

**A TWO PAN FEEDING TRIAL WITH COMPANION DOGS: CONSIDERATIONS
FOR FUTURE TESTING**

by

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Abstract

Palatability of pet foods is judged by the use of animals in colonies. Pet food manufacturers would like to understand how palatable a food is compared to another food. This generally is accomplished by a two pan test where a pet has the opportunity to freely choose between two foods. Preference is evaluated through the use of an intake ratio, the ratio of the amount of test food consumed divided by the total amount of the foods consumed. Although this is easy to do in laboratories, another option would be to do such studies with animals in more 'real-life' home environments. The purpose of this study was to develop, and test a method to capture feeding information from a study of canines in the home environment and analyze the results of the palatability tests. Individual dog owners were screened for information on the household and pets. Twenty-five dogs of different ages, breeds and sizes were selected to participate on the in-home panel. Seven different palatability tests were performed using the in-home panel with four of those tests being replicated; a total of 11 comparative tests. These dogs were tested using a proprietary computer-based technology that collected information about intake of each food for each individual dog for a duration of seven days for each of the 11 comparative studies. Data was analyzed and resulted in showing that differences between foods can be found. Statistical analyses compared initial day one data to subsequent day data collected during each study to determine whether a full seven day test was needed. In addition, comparisons were made to compare the impact of prior foods eaten to subsequent preferences of the dogs. Results of the in-home panel were the same on day one as for all seven days of testing. Also, previous exposure to a food did not alter subsequent preference for that food. Such data has implications for pet food manufacturers related to timing and cost of testing.

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Dedication

The work in this thesis is dedicated to my late father, John Huck. His influence has made me the woman that I am and I know he would be proud of this accomplishment.

CHAPTER 1-Literature Review

According to a recent survey published by the American Pet Products Association (APPA, 2012), domestic dogs (*Canis familiaris*) are a part of 39% of households in the United States. Since the last APPA survey taken in 2008, the number of households that own a dog increased to 46.3 million households from 45.6 million households.

The most important benefits of dog ownership include companionship, love, and stress relief (APPA, 2012). Pet owners often treat their pets like children, and the interactions that people have with pets are similar to those interactions that they have with people (Archer, 1996). Pets are emerging as replacements for children, serving that role for the empty-nesters of the baby boom generation (Salzman, 2000).

Dogs are mammals whose emotions and moods appear similar to those of humans, although the ways they express them are different. These interactions form the basis of communication between pet and pet owner which has been shown to enhance the bond between dogs and their owners (Archer, 1996).

People love their pets for a number of reasons; they see their pets as a source of security and unconditional positive regard (Archer, 1996). Pet owners' exhibit significantly reduced physiological risk factors for cardiovascular disease, as compared to non-pet owners (Archer, 1996). Friedmann and Tsai (2006) found that pet ownership reduced stress, anxiety, loneliness and depression, while increasing the exercise rate of pet owners. All this to suggest, pet owners have a better quality of life compared to those people without companion animals.

Archer (1996) found that even though pet owners felt that there were obstacles to forming a human-like relationship with their pet, due to limited intellect and lack of language, they still managed to communicate with and seemed to be well understood by their pet.

While the motivation that drives pet ownership is generally perceived as positive, Beverland, et al., (2007) recently compared two types of ownership motivation; pets as companions to love versus pets as toys, status markers, and brands. The study showed that owners differ in their motivation for ownership, their appreciation of the pet, the nature of the human-animal interaction, breed choice, and the purchase of pet-related paraphernalia.

A reported drawback of dog ownership is the costs for food and healthcare (APPA, 2012). Since owners treat their pets like a member of the family and they expressed concern with the food, nutrition and eating habits of their companion dog (Hart et al., 2006). There is a perception among some dog owners and even some veterinarians that dog food sold in grocery stores are inferior in quality to those sold in pet specialty outlets (Sanderson et al., 2005). While pet food quality is important it is true that many owners love their dogs, but do not really understand their needs or how to care for them (Cote, 2007).

Pet Food Industry

In 1986, pet food sales in the United States were \$5.1 billion (Enterline, 1986) and in 1995 they were reported as \$9.3 billion. A decade later sales nearly doubled to \$14.4 billion (Hand et al., 2010) indicating strong growth within the pet food industry.

European and Asian countries have followed a similar trend within the pet food industry. North America has the largest market followed by Western Europe and Asia (Hand et al., 2010). Pet food sales totaled \$13.2 billion in Western Europe, \$1.5 billion in Central and Eastern Europe and \$2.8 billion in Japan during 2005 (Euromonitor, 2006.) Brazil is predicted to be the second largest market for pet food in 2015, with India and Saudi Arabia listed as the top two fastest growing markets to 2015 (Taylor, 2011).

There are more than 1200 pet food manufacturers around the world (Intel GNPD, 2006) and approximately 175 manufacturers in the United States (Research and Markets, Inc., 2006).

Safety and efficacy of foods intended for cats and dogs are of prime interest not only to manufacturers, but ultimately veterinarians and consumers (Zicker, 2008).

Pet Food Types

According to Hand et al., (2010) there are three basic forms of pet food; dry, semi-moist and moist. Water content varies between the three forms; with dry foods consisting of 3-11% moisture, semi-moist foods at 25-35% moisture and moist foods ranging from 60-87% moisture.

The pet food industry is divided into various segments (Hand et al., 2010). One segment, grocery, is considered all-purpose foods, balanced for growth and lactation. Private label brands are popular in larger national or regional supermarket chains and pet retail outlets. These products are manufactured by a third party according to specifications requested by the store which is branding the product. Generic pet foods are non-branded products, which primary function is a low priced alternative for pet owners. Specialty brands, also called premium and super premium foods, are more likely to emphasize superior ingredients and nutrition. These products are generally available for sale in pet stores, pet superstores, veterinary hospitals and some farm/feed stores. Veterinary therapeutic foods have unique nutrient profiles that supplement treatment with specific disease states. These diets are only sold at veterinary practices or hospitals.

Shakhar et al., (2009) recently studied the feeding practices and blood metabolic profile of pet dogs reared on homemade diets. This study revealed that homemade diets constitute the mainstay of feeding pet dogs in India, but these diets were nutritionally inadequate and imbalanced especially with respect to protein, energy and minerals.

Palatability Enhancers

While a number of ingredients are used to commercially produce pet food, palatability enhancers are used to improve the sensorial characteristics of the food and are added to entice pets to consume the product. These products can be liquid or dry products, typically coated topically onto the dry kibble. In the case of wet foods, they are added to the ingredients prior to the retort process. Hand et al., (2010) identify the main flavor enhancing ingredient category added to pet food as digests. Digests are defined as animal tissues enzymatically altered by proteolytic enzymes. Digests are added to foods to provide the sensory impact of meat (AFB, 2013). Additional ingredients used as palatability enhancers include salt, fat, L-lysine, L-cysteine, monosodium glutamate, sugar, yeasts, whey, cheese powder, meat slurries and hydrolyzed vegetable protein.

Thombe (2004) reports that in addition to protein digests and hydrolysates, animal proteins, emulsified meats, amino acids, animal fats, sulfur, baked flavors, moisture and sugars improve palatability. Flavors that are considered to be negative were identified as vegetable protein meals, fibers, vegetable oils, vitamins, minerals and bitter tasting drugs.

According to Hand et al., (2010), dogs generally like fats, sugars, meat ingredients and digests. When formulating dry foods, a liquid mixture of meat, water and fat is pumped into the extruder. This process enhances palatability because the wet meat is cooked in the extruder as opposed to meat meals, which are rendered first then extruded.

Enrobing is the process by which fats and digests are generally topically applied to dry foods. Coatings may be applied to the kibble in a rotating drum, spinning disk coater or vacuum coater (AFB, 2013). Dry palatability enhancers are generally applied to the coated kibbles, in order to

ensure proper adherence to the kibble. Hand et al., (2010) states that flavor enhancers or palatants have their greatest effect on palatability when they are applied topically to dry kibble. Hand et al., (2010) also address palatability enhancer use in canned, or wet, products. However they are less of a driver of palatability as a result of the high moisture and meat composition of the food system. Palatants are typically added on top of the food just prior to the can being sealed, or may be mixed directly with the meat blend, gravy or chuck before the canning process occurs (AFB, 2013).

Dog Ownership in the US

The American Pet Products Association (APPA) publishes the National Pet Owners Survey every two years. This survey monitors consumer habits on an ongoing basis in order to identify short and long term trends in pet ownership, product and service consumption, and lifestyle and media habits.

The 2011/2012 survey reports that the average number of dogs owned per household is 1.69, with notable gains being seen in households owning two dogs (28% from 24%) or three or more dogs (12% from 9%). This has caused a gain in the total number of dogs owned in the US to 78.2 million from 77.5 million dogs. The average number of dogs owned in multiple dog owning households increased to 2.57 from 2.45. Six out of 10 dog owners have male dogs, with an equal number having female dogs.

The 2011/2012 survey states that there are more households with small dogs in 2010 than in 2008 (47% versus 44% percent). One quarter of dog owners consider their dog to be medium sized. Forty-seven percent of dog owners describe their dog as large sized. The past decade has evidenced an increase in ownership of small dogs with a concurrent decrease in ownership of medium sized dogs.

The APPA survey reports that more dogs in households with two or more dogs are considered to be pure breeds. More small dogs are pure breeds, than medium or large sized dogs. Mixed breed dogs are taken to the veterinarian less often and are usually large sized.

As stated in the APPA survey, the newest dog in the household (the third dog) is usually the youngest, at three and one third years old. The first dog in the household is the oldest at nearly seven years old. Households with a second dog have an average age of almost five years old.

This research suggests that the younger average age of dogs suggest that there are more new dog owners.

It is important to also note that improved nutrition and medical care have prolonged life spans in people and have been inferred to do the same for dogs (Zicker, 2005). Current estimates suggest that there are approximately 20 to 30 million dogs over the age of 7 years in the United States (AVMA, 2002).

The APPA 2011/2012 survey reports that more dogs stay indoors during the day (58% versus 42%). This is the highest number ever reported. Significantly more dogs remain indoors at night, 74%, than in 2008, 66%. Most dog owners' report their dog sleeps in an adult's bed (42%), especially small dogs (56%). This data is a direct correlation to the special relationship that people have with their pets.

The APPA US Dog Ownership survey reports small, medium, and large dog owners have the highest preference for premium dog food, followed equally by dog food fortified with vitamins, other dog food and human food. Less than 1-in-10 owners, of all sizes, prefer organic, gourmet or natural food. Premium dog food use increased from 42% to 44% percent, since the last study. Premium dog food is one of the fastest growing segments globally with a reported 9% increase in sales (Taylor, 2011). It was reported that natural, premium and gourmet dog food are more

likely to be purchased by owners who take their pet to the veterinarian more often (APPA, 2012). Overall, pet food retail sales are projected to grow at a stagnant 3.6% until 2015 (Taylor, 2011). The APPA 2011/2012 survey reports that though the choices of types of food bowls have expanded; the most popular type owned is still a single bowl (61%), across all sizes of dogs. Two out of 10 have a two sided or double diner bowl, while 1-in-10 has a raised bowl. A study published in Preventative Veterinary Medicine (Bland et al., 2009) reported that of the 302 dog population studied, 60% of the owners fed them twice a day, 33% of the fed once a day, 2% fed greater than or equal to three times daily and 5% fed free choice (food always available). Additionally, 99% of these owners fed treats daily.

