternative to traditional meats, the target market could follow this trend. Promoting the decrease in environmental impact of insects may correlate to this trend. Marketing that focuses on same values as plant-based and alternative proteins promotions, could be successful in capturing sales for the target market.

7.6 Co-Marketing of Pet and Human Food Products

97% of Americans consider their pets as part of their family and 51% of pet owners consider their pets as much a part of their family as a human member (Brown, 2023). Because of this, U.S. consumers tend to purchase pet foods that relate to their consumption including diets marketed as “chicken and sweet potato” and other humanized flavor profiles. In cultures where people do not consume insects, there is neophobia and significant aversion to insect-based pet foods (Fantechi, et al., 2024). Consumers who have tried insect ingredients for themselves may be more likely to consider purchasing it for

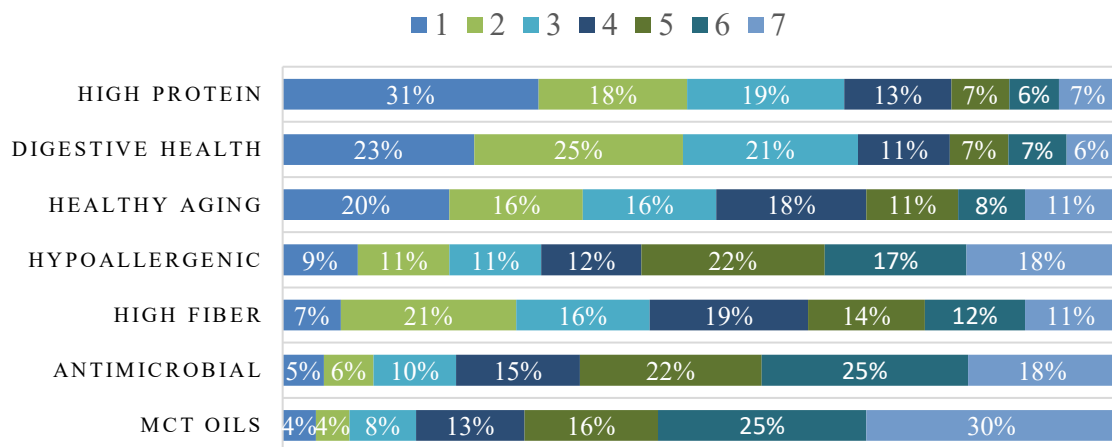
their pets. In objective one, there is a statistically significant increase in the probability of having purchased insect pet foods, for consumers who have tried insect ingredients themselves. In the survey responses, 0% of survey respondents indicated that they had eaten insect products themselves and not fed to their pet. This suggests there is a strong connection with consumers being more likely to feed to their pet, if they eat themselves. One potential way to harness this knowledge, would be to co-market human snacks and dog treats. Using the same brand of licensing could translate purchasers of insect-based foods for themselves to also purchase for their pet.

7.7 Functional Health Benefits

There are several potential additional functional health benefits of insect ingredients that extend beyond the basic nutritional requirements for dog and cat diets. In objective one, there is a statistically significant increase in the probability of having purchased insect pet foods, when purchasing functional foods for their pet. 89.44% of current purchasers of insect protein reported they have purchased functional pet foods for their pet only (21.13%) or for themselves and their pet (68.31%)

In the survey, consumers were asked to rank several functional health benefits of insect proteins and asked to rank them from the most (1) to least important (7) health benefits.

Figure 7.4: Responses to “If you were buying pet food made with insect protein, please rank the following health benefits in order of importance to you. 1 = most important and 7 = least important”



Functional benefits of insect proteins include anti-inflammatory and antioxidant properties, supported skin health, and added prebiotic fiber (Lani, 2022). Consumers who seek out functional food products for their pet, may be more aware of or more susceptible to the marketing of the functional benefits of insect proteins for pet.