Eating Behavior of Domestic Dogs (*Canis familiaris*)

The Evolutionary Basis for the Feeding Behavior of Domestic Dogs (*Canis familiaris*) and Cats (*Felis catus*) (Bradshaw, 2006) provides valuable insights into the reasons why dogs behave in the manners that they do with regard to food. Domestic dog (*Canis familiaris*) is a member of the order Carnivora. This group includes many species that specialize in carnivory, but this is not an absolute rule for the majority, most of which are omnivores; there are even some herbivores in this Order, such as the pandas (*Ailuridae*) and some frugivores, such as the kinkajou *Potos flavus* (*Procyonidae*) and the African palm civet *Nandina binotata* (*Viverridae*). Bradshaw (2006) reports most species within the dog family, *Canidae*, subsist mainly on prey, although this can be predominantly invertebrate in species such as the fennec *Fennecus zerda* and the crab-eating fox *Cerdocyon thous*. The jackals *Canis aureus*, *C. adustus* and *C. mesomelas*, from the same genus as the domestic dog are all omnivores. The coyote *C. latrans* can subsist on fruit and other plant materials when prey is difficult to find.

The diet of the ancestral species of the dog, the wolf *Canis lupus*, consists predominantly of meat in most habitats in which it is currently found. The dentations of the modern wolf are not dissimilar to that of jackals and are consistent with a more omnivorous diet (Bradshaw, 2006). Bradshaw (2006) goes on to explain pre-domestication of dogs, before control by humans, wolves were able to occupy a wider range of habitats than they do today; thus, it is possible that they formerly consumed a more wide ranging diet. It is generally agreed that dogs were the first species of animal to be domesticated, but precisely when, why and how domestication took place is still under debate. Archaeological evidence suggests that dogs first became distinguishable in appearance from wolves ~ 14,000 years ago. Their mitochondrial DNA points to a much older common ancestor, perhaps > 100,000 years ago. This discrepancy can be resolved if the appearance of the domestic wolves/dogs did not diverge from that of free-living wolves until the shift from hunter-gatherer lifestyles to the early stages of agriculture; at this point this is speculative. There is also argument about the purpose for which dogs were first kept by people. Whatever the details of their origin, today's dogs are extraordinarily diverse in form. Hand et al., (2010) suggests that experience based ingestive imprinting, aversion and novelty behaviors may help wild animals survive by allowing them to adapt to foods they are unaccustomed to when their typical food becomes scarce. Bradshaw (2006) states, in wild animals, food selections are a complex process that begins with the onset of foraging behavior and ends with the consumption of an item of food. Several breeds of dog have a reputation for being able to consume large meals very rapidly, and it is possible that this is the legacy of competitive feeding in the wolf. When a wolf pack makes a kill of a large mammal such as a caribou, a feeding hierarchy that allows the pack leaders to feed first is observed; once they have withdrawn, the juveniles may have to compete with each other for the best of what remains.

Wolves have a remarkable ability to gorge themselves, and it has been reported that they can consume up to one-fifth of their own body weight at one time. Even dogs fed commercial food have been reported to consume 10% of their body weight in canned food at one time (Hart et al., 2006).

Rapid feeding may also be an adaptation to scavenging during the early stages of domestication (Bradshaw, 2006). Dogs that retain this tendency can rapidly become obese if allowed to feed ad libitum. Although some breeds may be more prone to such behavior than others, there is also considerable variation among individuals within breeds.

Hunting behavior in domestic dogs was greatly modified genetically during the course of domestication, both in comparison with the wolf and between types. Feral dogs generally subsist by scavenging rather than by hunting, suggesting that most dogs do not retain a fully functional repertoire of hunting behaviors. Their diets consist of the entire carcass of rodents and larger mammals and occasionally vegetative matter, such as fruits and seeds (Hart et al., 2006).

Torres et al., (2003) state that dogs eat to meet their energy needs; thereby controlling their food consumption. Several factors that may influence dietary choices are: need for energy intake, need for specific nutrients, palatability of the food, preference for specific sensory attributes and learned taste aversions. Animals may develop an aversion to a food that has made them sick or nauseous (Hart et al., 2006). For most pet dogs, the selection of food provided by humans is based upon its appearance, odor, flavor and texture (Bradshaw, 2006).

Studies have been performed looking at the characteristics of heart rates in relation to the palatability of dog food. In 1982, Kostarczyk and Fonberg determined that the acceleration of heart rate on the beginning of consumption was greater when the most preferred food was offered. It was also reported that the definite pattern of visceral responses depended not only on

sensory characteristics of the food, but also on the food's hedonic value. While the delivery of food and the beginning of eating was seen to activate hunger (Konorski, 1967) it was also stated that during the state of initiation of eating the palatability of food is not critical for eating (Epstein, 1967; Booth, 1972). Dogs are less finicky when it comes to eating, but it has been demonstrated that the type of hunger was affected by the perceived attractiveness of the food (Booth, 1972). Kostarczyk (1980) demonstrated that autonomic responses (salivation and heart rate) accompanying food consumption were specific and reproducible, she also indicated that cardiac responses during food consumption were characterized mainly by heart rate acceleration at the beginning of eating and progressive heart rate deceleration towards baseline in the course of eating. Kostarczyk (1982) could not rule out the possibility that heart rate changes were just one component strictly related to the skeletal muscles' activities.

Hart et al., (2006) address many problems with feeding behavior in dogs. Finding an appealing food may be a problem, specifically for finicky dogs. Another issue reported was that a dog eats well for a while and then seems to stop eating for no apparent reason. One suggested solution was to create a competitive environment, by having other dogs around during the feeding experience. The effects of social facilitation are less apparent when food is readily available all day. If food is restricted, dominance interactions, especially among puppies occur during feeding. The dominant animals may get such a large proportion of the food that the more subordinate ones are undernourished. Feeding puppies with several pans of food is a way to prevent this problem.

The opposite of finicky eaters is non-selective eating behavior. This may lead to overconsumption and obesity. This is also a common issue, and caregivers may have little success in reducing the animal's weight if they are not equipped with the proper diet and

behavioral changes that may be necessary to succeed (Hart et al., 2006). Gossellin et al., (2007) estimate that 20% to 40% percent of dogs are obese. German (2006) reports the incidence appears to be increasing. An average pet activity level is one of low-intensity activity up to three hours per day (Buff, 2010). While decreasing the number of calories consumed is the principal strategy for weight loss in overweight dogs (Butterwick et al., 1998), palatability of the lower fat food needs to be ideal in order to achieve the goal of effective weight loss. That is to say highly palatable food may be helpful in reducing snacking and begging behavior.

Marshall-Pescini et al., (2011) performed experiments to understand how food tasks in dogs are affected by owners versus strangers to the animals. They reported that dogs are highly skilled in understanding a large variety of human social cues and use them to appropriately solve a number of different cognitive tasks. Dogs rely on human signals even when these are contradictory or misleading and ultimately prevent them from correctly solving a task. The question posed in these experiments was “Is there an existence of a relationship between the effectiveness of human indication and the nature of the bond with the person providing the cues?”

In these experiments, dogs conformed to the human’s indications even though these led to the selection of the less advantageous option. The owner and stranger did not differently influence the dogs’ behavior. Results showed that dogs were willing to follow a person’s indication, even when this is visibly counterproductive to them and they are socially prepared to rely equally on cues given by the owner and an unfamiliar friendly person. In free choice between two plates containing a large and a small food quantity, dogs would predominantly choose the large, but when their owners showed a manifest preference for the smaller one, they conformed their choice to the owners’ indication, even though this choice was visibly counterproductive.

Green and Rashotte (1984) published research that indicated dogs can detect quantitative differences in the amounts of foods available in a preference test. While data indicated that matching of behavior ratios to the ratios of food amounts obtained cannot be routinely expected on an individual animal basis, this phenomenon should be recognized as a potential for bias when conducting palatability tests.

Neophobia vs. Neophilia

According to Larose (2004), dietary history can greatly influence an animal's response to palatability tests, specifically when comparing an accustomed product to a less known product. Neophobia is defined as rejection of the new diet, while neophilia is defined as preference of the new diet. Bradshaw (2006) and Waterhouse and Fritsch (1967) stated that dogs fed the same diet for long periods often display enhanced preferences for other diets, an example of the so called novelty effect. Thorne (1962) reported that neophilia can be measured after only six consecutive days of single food feeding. In studies, dogs preferred novel foods and flavor changes when exposed to food rotation from weaning to two years of age (Corbin, 1995; Thorne, 1995).

Griffen et al., (1984) observed that discrepancies between home dogs and kennel dogs may be related to differences in feeding histories. Dogs may have been biased toward choosing the more novel of the two foods in the preference testing situation.

“Imprinting” is the preference for familiar food as influenced by an animal's early ingestion experiences (Thorne, 1995). While puppies and kittens imprint on the inherent flavor cues found in mother's milk, they learn these flavors are “safe” (Hand et al., 2010). Imprinting may be one way puppies and kittens learn what is to be hunted in addition to what is safe and nutritious (Thorne, 1995).

Larose (2004) does provide an extensive list of steps to avoid fixation. These steps include recruitment of palatability test participants as soon as possible (birth or weaning) and give them a varied diet. It is also important to make sure a minimum number of meals per tests are taken in order to avoid novelty effects. Novelty is the behavior of enjoying new foods and flavors (Hand et al., 2010). It is recommended to feed a large diversity of pet foods to a functional adult panel. Waterhouse and Fritsch (1967) mention this fact, specifically to bring to light that experiments should be designed to compensate for this source of potential error and bias when dogs involved in palatability tests have not been exposed to a wide variety of diets. Finally Larose (2004) suggests that when interpreting test results, the scientist should take into account the feeding experiences of the panel and realize that preferences can change as dietary history evolves.

Role of Olfaction in Pet Food Palatability

While flavor of a substance generally refers to its attributes of taste (gustation), odor (olfaction) and other qualities such as mouth feel (Thombre 2004), it is important to understand how olfaction influences palatability as the olfactory system of dogs is very highly developed. Hand et al., (2010), report that people have about three to four cm² of olfactory epithelia. Dogs have 18 to 150 cm², with a high density of central nervous system neurons related to olfaction (Dodd et al., 1980). Kalmus (1955) reports that this highly developed olfactory system gives some dogs the ability to detect extremely low concentrations (1×10^{-11} molar) of some solutions and to discriminate between the scents of identical twins.

Le Coutre (2003) provides perspective on how humans perceive taste. Humans are attracted or repelled by visual and olfactory signals of food, but once in the mouth only the gustatory sense tells them to spit or to swallow. Olfactory and gustatory inputs are integrated with visual, visceral, mechanical and auditory stimuli in the brain to generate complex flavor profiles. Each

profile is eventually classified with hedonic values of liking or disliking. The integration of sensory inputs into long term food preferences is the major basis of an individual's food choice. Kitchell (1978) observed that the ability of an animal to perceive flavor and discriminate between flavors is dependent on anatomic and physiologic substrates as well as on psychological phenomena. He defined taste or gustation as describing the sensation arising from the stimulation of chemoreceptors located in the oral, pharyngeal and laryngeal cavities. Odor or smell describes the effects of volatile components in food on olfactory receptors located in the nasal cavity. Flavor connotes perception of the combined input from taste and olfactory receptors as well as from general chemical receptors located in the oral, nasal and laryngeal cavities.

Specific research performed by Houpt et al. (1978) titled *The Role of Olfaction in Canine Food Preferences* provided valuable insights into this particular phenomenon. The first experiment presented the dogs with two identical diets, one of which smelled like meat and the preference for the two diets were measured. Taste properties were held constant and the smell of the food varied. In this experiment, an apparatus was constructed to blow the odor of a meat through the bland basal diet.

In the second experiment, the dogs were made anosmic and their preferences were compared to those of intact dogs. Smell was eliminated and food choice was based on non-olfactory senses, presumably taste, although tactile properties of the diet may have also been involved in the choice of the dogs on the panel.

The conclusions reached in this study were that olfaction is not essential for preference for some types of food, for example meat and sweet foods. Olfaction is necessary for preferences based

on discrimination between types of meat. That being said, smell alone cannot sustain a food preference. It must be paired with another sensory input, most likely taste.

Palatability

Palatability of food is an important measure of performance in the pet food industry. The term palatability has been generally defined several ways; as the subjective pleasure associated with eating a particular food (Araujo et al., 2004), and as an all-encompassing term that covers all perceptions derived at the time a food is being consumed (Kitchell, 1978).

Hand et al., (2010) present the term of acceptance, which is defined as if a food is palatable enough to be eaten in sufficient quantity to maintain the subject's body weight in a neutral state. Thombre (2004) defines acceptance or voluntary acceptance as the notion that the animal voluntarily takes the food into the mouth and consumes the food.

To say that a food has increased palatability means that it is more likely to be consumed than a less palatable food under some specific conditions (e.g., some level of food deprivation, in the context of certain other foods, etc.) (Griffin et al., 1984). Pets today are like their owners in that food choice often is disconnected from the need to survive and is dominated instead by the pursuit of pleasure (le Coutre, 2003).

There are disagreements in research with regard to the specific definition of palatability.

Kitchell (1978) includes not only the flavor of the food, but also the perception of appearance, temperature, size, texture and consistency of the tested food as important factors of palatability. Griffin et al., (1984) argue that a difficulty arises when palatability is used to refer to some other property of the food that induces eating (e.g., ingredient, texture aroma, etc.). Then when conditions are changed and eating is not observed, individuals who have used the term incorrectly are surprised since, from their perspective, "the palatability of the food" has changed.

For the purposes of this research, palatability will be defined as the likelihood that a food will be ingested under a set of specific conditions.

Palatability cannot be directly determined in companion animals because they are unable to state preferences of hedonic value. Assessment of palatability must be based on objective behavioral measure that enables two or more foods to be ranked on the basis of preference while ruling out interferences by other factors, such as satiety (Araujo et al., 2004). There are many different methods for measuring palatability, which will be discussed in greater detail in this examination, but additional information regarding other measures observed in pet food testing must be defined.

Sanderson et al., (2005) report that owners rarely cite palatability as a reason to purchase the particular diet when initially choosing a diet to feed their pet, but when owners focus on palatability it becomes the main reason to change foods or make the decision to feed that particular food for the long term.

Preference

Palatability and preference information are often gathered in comparison feeding. Preference is the quantitative measurement of varying palatability. The general hypothesis is that if a dog ingests more of one of the test diets, the dog prefers that diet. Preference involves questions such as “Is this food ‘good’, ‘bad’ or ‘indifferent’?” (Kitchell, 1978). Preference is defined by Griffin and Beidler (1984) as the relatively high likelihood of ingesting one of two available foods under very specific conditions. They go on to contend that if these conditions are changed (e.g., pre-feeding of one of the foods, method of testing, etc.) the relative likelihood of eating the two foods may or may not change. They feel that an error made with the use of the term of preference is one that directly contradicts the general hypothesis regarding preference that the

term preference refers to a cause for the differential eating, i.e. the dog eats more of a food because it prefers that food.

Griffin et al., (1984) continue to state that dogs do not have preferences. Under one set of specific conditions (e.g., two pan method) a dog may display differential behavior (i.e., eating more of one food than another), but when conditions are changed (operant method), the dog may respond non-differently (i.e., press both levers equally often). No trait in the dog changed, the dog behaved differently under different conditions. This illustrates the real challenge in preference testing, to isolate the conditions that bring about behavioral changes.

The only bias-free method of quantifying and expressing preference results is based on the Intake Ratio (Griffin, 1995). $IR = A \div (A + B)$, where A and B are an individual animal's daily food consumption of each of two different foods. Hand et al., (2010) state that this ratio can be summarized for a group of animals by evaluating intake ratio. Any animal with a ratio greater than 0.51 can be classified as preferring Food A, where animals with a ratio less than 0.49 are classified as preferring Food B. Any animal that falls between 0.49 and 0.51 would be classified as having no preference. The result for the group can then be expressed as the percentage of animals preferring Food A, Food B and having no preference. This ratio can also be summarized for a group of animals by reporting the average intake ratio.

A Student's t-test is conducted using a 95% confidence interval to classify palatability results. In the statistical analysis of the data the relative hypothesis are determined as:

$$H_0: IR > 0.50$$

$$H_a: IR < 0.50$$

The p-value is the final judgment in the categorization of the test. A p-value of less than 0.05 expresses that the intake ratio of the test is either greater than or less than 0.50, with a 95%

statistical certainty. The verdict of the test is then determined by evaluating the intake ratio of the test food to determine how to interpret the results of the palatability test.

Generally speaking, a test is considered a loss when the intake ratio is below 0.40. In this case the test food would be less preferred than the control food. When the intake ratio is between 0.40 and 0.60, the foods are considered to be parity to one another, which there is no preference between control and test food. When the intake ratio exceeds 0.60, the test is considered a win. The test food was preferred over the control food. Again, the judgments of win, loss, and parity are all dependent on the pre-determined p-value.

According to Murphy et al. (1998), there are two advantages to testing hypothesis. The first being there is a wealth of knowledge regarding hypothesis tests and the second being that if the hypothesis that treatments have no effect is rejected, what is left is the alternative that they have some effect. The most general criticism of this approach is that nobody believes the null hypothesis, meaning the tests of this hypothesis are not necessarily meaningful (Murphy, 1990). A Type I error is committed if the null hypothesis is rejected when it is true. The probability of a Type I error is denoted by α . A Type II error is committed when the null hypothesis is accepted when it is truly false and the research hypothesis is true. The probability of a Type II error is denoted by β . According to Ott and Longnecker (2010), it would be desirable to determine the acceptance and rejection regions by simultaneously minimizing both α and β , but alas, it is not possible. The probabilities associated with Type I and Type II errors are inversely related. Hutton (2002) defined consumption ratio as the amount of Food A (test product) consumed divided by the amount of Food B (control product) consumed. Consumption ratio (CR) must be used as a group value that does not take into account individual variation among the animals. CR must be calculated using the total amount of test food consumed by the whole group of

animals divided by the total amount of control food consumed by the group. This can be a problematic calculation as when CR is calculated for the group of animals as a whole, the results are skewed by the larger animals in the group. CR should be calculated from the IR using the calculation $CR = IR / (1 - IR)$, where an IR has been calculated for each individual animal and the individual IRs are then averaged to get an overall IR. A CR of 1.0 indicates that the animals on a panel showed equal preference for the test and control product.

A number of general statements regarding dogs' preferences are available in scientific publications. Kitchell (1972) states that dogs prefer canned and semi-moist foods over dry foods, regardless of flavor. This same conclusion was made by Houpt and Smith in 1981. They go on to state that canned meat is preferred to fresh meat, ground meat is preferred to cubed meat and cooked meat is preferred to raw meat. Thombe (2004) reports that generally treats and premium canned food are considered highly palatable, and both of these products outperform dry pet food rations in palatability tests.

Dogs are classified as omnivores and can eat food of both animal and vegetable origin (Thombe 2004). While, this may be physiologically true, Houpt and Smith (1981) reported that laboratory dogs preferred diets containing meat to those containing a high protein diet consisting of soybean and corn. They go on to state that dogs prefer a diet containing sugar to one that does not.

There are discrepancies in the literature with regard to reported preferences of dogs. Kitchell (1972) reports that horsemeat was preferred over chicken and liver, with chicken being preferred over liver, while Houpt and Smith (1981) state that dogs prefer beef, pork and lamb to chicken, liver and horsemeat. These later tests were performed using pet dogs, with the owner's evaluation serving as the measurement of preference. Bradshaw (2006) cautions that generalizing about dog preferences can be difficult due to the great diversity of form and

behavior within this species, resulting from its long history of domestication and the many different functions for which dogs have been bred.

Houpt and Smith (1981) observe that the preferences of dogs in laboratory situations seem to be relatively uniform with regards to food. They also make the important point that published information on food preferences is based solely on research on laboratory dogs. This statement further justifies the experiments performed in this research thesis, in that these experiments studies preference in a non-laboratory setting.

As stated by Houpt and Smith (1981), pet animals live in a much more varied environment and have more complex past histories than laboratory animals; it stands to reason that food preferences will be influenced. In addition, the pet owner purchases the food presented to the animals, thus food selection will be based on the owners subjective evaluation of the dogs preference or needs. These authors concluded that pet dogs have more variable food flavor preferences than laboratory dogs. They also have an acceptability range for food flavors not based on flavors alone.

Smith et al., (1983) had similar findings with regard to preferences of laboratory dogs and pet dogs as the study concluded that there were differing preferences for the same test food, with owners interpreting the dogs' responses to indicate preference of the foods tested. The results of this study indicated a need to examine typical feeding behaviors in pet dogs within the context of the home environment. These authors were unable to conclude that laboratory palatability test results were reliable when used in the context of predicting palatability preferences for the broader canine population.

Methods of Testing Palatability

The two primary pet food assessment tools are the one-pan acceptance test (monadic test) and the two-pan preference test. The one-pan test measures acceptability, while the two-pan preference test measure “choice” between a pair of test foods that are fed simultaneously side by side (Hatcher et al., 2010). The two pan test is currently the most reliable method for determining pet food preference (Hutton, 2002).

“Dog Food Palatability Tests and Sources of Potential Bias” (Waterhouse and Fritsch, 1967) outlined the classic approach to palatability. A method for a two sample, free-choice palatability test procedure was described, as well as the statistical evaluation of the data. This article recommended that due to the inherent biological variations, several animals are required for precision in testing and the best method of determining average values. The number of dogs and number of test days required to determine palatability depend on desired accuracy of the test results. In this particular study, 20 dogs and 2 days were found to be adequate. A chi-square test was used in this methodology to determine if the mean intakes of the foods were significantly different. The pattern of food selection was interpreted using rank analysis of paired replicates and frequency distribution tables.

Larose (2003) suggests that 30 animals are the minimum number for optimal for palatability testing to ensure repeatability and reduce individual variability, thus reducing any potential bias of the test. She also states that the number of individuals per test seems to be more important than the number of days the foods are tested.

Waterhouse and Fritsch (1967) also studied the effect of position of the food dishes. This article reported that only five percent of the dogs tested had a preference for a particular bowl position, but the authors advised that any new candidate for palatability testing should be screened to

ensure that there is no apparent bowl position bias. SPF Palatability (2010) identified these animals that exhibit position bias as “true position eaters”, meaning exerting a preference for one side regardless of the product or conditions.

Additional ways to evaluate an animal’s ability to discriminate was outlined by AFB International® (2013). The first test was defined as an Obvious Test, meaning two products that have a known large difference are compared. The winner of this test (coated kibble versus uncoated kibble) should be “obvious”. The second test outlined was an A/A Test, where the same product is placed in both bowls. If there is a preference shown for either bowl, the animal may be a “true position eater”. The Application Test is a way to identify animals which can discern slight differences in flavor usage level.

Larose (2003) outlined the importance of training of the potential panelists. These specific parameters included test conditions, varieties of food and exposure to the kennel animal technicians in order to avoid any negative interference linked to a bad socialization.

While it is important for the animals to be trained to properly perform the tasks asked of them, Larose (2003) also indicated that procedures should be clearly written to ensure that technicians execute the palatability tests in a repeatable manner.

Kitchell (1972) discussed the development of an operant testing method to understand whether or not dogs have food preferences based specifically upon flavor or palatability. This author argued that researchers erroneously assumed that if a dog eats more of one dog food than another, it is entirely because they like the flavor of the food that they consumed more of.