7.8 Allergy Solution

Insect proteins show potential as a hypoallergenic solution for dogs and cats with food sensitivities (Beynen, 2018). Eight out of the twelve initial insect pet foods in Europe were marketed as hypoallergenic (Beynen, 2018). In objective one, there is a statistically significant increase in the probability of having purchased insect pet foods, when having purchased allergy specific foods. Additionally, there is a statistically significant increase the probability of having purchased insect pet foods, when having purchased hypoallergenic pet foods. 65.49% of current purchasers of insect protein reported they have purchased allergy specific foods for their pet only (26.06%) or for themselves and their pet (39.44%). Developing pet foods that specifically target reducing immune response for food sensitivities, utilizing insect protein, may be an effective market strategy.

7.9 Science-Based

Insect proteins are a relatively new ingredient in pet food and consumers may be concerned with the nutritional and safety science around the new ingredient. In section two, there is a statistically significant increase in the probability of being a potential buyer occurring if science-based is a must have for insect pet foods. 63.74% of the potential buyer subpopulation reported that insect protein that “is based in science” is a “must have” for them when considering purchasing insect-based pet food. Consumers who are concerned and educated on the science of pet nutrition may be more skeptical of a new ingredient and require scientific validation of health benefits before consuming. If their pet food did address scientific validity, they may be more likely to purchase. Marketing education that focuses on the science behind insect protein may help consumers feel more comfortable feeding it to their pet.

7.10 Flavor Education

Palatability is vital to ensure pets consume their nutrition. Because western cultures do not practice entomophagy, they may not be aware of the aroma and flavor profile of insect ingredients and have concerns that their pet would like to eat it. Therefore, learning that insects have a pleasant aroma and flavor may make consumers feel more comfortable feeding it to their pet.

In objective three, there is a statistically significant increase in the probability of being a potential buyer occurring when responding “my pet likes the flavor” a must have for insect pet foods. 72.3% of respondents reported “my pet likes the flavor” as a “must have”. Additionally, 57% of respondents were slightly or very much more likely to feel comfortable with insects in pet foods when educated on their aroma and flavor being enjoyable to pets. In the subpopulation of comfortable consumers, 78% were slightly or

very much more likely to feel comfortable with insects in pet foods when educated on their aroma and flavor.

Marketing campaigns that site the palatability results of their pet food may be more successful. For example, pet food companies could conduct palatability trials to compare insect diets to other proteins. If scientifically validated, advertising that 9 in 10 dogs prefer insect diet over chicken may increase consumers education on the flavor and aroma and make them more likely to purchase.

7.11 Wild Cat Education

Feral cats eat insects as part of a natural food source (Zou, et al., 2024). Consumers may not be aware of that and by learning it, feel more comfortable feeding it as a natural part of their cats' diet. 62.64% of respondents reported "is all natural" as a "must have." In objective three, 56% of respondents were slightly or very much more likely to feel comfortable with insects in pet foods when educated on insects being a natural part of a wild cat's diet. In the subpopulation of comfortable consumers, 78% were slightly or very much more likely to feel comfortable with insects in pet foods when educated on insects being a natural part of a wild cat's diet. In objective three, there is a increase in the probability of feeling comfortable when learning about insects in wild cat diets. Marketing education that celebrates the history and science behind wild cats eating insects as part of their natural diet may be successful for target consumers.

CHAPTER VIII: CONCLUSION

Insect proteins are a nutritious and sustainable option to feed the growing companion animal population in the U.S. American consumers are restricted by an “ick-factor” and lack of education about insect proteins. Understanding the current consumer perception of insects in pet food is important in determining the best ways to market to American consumers. Certain demographics of consumers may relate to them being more likely to be current buyers of insect pet foods. There are several important requirements consumers have when considering purchasing insect pet foods. American consumers can be educated with facts about insect proteins into becoming more likely to purchase insect-based pet foods.

8.1 Limitations

The largest limitation in this research was the bounds of a consumer survey. The consumer was self-reported, which allows room for subconscious biases of respondents. There was also a limited sample of 509 respondents.

Additionally, this survey prompted education on insect protein in a direct manner. Respondents may be more likely to be influenced by this in the short term and not as impacted by traditional marketing tactics in the real world.