According to this author other factors, such as rapid eating pace and energy balance, also play important roles in controlling the food intake of dogs. The findings of this article indicated that

dogs can be trained to reveal preferences for certain flavors by means of operant flavor preference testing procedures.

Kitchell furthered research in 1978, with the publication *Taste Perception and Discrimination by the Dog*. A number of behavioral tests were conducted in order to reveal what an animal perceives about the food it consumes. The author outlined four questions that the animal's ability to detect the test food item answers. Essentially these were; detection of the food, recognition of the food, scaling or intensity of the food and discrimination of the food. This research used flavored water to study consumption behaviors, but the author stated that the idea is applicable to dry foods as well. The test determines whether or not an animal can detect the test food and the amount of the test food consumed is compared to the consumption of water. Rashotte et al., (1984) also studied feeding behavior of freely feeding dogs. Observations across the eight month period indicated that the dogs ate periodically, more specifically in "meals". Total daily intake of food and water changed throughout the observation period. This change was assumed to be a consequence of the change in the ambient environmental conditions across seasons.

Smith et al., (1984) discussed modern computer technology to effectively capture data about eating behavior of dogs. The article classified this type of information as fine-grained or cumulative amounts of food eaten on a moment-by-moment basis during the test. A series of tests were performed to study dogs' reactions to different dry foods and to semi-moist and canned foods. The results of these experiments indicated that fine-grained measurements of feeding behavior in one and two pan tests can provide quantitative information about individual differences in the feeding styles of dogs (rapid eaters vs. slow eaters), the ways dogs distribute their feeding between two foods in a choice test and any disruptive effects of the introduction of

a new diet. This research provides further justification for the notion of gathering data in-home, using vastly improved technology, to collect these fine-grained measurements to truly understand pet dogs eating behaviors.

Technology has also allowed for the notion of “virtual” panels, meaning that the animals performing the palatability test do not need to be located in the same colony. SPF Palatability (2010) utilizes virtual panels at a subgroup level or at an individual level, which provides the organization the advantage of not physically moving animals, which could create additional disturbances.

Statistical Analysis: Power of the Test

The power of the test represents the probability of rejecting H_0 when it is in fact false (Brase et al, 2003). In order to calculate power the scientist must specify the sample size, α -level, sampling variance and the effect size (Thomas, 1997). Beta must also be identified. Beta is defined as the long term probability of missing a true difference, or a Type II error is committed (Lawless and Heyman, 1999). The power of the test is then calculated as

$$Power\ of\ Test = 1 - \beta$$

Effect size is defined as the difference between the null and alternative hypothesis. Many measures of effect size are available (Cohen 1990). Two major classes of effect size can be defined as 1) standardized, dimensionless measures such as correlation coefficients or d -values and 2) raw measures such as slope in the regression analysis or difference between means (Thomas, 1997).

According to Murphy and Myors (1998), the power of a statistical test is a function of its sensitivity, the size of the effect in the population and, as mentioned above, the criteria used to test statistical hypothesis (α -level). Ways to improve power of test were suggested as 1)

increasing the sample size in order to increase the sensitivity of the study 2) using large effect size measurement, thus there is a true difference between the null and alternative hypothesis and finally 3) set standards that are easy to reject the null hypothesis perhaps by using a larger α to define the significance of the result.

Murphy and Myers (1998) also state that research in the social and behavioral science often shows low levels of power. Cohen (1962) published a review which stated that studies in psychology, education, communication, journalism and other related fields have routinely documented power in the range of .20 to .50 for detecting small to medium treatment effects (Sedlmeier and Gigerenzer, 1989).

Murphy and Myers (1998) go on to state that the best explanation for the low levels of power observed in many areas of research was due to small sample size used to provide accurate and credible results. On the other hand, very large samples allowed the rejection of the null hypothesis even when it was very nearly true.

Murphy and Myers (1998) address the question of desired level of power. It was explained that high levels of power can be achieved by using very large numbers of samples, but the incurred expenses of such an approach may not be worth the effort. It was also stated that power should be above 0.50, with power above 0.80 recognized as generally acceptable. Researchers should expect less power when testing the hypothesis that the effect in the study exceeds some predetermined minimum value than when testing the hypothesis is exactly zero. There are two ways to attain high level of power. The first being changing the alpha level to more lenient provision, as this approach will lead to more power with no meaningful increase in the likelihood of Type I error. According to Schmidt (1992), the use of large sample size helps to minimize

one of the recurring problems in social science research, the overreliance on the unstable results obtained in small samples.

Differences in Methodologies – Two Pan Tests vs. Cognitive Tests

Arujo et al., (2004) provided a comparison of the cognitive palatability assessment protocols and the two pan test for use in assessing palatability of two similar foods in dogs. They outlined the limitations of two pan tests as; inability to control for food interactions, inability to control for the satiating effects of a test food, the inability to deal with the dynamic aspects of palatability over time. They also noted that the differences in caloric or nutritional values of meals may cause differences in food consumption and that the large portions provided during some of the two pan test may prove unhealthy for some animals over time, particularly animals that do not self-limit their food consumption. Test sensitivity was also addressed, as the degree of difference between the two test foods must be determined to ensure reliable results.

The cognitive palatability assessment protocol provides an objective measure of food preference while minimizing the influence of other factors, such as satiety and post-intestinal signals. These tests use fewer subjects to obtain a high power value for finding differences in food preference for similar foods. These tests can be used as a replacement or an adjunct to other currently used palatability test protocols.

Rashotte and Smith (1984) also provided observations regarding differences in the two bowl preference test and operant testing. The operant methodology is technically demanding and time consuming. This method involves the study of preferences in a few highly trained animals with which tests must be conducted for relatively long periods of time in order to obtain the kind of data necessary for constructing a scale of hedonic value.

Rashotte et al., (1984) reported that preference data obtained with two pan and cognitive palatability tests do not always point to the same conclusion. This may be the result of food intake control independent of palatability difference. This showed the complexities involved in predicting the outcome of a preference test from performance on previous tests.

Palatability Results – Testing Kennels vs. In Consumers Homes

In general, a formal sensory facility is expected to provide the best control over testing, however testing in this location is not representative of normal consumption of the samples and may produce different scores than would be obtained in a home use test (Pound et al., 2000). As stated in human sensory evaluation research, different types of testing locations (i.e., central location, home use, laboratory testing) exhibit different degrees of control which will ultimately affect consumer responses to the product being tested (Meilgaard et al., 1986).

Research published by Pound et al., (2000) indicated that in-home testing effectively simulated testing in all other locations. The implication was that the in-home test is a suitable substitute for testing in the laboratory when this is the best way to reach the consumers you are targeting.

Further conclusions of this study were that the assumption that sensory panels in to be held in a controlled environment and/or supervised by a researcher in order to obtain valid data has been shown not to be true. This suggestion truly expands the possible panel candidates to any willing pet owner participant, regardless of where they live. This research was performed with human subjects, thus providing further justification to parallel this investigation into the world of pets.

Griffin et al., (1984) directly compared food preferences of dogs housed in testing kennels and in consumers' homes. They stated that preferences of kennel dogs are assumed to be indicative of the preferences of dogs living in-homes. They also reported that dog owners' evaluation of a particular product is assumed to be strongly influenced by the eating behavior of their dogs.

Smith et al., (1983) also studied the owners' perception of food flavor preferences of pet dogs in relation to measured preferences of laboratory dogs. In these experiments, the food flavor preferences in pet dogs and laboratory dogs were examined, with owners interpreting the dogs' responses to indicate preference of the foods tested. The conclusions of this study were differing preferences for the same test foods between the two test populations.

When animals are tested in kennel settings, there is an assumption of no human influence on the animal's food choice. One potential negative of in-home testing is bias that may be introduced by the pet owner. A study published by Prato-Revide et al., (2007) provides evidence that dogs can be influenced by their owners even when their indications are clearly in contrast with direct perceptual information, thus leading dogs to make counterproductive choices. Protocols must be clearly defined in order to avoid this type of bias.

Thombe (2004) identified the major difference between laboratory and in-home testing as the lack of owner-pet interaction in the laboratory setting. He goes on to suggest that it is highly recommended that the definitive assessment of palatability be done in consumers' homes.

Larose (2003) states that palatability tests which are conducted in laboratory settings take into account the environmental parameters (temperature, hygrometry, smell, storms, etc.) and that interpretation of results are affected by these parameters. These types of observations would need to be carefully planned for, if the researcher saw fit, in a home testing situation.

Survey Development

There are two primary ways that surveys are conducted. The first method is interviewing, either by telephone or in person. With the increased use of computers in today's society, web based surveys have been identified as the emerging method of gathering participants for consumer panels. Bradburn et al., (2004) report that the computer assisted interviewing methods have

grown in popularity for a number of reasons, including: 1) ease of interviewee response that does not depend on an interviewer; 2) improved quality of responses through elimination of skip errors; 3) elimination of interviewer bias; 4) shorter turnaround times; 5) simple integration of images, sound and video; 6) automatic data entry and; 7) elimination of clerical errors caused by interviewers during the stress of the interview. Web based survey development and distribution was employed in this research thesis.

Bradburn et al., (2004) provide detailed information about organizing and designing questionnaires. They report that the format of the questionnaire determines how easy it is for interviewers, respondents and data processing personnel to read and understand the questions and the kind of answers required. The quality of the data becomes heavily influenced by the questionnaire format (Sanchez, 1992).

Bradburn et al., (2004) discuss the importance typefaces as they should be sufficiently large and clear as to cause no strain in rapid reading for all potential respondents. They also report that all questions should be numbered in order to avoid skipping questions. Numbering the questions also provides a visual cue to the respondent to indicate how long the survey is so they know how much time it will take to complete the survey. A question that can fit on a single page should never be split between two pages or two screens. Finally Bradburn et al., (2004) suggest that single columns of questions are necessary as multiple columns on the paper interferes with standard English reading patterns of left to right and top to bottom.

Informed consent is a respondent's implicit or explicit agreement to participate in the interview after being informed of the nature of the task (Bradburn et al., 2004). Most surveys do not require written consent unless additional access to records is required or respondents are minors.

In this research, informed consent was not obtained from participants who took the screening survey, but was provided to those participants who were selected as final panelists.

A recent study published by Sanderson et al., (2005) discussed surveying owners regarding their impressions of three premium diets fed to healthy adult dogs. In this study owners completed a questionnaire soliciting information on home environment and dietary history prior to enrollment of their dogs in the study. Additional information obtained about the dog during the study included how well the dog ate the study diet; the dog's overall attitude, energy level, fecal consistency, frequency of defecation, hair and coat quality, and body condition. The owner was also asked about any adverse clinical signs encountered while feeding the study diet and whether the owner would consider feeding the diet on a long-term basis. Results of the study suggested that owners had similar impressions of the 3 diets fed in the study, when retail price and source were blinded.

Consumer Panels-Past and Future

Consumer panels play a major role in market research. They are particularly valuable in providing a regular monitor of the marketplace as well as a databank from which answers to many important ad hoc questions can be answered at low additional cost (Buck et al., 1977) Early research published by Allison et al., (1958) pertained to human consumer panels detailed specific suggestions for maintaining a consumer panel. In this publication, a participation reward was offered in order to encourage panel membership. The amount decided upon was \$10.00 for one year of panel participation. No payments were made directly to the panel family in cash; instead, the panel family was given the choice of selecting a gift valued at \$10.00, including handling costs, from the prize catalogue or of designating a charity organization to which the \$10.00 would be sent in the family's name. Maintaining membership was an

administrative practice by sending newsletters, unanticipated prizes and visits, phone calls or letters covering personal matters such as birthday wishes, birth congratulations and death condolences.

Sansink and Sudman (2002) published information about the influence of technology on human consumer panels. This article provided many insights as to how technology will influence the way data are collected and how the sociology of how panelists, researchers and managers respond to these data. It was suggested that the ability to 'reference and reinforce' will make the panel experience more personalized and more efficient. The objective is to reference those details that show familiarity with the panelist and reinforce the notion that the panelist's answers are important and that they are remembered.

Sansink and Sudman (2002) go on to discuss 'smart databases' which will facilitate a researcher's ability to develop a global perspective. These automated databases will be able to search out a stratified or diversified panel, including one consisting of members from many different countries, for each survey. The databases will be supported by an increase in the availability of instantaneous language translation programs that allow an unprecedented opportunity for cross-country comparisons. These advances will more quickly bring global markets together into one heterogeneous but coordinated market. Understanding of the diversity of these different groups will increase, and the ability to provide recommendations and to understand why they differ will help companies better satisfy them while also enabling them to keep their identity. Global potential for certain products can be assessed early in their development. Changes can then be made to the product that make it most promising for a world market or which makes it customizable by different panelists in different markets.

While technology is seen as an advance in data collection and interpretation, it is important to understand how Internet privacy can be affected. The FTC offers five principles of fair information practices that should be followed (Gillin 2000):

- Notice: communicating how data are collected, the uses of the information, as well as which third parties may receive the information
- Choices: giving consumers options as to how any personal information collected from them may be used (opt-in or opt-out)
- Access: Allowing an individual the ability to access data about themselves and to correct any inaccuracies
- Security: taking reasonable steps to ensure the security of information collected
- Enforcement: the core principles of privacy protection can only be effective if there is a mechanism in place to enforce them.

Summary

Great strides have been made in the development of methodologies to quantitatively measure palatability and preference of dog food. Questions arise regarding the reliability of laboratory palatability test results when used in the context of predicating palatability preferences for the broader canine population. There is a need to examine typical feeding behaviors in pet dogs within the context of the home environment.

A better representation of the real world would be obtained by conducting palatability tests amongst a group of randomly selected home dogs. That such testing will be more expensive simply means a stronger rationale may be necessary to support this choice.

Given the knowledge that the majority of published results pertain specifically to dogs housed in laboratory kennels, previously cited research identifies a gap in published research. Therefore

the objective of this research thesis was to capture in-home palatability data by objectively gathering quantifiable intake measurement of the dogs' food consumption.

Human influence was also minimized with the automation of the data collection and appropriate survey development and implementation. While human perceptions of the food and the animals enthusiasm regarding the food could be captured in future research, it would not affect the quantitative data gathered with respect to the dogs' consumption of the food.

Effective length of the in-home test was also studied. No previous studies were available in published literature to understand if 2 day protocols would be effective for data collection in-home comparison testing. This research studies the differences in a 7 day protocol versus standard 2 day protocols.

CHAPTER 2 - A Method for Survey Development and Panel Recruitment for In-home Feeding With Companion Dogs

Abstract

Palatability of pet foods traditionally has been determined by using animals in laboratory settings. Pet food manufacturers often employ a two pan test to judge the acceptance and preference of their products. The purpose of this project was to develop a screening survey that could be used to effectively recruit a canine panel to perform palatability tests in the home environment using electronic equipment to capture and analyze the results of the palatability tests. One hundred and eighteen consumers responded to a survey in order to understand their level of commitment to participation and willingness to feed different types of commercial products to their dogs. Dogs were screened for general good health, ability to be isolated in the home when eating, and age. Twenty-five dogs of different ages, breeds and sizes were selected to participate on the in-home panel. Seven different palatability tests were performed on the in-home panel and four of those tests were replicated. These dogs were tested using proprietary technology, which collected information about intake of each food for each individual dog for a duration of seven days. Results indicated that the screening questionnaire could be an effective tool for recruitment with minor modification.

Introduction

A recent study published by the American Pet Products Association (2012), reports that the number of households with pets has increased from the 2008 study by 1.5% to 46.3 million households. There are many reported benefits of having a dog: companionship, unconditional love, and enjoyment of watching and having an animal in the household. Many owners in this survey perceive their dog as a child or family member.

In addition to the increasing number of households, costs for food, care and medicine has increased to 32% from 25% from the 2008 APPA survey results. Average food expenditures were reported to be \$254 annually (APPA 2012). Research shows that 70% of dog owners recognize their pets as part of the family (APPA 2012), therefore there is a belief by pet food manufacturers that dog owners are concerned about how their dogs enjoys their eating experience. These questions generally are answered by using palatability tests. Most commercial dog food manufacturers maintain kennels to evaluate nutritional quality and palatability of their pet products (Waterhouse, Fritsch 1967).

The most common method of assessing palatability in dogs is with the two pan test, which involves comparing the consumption of two different foods (Araujo, Milgram 2004). The hypothesis is that the dog will consume more of the food that tastes better, thus the dog prefers the food that has a higher consumption.

Griffin et al., (1984) directly compared food preferences of dogs housed in testing kennels and in consumers' homes. They stated that preferences of kennel dogs are assumed to be indicative of the preferences of dogs living in-homes. They also reported that dog owners' evaluation of a particular product is assumed to be strongly influenced by the eating behavior of their dogs.

Smith et al., (1983) also studied the owners' perception of food flavor preferences of pet dogs in relation to measured preferences of laboratory dogs. In these experiments owners interpreted the dogs' responses to indicate preference of the foods tested. The conclusions of this study were differing preferences for the same test foods between the two test populations.

When animals are tested in kennel settings, there is an assumption of no human influence on the animal's food choice. One potential negative of in-home testing is bias that may be introduced

by the pet owner. A study published by Prato-Revide et al., (2007) provided evidence that dogs can be influenced by their owners even when their indications are clearly in contrast with direct perceptual information, thus leading dogs to make counterproductive choices. Thus, protocols must be clearly defined in order to avoid this type of bias.

However, questions arise regarding the reliability of laboratory palatability test results when used in the context of predicating palatability preferences for the broader canine population. There is a need to examine typical feeding behaviors in pet dogs within the context of the home environment. Great strides have been made in the development of methodologies to quantitatively measure palatability and preference of dog food.

A better representation of the real world would be obtained by conducting palatability tests among a group of randomly selected home dogs. While this approach to testing could be more expensive, the concept of more representative data may be enough to compel researchers to conduct the comparison.

Thoughtful consideration and preparation of the screening survey is extremely important to obtain clear responses from potential panelists. Bradburn et al., (2004) report that the format of the questionnaire determines how easy it is for interviewers, respondents and data processing personnel to read and understand the questions and the kind of answers required. The quality of the data becomes heavily influenced by the questionnaire format (Sanchez, 1992).

Bradburn et al., (2004) discussed the importance of typefaces as they should be sufficiently large and clear as to cause no strain in rapid reading for all potential respondents. They also report that all questions should be numbered in order to avoid skipping questions. Numbering the

questions also provides a visual cue to the respondent to indicate how long the survey is so they know how much time it will take to complete the survey.

Additional suggestions taken into consideration were question organization on the page. A question that can fit on a single page should never be split between two pages or two screens. Single columns of questions are necessary as multiple columns on the paper interferes with standard English reading patterns of left to right and top to bottom (Bradburn et al., 2004).

No information was found on the development of screening questionnaires to select participants for home testing of companion animals for feeding trials. Thus, the objectives of this research were 1) develop a survey for dog owners to screen candidates and 2) conduct a trial to examine effectiveness of the screening questionnaire to recruit a panel for and successfully complete an in-home trial of dog food palatability.

Materials and Methods

Subjects: Approximately one hundred and fifty Hill's Pet Nutrition Center and five hundred Hill's corporate employees were surveyed initially using a screening questionnaire developed for this project. These participants constitute a convenience sample of potential respondent.

Because the purpose of the study was to examine the effectiveness of the screening questionnaire to aid in selecting household that could participate, the sample is adequate.

Survey:

There were three sections of the survey. The first section gathered information about the participants' household and the dog that would participate in the study (Figure 2.1 and 2.2). The second section asked questions regarding current feeding information (Figure 2.3 and 2.4). The

final section provided detailed information about the study and, given this information, asked about willingness to participate (Figure 2.5). SurveyMonkey®, an online survey generator, was used to create the survey and manage responses. A brief outline of the survey is given below. Bradburn et al., (2004) reported that computer assisted interviewing methods have grown in popularity for a number of reasons, including; ease of interviewee response not dependent on an interviewer; elimination of skip errors thus improving the quality of data; eradication of interviewer bias; faster results; integration of images, sound and video; automated data entry and; removal of errors caused by interviewers.

Survey Section One:

General Description of Study:

Demographic and Contact Questions:

- Human Panelist Name
 - E-mail and phone number
- Household
 - Age of humans in household
 - Number of dogs in the Household
- Dog Information
 - Name
 - Gender
 - Age
 - Breed
 - Weight
 - Health

Section Two:

Feeding Information:

- Members of household who feed dog
- Frequency of feeding
- Location of feeding
- Type of food currently eating
 - Form(s) and product(s)
- Amount of food eaten daily
- Dog behavior towards food

Section Three:**Study Description:**

- Types of products being tested
- Duration of test

Participation Expectations for Humans:

- Return data to researchers in a timely fashion
- Participate in follow up surveys

Informed consent is a respondent's implicit or explicit agreement to participate in the interview after being informed of the nature of the task (Bradburn et al., 2004). In this research, informed consent was provided to participants..

The purpose of the study was provided to help the prospective participants understand the objective of the study. Households with multiple dogs in the home were encouraged to respond, but were asked to respond with information about the dog in their home that they felt best suited the palatability study.

Results and Discussion

Based on what the researchers knew about palatability testing in a laboratory setting, there were several pieces of information that was considered to be imperative to recruit a robust panel.

- The feeding apparatus (US patent # 20120199076) was an automated, computerized feeder with weighing scales that sits on the floor. In order to avoid potential for damage to the equipment, homes that had children under 5 years of age were eliminated.
- Data needed to be collected from an individual dog. It was important to ensure that a dog in multiple dog households could be isolated during the feeding time, so the data that was reported was for individual intake and not confounded by other dogs eating out of the same bowls.
- Age of the potential canine panelist also was important. Feeding a variety of life stage foods to growing puppies would not be in their best nutritional interests. Conversely as dogs advance in age, specifically over 10 years old, they may have issues with their teeth or other strict nutritional considerations, thus these dogs were not ideal for the objective of this particular pilot study. This is not to say that either life stage does not warrant in-home palatability results, but for general studies those dogs should be eliminated and included only when the specific objective calls for dogs of that type.

- Dogs in palatability tests generally are fed once per day. It was important to ensure that owners were either already feeding or willing to feed dogs in the in-home study once daily.
- Dogs needed to be fed indoors in order to protect the feeding apparatus.
- Considerations were also taken for the type of food the dog was currently eating.
 - A dog eating any veterinarian *prescribed* diet was eliminated from consideration from the study.
 - Because the focus of this study was dry dog foods, any dog eating wet foods were eliminated from the study.
 - Dietary history can influence an animal's response to palatability tests, specifically when comparing an accustomed product to a less known product (Larose 2004). Thus, information about what types of diet(s) the panelists were eating at the time of questioning also was gathered.
- Behavior of the dog related to eating also was taken into consideration. Owners were asked to identify the severity of their dog's reactions to food. Because the food was removed after 45 minutes of feeding, dogs that had an aggressive reaction to food removal were excluded from consideration.