8.2 Future Research

Future study could continue to enrich the intended objectives of this research. More demographic information may be able to be extracted from the survey system to better understand the subpopulation of swayed potential buyers. Additional econometric models could be run on this survey data for a better understanding of certain consumer subgroups. For example, the same logistic regression models done in objectives one through three

could be run for cat owners verses dog owners or certain income levels, and the magnitude of effect for the independent variables could be compared.

The logistic regression models could be fine-tuned to a goodness of fit. A well fit logistic regression would allow the potential to calculate the probability of a certain type of person being a current buyer, potential buyer, or comfortable consumer. You could create a fictional type of person (example: urban, college educated, with \$100,000+ income) and determine what their probability was of being a potential purchaser.

WORKS CITED

- Aiking, H. (2011). Future protein supply. *Trends in Food Science & Technology*, 22(2–3), 112–120. <https://doi.org/10.1016/j.tifs.2010.04.005>
- Alhujaili, A., Nocella, G., & Macready, A. (2023). Insects as food: Consumers' acceptance and marketing. *Foods*, 12(4), 886. <https://doi.org/10.3390/foods12040886>
- Alexander, P., Berri, A., Moran, D., Reay, D., & Rounsevell, M. D. A. (2020). The global environmental paw print of Pet Food. *Global Environmental Change*, 65, 102153. <https://doi.org/10.1016/j.gloenvcha.2020.102153>
- American Pet Products Association (APPA). (2023b, December 7). Post-covid rise in pet ownership evident & persistent. American Pet Products . <https://www.americanpetproducts.org/news/blogpost/2023/12/07/post-covid-rise-in-pet-ownership-evident-persistent>
- Ardoin, R., & Prinyawiwatkul, W. (2021b). Consumer perceptions of insect consumption: A review of Western Research since 2015. *International Journal of Food Science & Technology*, 56(10), 4942–4958. <https://doi.org/10.1111/ijfs.15167>
- Aschemann-Witzel, J., Gantriis, R. F., Fraga, P., & Perez-Cueto, F. J. (2020). Plant-based food and protein trend from a business perspective: Markets, consumers, and the challenges and opportunities in the future. *Critical Reviews in Food Science and Nutrition*, 61(18), 3119–3128. <https://doi.org/10.1080/10408398.2020.1793730>
- AVMA 2022 Pet Ownership and Demographic Sourcebook. (n.d.). U.S. pet ownership statistics. American Veterinary Medical Association. <https://www.avma.org/resources-tools/reports-statistics/us-pet-ownership-statistics>
- Bloomberg. (n.d.). Global Pet Industry to grow to \$500 billion by 2030, Bloomberg Intelligence Report finds | press | Bloomberg LP. Bloomberg.com. <https://www.bloomberg.com/company/press/global-pet-industry-to-grow-to-500-billion-by-2030-bloomberg-intelligence-finds/>
- Böhm, T. M. S. A., Gedon, N., Udraite, L., Hiltenkamp, K., Mueller, R., Böhm, T., & Klinger, C. (2018). Effekt eines insektenprotein-basierten futters auf die symptomatik von Futtermittelallergischen Hunden. *Tierärztliche Praxis Ausgabe K: Kleintiere / Heimtiere*, 46(05), 297–302. <https://doi.org/10.15654/tpk-170833>
- Brown, A. (2023, July 7). About half of U.S. pet owners say their pets are as much a part of their family as a human member. Pew Research Center. <https://www.pewresearch.org/short-reads/2023/07/07/about-half-us-of-pet-owners-say-their-pets-are-as-much-a-part-of-their-family-as-a-human-member/#:~:text=Families%20come%20in%20all%20shapes,new%20Pew%20Research%20Center%20survey.>