Because previous internal research had shown that Hill's® Pet Nutrition employees are loyal to the Science Diet® brand, some potential participants were uncomfortable feeding competitor diets to their pets. This could be true for any population; thus an exclusion related to an

unwillingness to feed an unbranded, unknown (though safe and nutritious) food to their pets was required.

Since this was a pilot study, the request to the participants was made to answer surveys about their opinion of the study and the feeding apparatus. Participants were excluded if they were not willing to participate in these surveys or return data to the researcher in a timely fashion.

One hundred and eighteen survey responses were received. Of these responses, 78 respondents were excluded from participation. The largest two exclusions were age of the pet and children under five years of age living in the household. Figure 2.6 further details the summary of exclusions.

As the recruiting process progressed, additional exclusions were incorporated (Figure 2.7).

Sixteen participants provided logistical challenges for the pilot study. When the feeding studies started, it was noted that two dogs were not eating an appropriate amount of food in the specified duration of the test. One dog was rehomed during the test. The final dog, a toy poodle, was not tall enough to eat out of the feeding apparatus.

A total of 20 households participated in the study, with 4 households using additional feeders for different dogs in their home. It should be noted the survey description that one dog per household was requested. As the feeding study progressed, multiple dog households were allowed to use two feeders with the understanding that the human participant would closely monitor the dog(s) eating during the study to ensure that the data was truly of one dog's consumption of the food.

Thirteen female and twelve male dogs were designated for participation in the study. Nine of the female dogs and ten of the male dogs were between the ages of two and six years of age and

classified in the Adult life stage while the remaining four female dogs and two male dogs were over six years old and less than 10 years old and were classified in the Mature Adult life stage.

Size classifications of the dogs were determined by weight of the dogs (Figure 2.8). According to the Hill's® Key to Clinical Nutrition, small dogs are classified as dogs that weigh less than 26 pounds, medium dogs weigh between 26 and 55 pounds, and large dogs weigh more than 55 pounds at maturity. The 25 dog panel contained seven small and medium sized dogs, four female and three male in each category. The remaining 11 dogs were classified as large, five female and six male.

A number of different breeds were represented on the in-home panel (Figure 2.9). Of the 25 panelists, four were mixed breeds and three were Labradors. There were one of each of the following breeds on the panel; Shetland Sheepdog, Boxer, Miniature Pinscher, Greyhound, Australian Shepherd, Siberian Husky, Cockapoo, Coonhound, Pit Bull, Golden Retriever, Cocker Spaniel, Rat Terrier, Blue Heeler, English Mastiff, Dachshund, Italian Greyhound and Basset Hound.

Nationally, 57% of households own a male dog(s) and 61% percent of households own a female dog(s) (APPA 2012). The in-home panel was similar in division of gender as 48% of the dogs represented were male and 52% of the dogs were female.

Comparisons between sizes of dogs nationally versus those on the in-home panel cannot be made as the two scales used to determine the categories were different. The APPA survey (2012) classified small dogs under 25 pounds, medium dogs between 25 and 40 pounds and large dogs over 40 pounds.

Fifty-eight percent of dogs owned are classified as pure bred, while 56% of dogs owned are mix breeds (APPA, 2012). The in-home panel recruited 84% pure bred dogs and 16% mixed breed dogs for participation.

Life stage of dogs in the United States could not be compared as average age of domestic dogs was not reported in the APPA survey. The in-home panel did have considerably more adult dogs (76%) than mature adult dogs (24%). It is important to remember that puppies were excluded from participation so as not to disrupt their development.

Sixty percent of households in the United States own one dog, 28% percent of households own two dogs and the remaining 12% own three or more dogs (APPA, 2012). The number of dogs owned in each household on the in-home panel represented more dogs per household than the national average, with 15% of participating household owning one dog, 40% of households owning two dogs and the remaining 45% owning three or more dogs (Figure 2.9). Each dog was isolated during the feeding session, so feeding intake data was not compromised.

All panelists were Hill's® Pet Nutrition employees' personal pets. Questions in the screening process asked what specific diet that the pet owner was feeding their dog. One hundred percent of the panel was eating a Hill's Science Diet® product at the launch of the study.

When comparing the demographics of the in-home panel to the United States dog owner demographics, gender distribution was accurately reflected on the in-home panel. The number of dogs in the household and breed of dog were not similar to the national demographics. Sizes of dogs nationally could not be compared to the population of the in-home panel due to classification differences.

A number of new developments were realized in this pilot study.

- The height of the dog is an important factor to consider. If a dog is not tall enough to eat out of the apparatus, they could either be eliminated from consideration or the apparatus would need to be retrofitted to accommodate their height by using smaller, shorter bowls for feeding.
- A question should be asked about the dog's enthusiasm when being fed. If a dog free feeds, meaning the food is available throughout the day, they would not be eligible for this type of in-home study.
- Logistics of mailing or shipping food and the feeding apparatus were not addressed specifically in this study. This will be needed to be strategically investigated for budgetary purposes and also the integrity of the test. Will the feeding apparatus withstand the stresses of shipment? How will food be delivered to different regions in different climates? Will the food be shipped to a centralized distribution location or sent directly to the participants' homes?

Another important topic that this research did not explore in depth was the area of panel reimbursement. An early study published by Allison et al., (1958) stated that panelists received a \$10 prize selected from a prize catalogue for a yearlong commitment to the consumer panel. Maintaining membership on this panel was supplemented by sending newsletters, unanticipated prizes and visits, phone calls or letters covering personal matters such as birthday wishes, birth congratulations and death condolences.

Initially, the compensation for this study was free pet food for the duration of the study. This is a common incentive for in-home long-term feeding trials. As previously stated, this panel was composed of Hill's® Pet Nutrition Employees. A benefit provided to the employees is the

opportunity to buy Science Diet® food at a discounted price. An early criticism from the panelists was that the free food provided for the study was not enough incentive to keep them interested in participating on the panel over the multi-month period required for this study. Thus, intermittent rewards were implemented. A \$5 gift cards was given at the half way point of the study to show appreciation for the panelists' efforts. When the panelists completed the tests, \$10 gift cards were distributed to all panelists and they were entered in a drawing for a \$75 gift certificate. At the conclusion of the study, only one of the participants reported that they would not participate again if given the opportunity.

Additional research would need to be performed in order to understand what type of reimbursement would be sufficient for a set of external panelists. Is the notion of free super premium pet food enough for what could be an ongoing duration of in-home palatability tests? What other types of rewards would need to be budgeted? A focus group of potential in-home panel participants outside of the Hill's Pet Nutrition employee pool could be used to understand what expectations for reimbursement would be.

Sansink and Sudman (2002) state that technology will not only influence the way in which data are collected, but it also will influence the sociology of how panelists, researcher and managers respond to these data. Specifically, the ability to 'reference and reinforce' will make the panel experience more personalized and more efficient. A consumer will see their dog's name on the computer screen and will feel more connected to the test. The objective of this added personal reference is to show familiarity with the panelist and reinforce the notion that the panelists' answers are important and that they are remembered.

Sansink and Sudman (2002) also address the notion of how technology can facilitate a researcher's ability to develop a global perspective. The launch of global pet food in-home palatability panels is now possible due to these advances in technology. Language translation software or a local business unit will need to be employed for the screening survey and troubleshooting any issues that may arise in the execution of the palatability tests. Budgetary funds will need to be allocated to shipping the food and feeding apparatus to the panelists' homes. It is up to the researcher to determine if the amount of resources to undertake this global panel is worth the value of the data you would receive in return.

Conclusions

The scope of this research was fundamental, yet broad. The objective of the study was to develop a questionnaire to use in the recruitment of a functional in-home dog palatability panel. While this objective was achieved, valuable wisdom was gathered in this research.

Five pages of screening questions may have fatigued the preliminary population of possible dog owners, thus extinguishing enthusiasm about completing the questionnaire. Future research studies may include questions regarding the population of the household, both human and animal information, and feeding situations for the animal(s) in that household. The researcher will need to identify any disqualifications based on the household environment of potential panelists to ensure that the objectives of their particular study are met.

General questions about the health and age of the dog serve to provide important information about the potential panelist. In this study, comprehensive information was collected about the date of the animal's last wellness exam and diagnoses of health issues. While this provides a certain protection from liability, the questions were not an effective way to capture this

information. This type of information could be determined by the type of food the dog was currently eating, veterinarian prescribed versus commercially available. The objectives of the specific study determine the type of population the researcher desires to recruit.

The need to know how much of food the dog was provided on a daily basis in this study was also an unnecessary question to ask in the screening questionnaire. This study used nutritional guidelines from the Hill's® Key to Clinical Nutrition for each diet studied and applied those recommendations to each individual panelist's specific nutritional needs.

Imperative information to communicate to prospective panelists was the duration of the study and the rewards associated with participating and completing the study. This information should not be excluded as to ensure full disclosure of the researcher's expectations with the potential panelists.

Further research advocates the application of this recommended simplified questionnaire to a pool of cat owners. This would help pet food industry professionals understand how to recruit a similar in-home palatability panel for cats and identify any important differences between the two populations of pet owners.

Figure 2.1 Participant Screening Survey, Section 1 Page 1

Survey Description

The purpose of this survey is to screen candidates for an upcoming in-home feeding study. If you have multiple dogs in your household, please answer these questions keeping in mind the dog in your household that would be best suited for a feeding study. Only one dog per household is able to participate in the study.

In the first section of the survey, we would like to gather some information about your household and specific information about the dog that would participate in the study.

1. Please enter your first and last name.

2. Do you have children under the age of five in your household?

Yes

No

3. How many dogs do you currently have in your home?

1

2

3

4

5+

4. If you have multiple dogs in your household, can the feeding study candidate be fed in a room without interruption from the other pets in your home?

Yes

No

I only have one dog

5. What is your dog's name?

6. Is the dog male or female?

Male

Female

Figure 2.2 Participant Screening Survey, Section 1 Page 2

7. How old is the dog that you have in mind to participate in the study?

- 0-1 Year Old
- 2-5 Years Old
- 6-10 Years Old
- 10+ Years Old

8. What is the breed of the dog that is a candidate in the feeding study?

9. How much does this dog weigh (lbs.)?

10. When was your dog's last wellness exam?

- 0-6 Months Ago
- 7-12 Months Ago
- Over 12 Months Ago

11. Was your dog considered to be in good health?

- Yes
- No
- Other (please specify)

Figure 2.3 Participant Screening Survey, Section 2 Page 1
Feeding Information

In the second section of the study, we would like to gather information about how you currently feed your dog.

1. Who is the person in your household that is responsible for feeding your pets on a daily basis?

- I am
- Another adult in the house
- Other (please specify)

2. How often do you feed your dog?

- Once Daily
- Twice Daily
- More Than Twice Daily

3. If you feed your dog twice daily, would you be willing to feed them once daily in order to participate in a feeding study?

- Yes
- No

4. Is your dog fed indoors?

- Yes
- No

5. What type of diet does your dog currently eat?

- Dry
- Wet
- Both Wet and Dry

6. How many diets does your dog currently eat?

- 1
- 2
- More Than 2

Figure 2.4 Participant Screening Survey, Section 2 Page 2

7. Please select the brand of food that your dog eats.

- Hill's Prescription Diet
- Hill's Science Diet
- Both
- Other Brand

8. Please type the name of the diet(s) your dog currently eats.

9. How many cups do you feed your dog at each meal?

10. Does your dog have any conditions that preclude feeding him/her a variety of products?

- Yes
- No

11. Is your dog prone to weight gain?

- Yes
- No

12. In your opinion, how aggressively does your dog behave in regards to food. Select the severity of the reaction below.

- No aggressive reaction: Can easily take a bowl of food
- Slight reaction: Slight struggle to take a bowl of food, but no fear of injury
- Aggressive reaction: Dog growls and/or snaps if you reach for food

Figure 2.5 Participant Screening Survey, Section 3 Page 1

Study Details

As part of planned the studies, we may be feeding competitive product along with Hill's products. Food will be provided for the studies.

1. Knowing this, would you be willing to participate in the feeding studies?

- Yes
- No

2. If selected for the study, you will be provided a feeding station that will collect data about your pet's eating preferences. This information will be collected on a USB drive and will need to be returned to Hill's Pet Nutrition Center weekly. Would you be willing to make sure that the drive is delivered promptly?

- Yes
- No

3. Would you be willing to answer questions, via a secure Internet site, about you and your dog's opinions and reactions to the food?

- Yes
- No

4. The anticipated duration of this study is 16 up weeks. During the study, all food will be provided. Would you be willing to commit to this amount of participation?

- Yes
- No

5. Do you have any questions regarding this study?

6. If you are willing to participate, please type your phone number and e-mail address in the box provided below.

Figure 2.6 In-home Panel Summary of Participant Exclusion

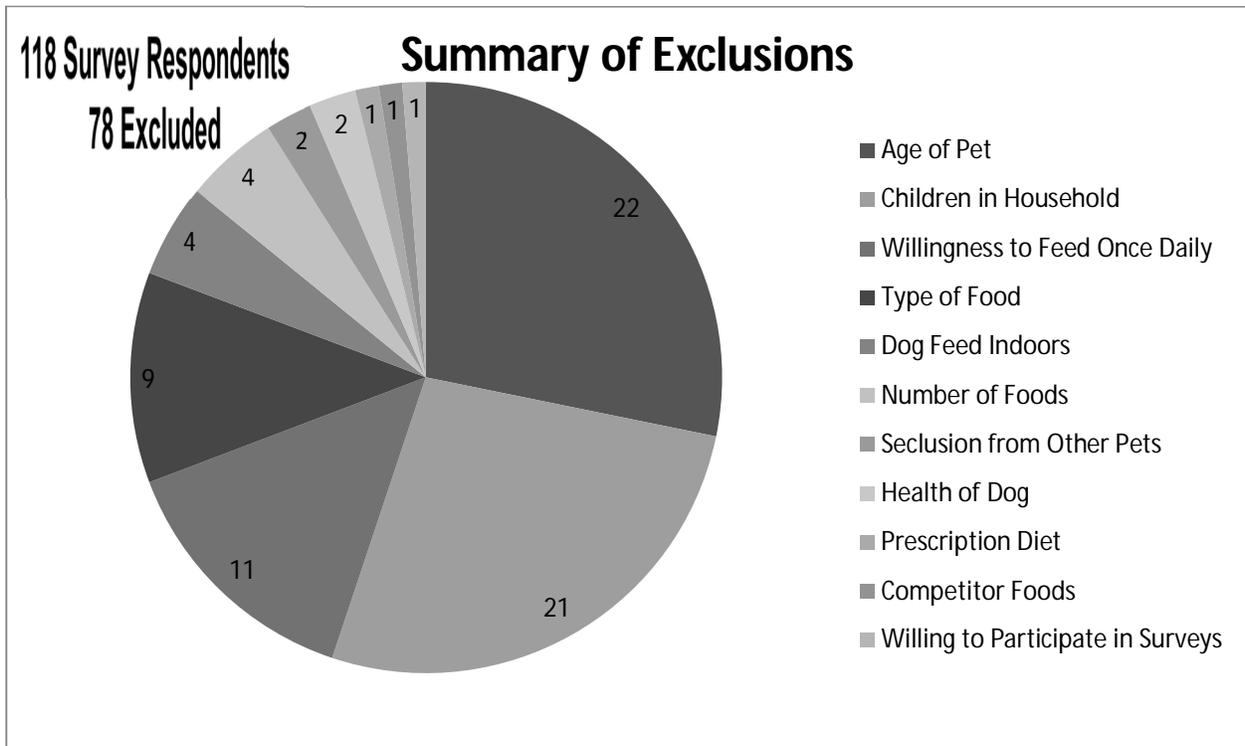


Figure 2.7 In-home Panel Additional Exclusions as Study Progressed

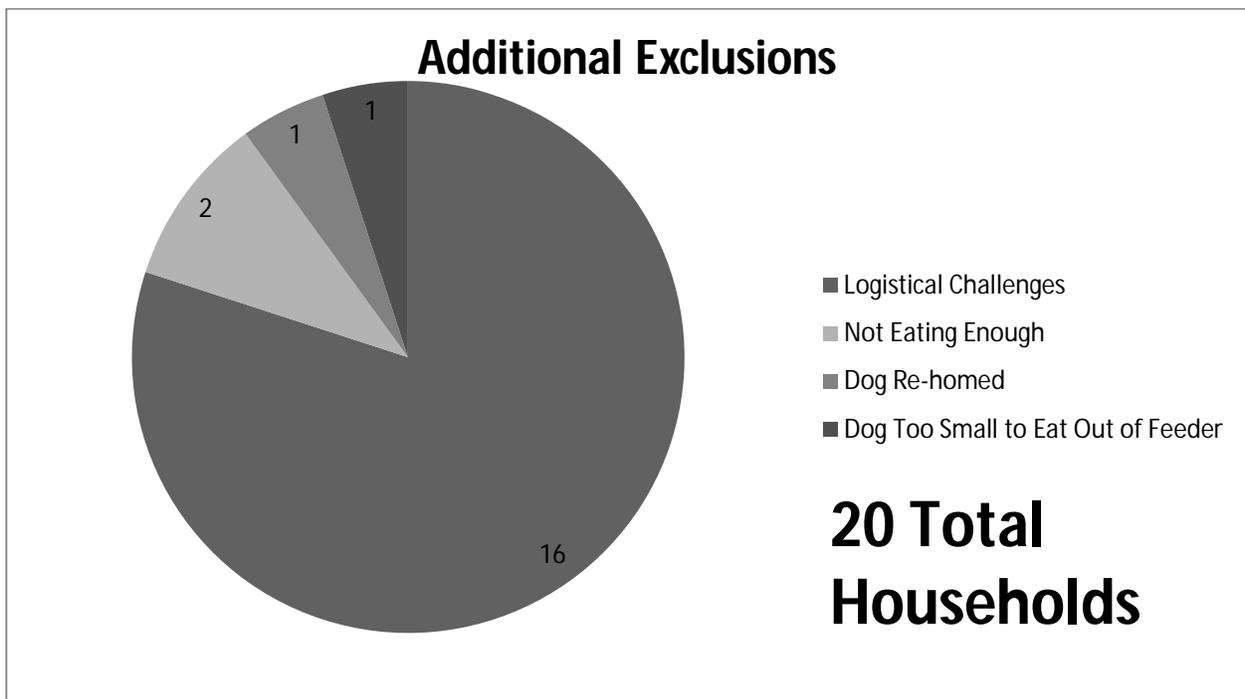


Figure 2.8 In-home Panel Size Classifications

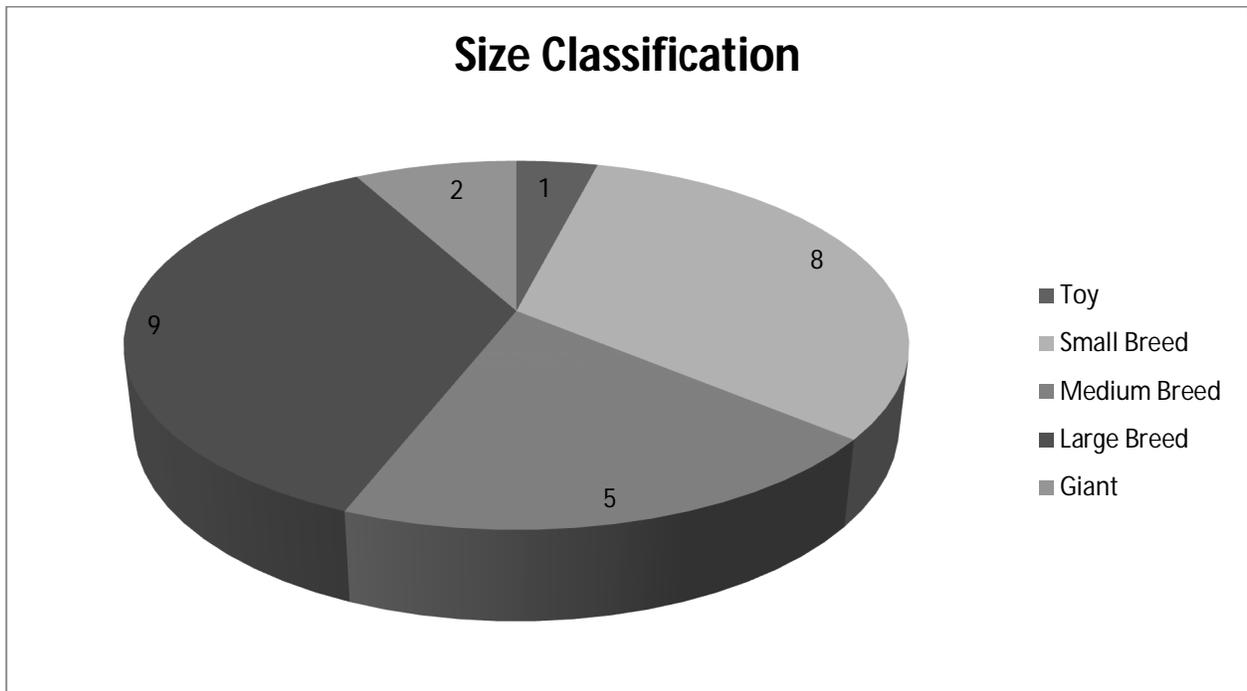


Figure 2.9 In-home Panel Number of Dogs in Household

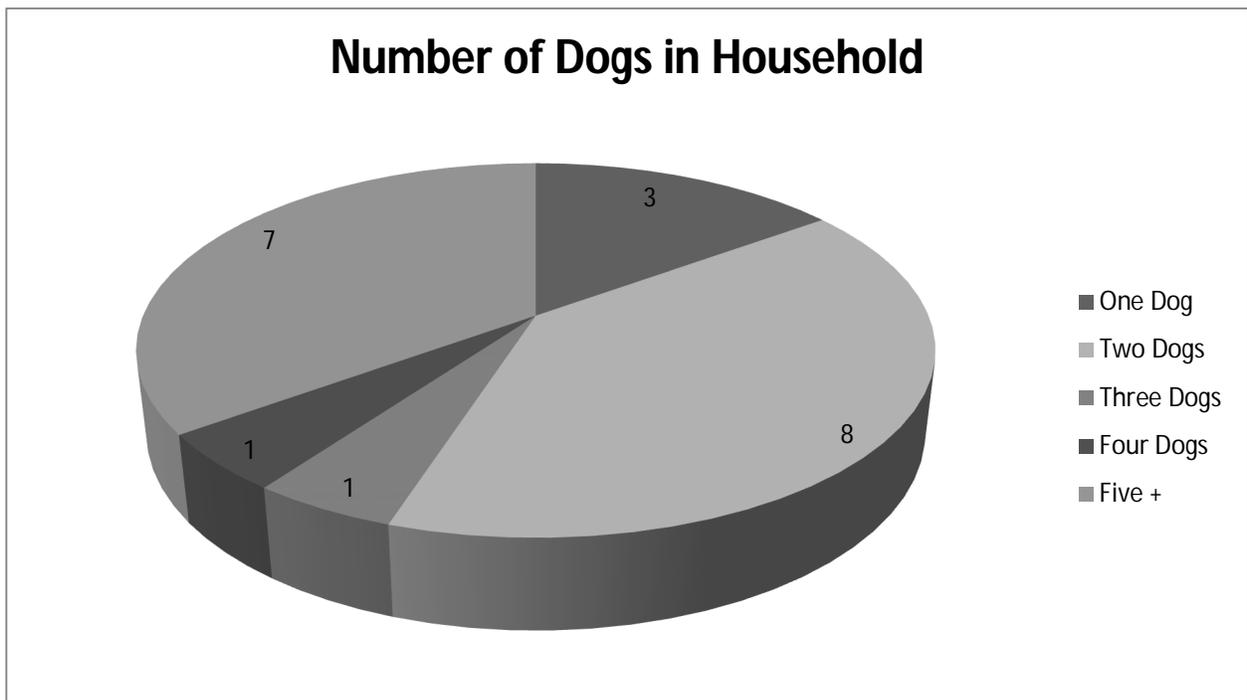
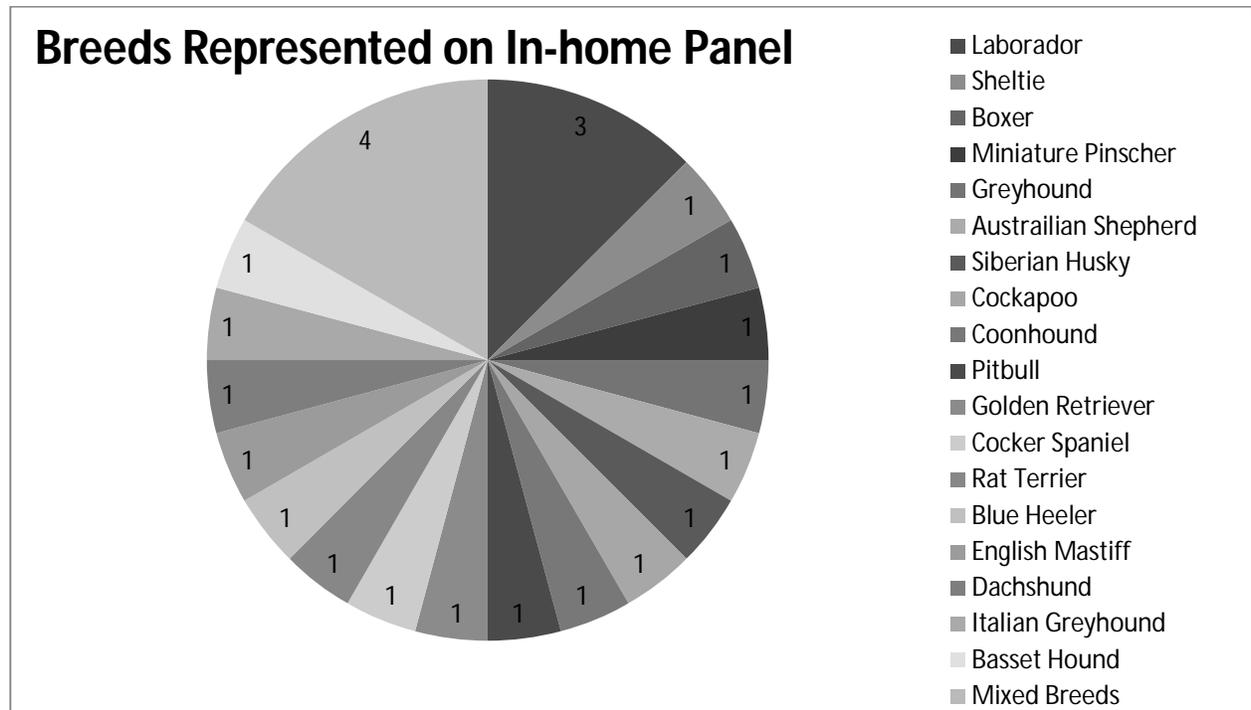


Figure 2.10 In-home Panel Breed Representation



CHAPTER 3 - A Two Pan Home Feeding Trial with Companion Dogs: Considerations for Future Testing

Abstract

Scientists in the pet food industry leverage the use of animals in colonies to judge the palatability of pet foods. These tests vary from single monadic feeding to judge if a dog or cat will eat the food to multi day multi-food comparisons. Often, pet food manufacturers would like to understand how palatable a food is compared to another food. This generally is accomplished by a two pan test where a pet has the opportunity to freely choose between two foods. Preference is evaluated through the use of an intake ratio, the ratio of the amount of test food consumed divided by the total amount of the foods consumed. Although this is easy to do in laboratories, another option would be to do such studies with animals in more ‘real-life’ home environments. The purpose of this study was to develop and test a method to capture feeding information from a study of canines in the home environment and analyze the results of the palatability tests. Individual dog owners were screened for information on the household and pets. Twenty-five dogs of different ages, breeds and sizes were selected to participate on the in-home panel. Seven different palatability tests were performed using the in-home panel with four of those tests being replicated; a total of 11 comparative tests. These dogs were tested using a proprietary computer-based technology that collected information about intake of each food for each individual dog for a duration of seven days for each of the 11 comparative studies. Data was analyzed and resulted in showing that differences between foods can be found. Statistical analyses compared initial day one data to subsequent day data collected during each study to determine whether a full seven day test was needed. In addition, comparisons were made to compare the impact of prior foods eaten to subsequent preferences of the dogs. Results of the in-home panel were the same on day one as for all seven days of testing. Also, previous exposure to a food did not alter

subsequent preference for that food. Such data has implications for pet food manufacturers related to timing and cost of testing.

Introduction

According to the 2011-2012 National Pet Owners Survey, there were 46.3 million households owning dogs in the United States (APPA, 2012). That was an increase of 1.5% from the 2008 survey. Ninety-four percent of dog owners reported companionship and love as a benefit of owning a dog and 77% of dog owners proclaim that dogs are fun to watch and have in the household. In addition, 70% of dog owners perceive their dog as a child or family member. Because the number of households that own a dog is increasing, it stands to reason that the amount of dollars spent on dog food also is increasing. Average annual food expenditures were reported to be \$254 in the 2011-2012 survey. This expense was fourth on the list of average annual expenses for all dogs owned, only surpassed in average dollars spent by surgical veterinarian visits, which were reported to be \$407, grooming from a mobile service, which averaged \$303, and boarding expenses, reported to be \$274 (APPA, 2012).

The majority of dog owners perceive their dog as a member of their family and a large portion of dollars spent on dog ownership is due to food expenses. Thus, it is reasonable to expect that dog owners are concerned about how much their dogs enjoy the eating experience.

Premium dog food is one of the fastest growing segments globally with a reported 9% increase (Taylor, 2011). It was reported that natural, premium and gourmet dog food are more likely to be purchased by owners who take their pet to the veterinarian more often (APPA, 2012). There is a perception among some dog owners and even some veterinarians that dog foods sold in grocery stores are inferior in quality to those sold in pet specialty outlets (Sanderson et al., 2005). Sanderson et al., (2005) asked owners to complete a questionnaire soliciting information on