- Delgado, C. L. (2003a). Rising consumption of meat and milk in developing countries has created a new Food Revolution. *The Journal of Nutrition*, 133(11).
<https://doi.org/10.1093/jn/133.11.3907s>
- Dobermann, D., J. A. Swift, and L. M. Field. “Opportunities and Hurdles of Edible Insects for Food and Feed.” *Nutrition Bulletin* 42, no. 4 (2017): 293–308.
<https://doi.org/10.1111/nbu.12291>.
- Fantechi, T., Califano, G., Caracciolo, F., & Contini, C. (2024). Puppy power: How neophobia, attitude towards sustainability, and animal empathy affect the demand for insect-based pet food. *Food Research International*, 177, 113879.
<https://doi.org/10.1016/j.foodres.2023.113879>
- Grafton, R. Quentin, Carsten Daugbjerg, and M. Ejaz Qureshi. “Towards Food Security by 2050.” *Food Security* 7, no. 2 (2015): 179–83. <https://doi.org/10.1007/s12571-015-0445-x>.
- Higa, J. E., Ruby, M. B., & Rozin, P. (2021). Americans’ acceptance of black soldier fly larvae as food for themselves, their dogs, and farmed animals. *Food Quality and Preference*, 90, 104119. <https://doi.org/10.1016/j.foodqual.2020.104119>
- Hill, M. R. (2022). Evaluating the supply chain of animal protein-based pet food ingredients and international trade of Pet Food (thesis).
- Kim, Tae-Kyung, Hae In Yong, Young-Boong Kim, Hyun-Wook Kim, and Yun-Sang Choi. “Edible Insects as a Protein Source: A Review of Public Perception, Processing Technology, and Research Trends.” *Food Science of Animal Resources* 39, no. 4 (2019): 521–40. <https://doi.org/10.5851/kosfa.2019.e53>.
- Kröger, T., Dupont, J., Büsing, L., & Fiebelkorn, F. (2021, December 7). Acceptance of insect-based food products in western societies: A systematic review. *Frontiers*.
<https://www.frontiersin.org/articles/10.3389/fnut.2021.759885/full>
- Kępińska-Pacelik, J., & Biel, W. (2022). Insects in pet food industry—hope or threat? *Animals*, 12(12), 1515. <https://doi.org/10.3390/ani12121515>
- Lange, K. W., & Nakamura, Y. (2023). Potential contribution of edible insects to sustainable consumption and production. *Frontiers in Sustainability*, 4.
<https://doi.org/10.3389/frsus.2023.1112950>
- Larkin, M. (2021, November 17). Pet population still on the rise, with fewer pets per household. AVMA Publications. <https://avmajournals.avma.org/display/post/news/pet-population-still-on-the-rise--with-fewer-pets-per-household.xml?print>
- Mridul, A. (2024, January 22). Insect Pet Food: An update - go-to resource for the global pet industry: Globalpets. Go-to resource for the global pet industry | GlobalPETS.
<https://globalpetindustry.com/article/insect-pet-food->

- Valdés, F., Villanueva, V., Durán, E., Campos, F., Avendaño, C., Sánchez, M., Domingoz-Araujo, C., & Valenzuela, C. (2022). Insects as feed for companion and Exotic Pets: A current trend. *Animals*, 12(11), 1450. <https://doi.org/10.3390/ani12111450>
- Verdon, J. (2022, September 27). How the pet humanization trend is creating new brands and Business Opportunities. CO. <https://www.uschamber.com/co/good-company/launch-pad/pet-humanization-trend-creates-business-opportunities>
- Wall, T. (2022, July 26). Pet food growth may outstrip animal protein supply. *Petfood Industry*. <https://www.petfoodindustry.com/news-newsletters/pet-food-news/article/15469008/pet-food-growth-may-outstrip-animal-protein-supply>
- White, B. L. (2022). Insights-driven development of humanized foods for pets. *Meat and Muscle Biology*. <https://doi.org/10.22175/mmb.14397>
- Zou, X., Liu, M., Li, X., Pan, F., Wu, X., Fang, X., Zhou, F., Peng, W., & Tian, W. (2024). Applications of insect nutrition resources in animal production. *Journal of Agriculture and Food Research*, 15, 100966. <https://doi.org/10.1016/j.jafr.2024.100966>