home environment and dietary history prior to enrollment of their dogs in the study. Additional information obtained about the dog during the study included how well the dog ate the study diet; the dog's overall attitude, energy level, fecal consistency, frequency of defecation, hair and coat quality, and body condition. The owner was also asked about any adverse clinical signs encountered while feeding the study diet and whether the owner would consider feeding the diet on a long-term basis. This particular study resulted in an indication that when unaware of retail price and source, owners have similar impressions of three premium diets fed to healthy adult dogs, suggesting that factors other than the diets themselves may affect owner impressions. Palatability is generally defined as a measure of subjective food preference (Araujo, Milgram 2004). Although palatability generally determines whether an animal will consume the food, preference is a measure of the likelihood of ingesting one of two available foods under very specific conditions (Griffin, Beidler 1984). Thombre (2004) defines acceptance or voluntary acceptance as the notion that the animal voluntarily takes the food into the mouth and consumes the food.

It is standard in the pet food industry for manufacturers to maintain kennels for testing of nutritional quality and palatability of their pet products (Waterhouse, Fritsch 1967). Griffin et al. (1984) noted the assumption that the preferences of dogs housed in these types of testing kennels can be projected to be true of the preferences of domesticated companion dogs.

Araujo and Milgram stated in 2004 that the consumption of two different foods in one presentation is the most common method of assessing palatability in dogs. This is more commonly known as a two pan test. The hypothesis is that the dog will consume more of the food that tastes better, thus the dog prefers the food that has a higher consumption.

The two primary pet food assessment tools are the one-pan acceptance test (monadic test) and the two-pan preference test. The one-pan test measures acceptability, while the two-pan preference test measure “choice” between a pair of test foods that are fed simultaneously side by side (Hatcher et al., 2010).

A study published in Preventative Veterinary Medicine (Bland et al., 2009) reported that of the 302 dog populations studied, 60% of the owners fed them twice a day, 33% fed once a day, 2% fed greater than or equal to 3 times daily and 5% fed free choice, where the food was always available. Additionally, 99% of these owners fed treats daily.

The test protocol employed in this research is based on the two pan feeding in which the two foods are placed in individual bowls and presented simultaneously to the animal, and often is replicated on a subsequent day. Amounts of the foods are based on the animal’s weight. In the traditional two pan test, the dog is given a predetermined amount of time to consume the daily caloric amount, which can be all of either of the foods or a combination of the foods. When this predetermined amount of calories have been consumed, the pans are removed and the remaining food is weighed and recorded. On the second day of feeding, the bowl position is switched in order to avoid a sided bias. The testing and data protocol is repeated on that second day. When the two day test is completed, simple calculations of intake are computed to judge the animal preference of the foods presented. Total consumption of each food is recorded and specific ratios are calculated.

Preference can be determined from the intake ratio of the test food. Intake ratio is calculated by the following equation:

$$\textit{Intake Ratio} = \frac{\textit{Test Food Consumed}}{(\textit{Test Food Consumed} + \textit{Control Food Consumed})}$$

An intake ratio of 0.50 would indicate no preference between the two foods. The dog ate exactly the same amount of each food, while a one or a zero result indicates the dog ate the entire test or all of the control food, respectively.

As the panel preference is investigated as a whole, the same calculation for intake ratio is used. The total amount of test food that was consumed by the panel is divided by the total amount of test and control food consumed by the panel. This final intake ratio is used to understand the panel preference of the test food as compared to the control food.

A Student's t-test is conducted using a 95% confidence interval to classify palatability results. In the statistical analysis of the data the relative hypothesis are determined as:

$$H_o: IR < 0.50$$

$$H_a: IR > 0.50$$

The p-value is the final judgment in the categorization of the test. A p-value of less than 0.05 expresses that the intake ratio of the test is either greater than or less than 0.50, with a 95% statistical certainty. The verdict of the test is then determined by evaluating the intake ratio of the test food to determine how to interpret the results of the palatability test.

Preference also can be captured by understanding the number of animals that preferred the test food and the number of animals that preferred the control food. The preference can be stated in percentages of the panel participants. For example, if five dogs preferred the test food and 20 dogs preferred the control food on a 25 dog panel then the preference would be stated as 20/80, with 20% of the panel preferring the test food and 80% of the panel preferring the control food. Animals that are reported as eating no food or do not eat a reasonable predetermined amount of food typically are excluded from the analysis and considered invalid.

Smith et al., (1984) discussed the idea of modern computer technology being used to effectively capture data about eating behavior of dogs. The article classified this type of information as fine-grained or cumulative amounts of food eaten on a moment-by-moment basis during the test. The results of those experiments indicated that fine-grained measurements of feeding behavior in one and two pan tests can provide quantitative information about individual differences in the feeding styles of dogs (rapid eaters vs. slow eaters), the ways dogs distribute their feeding between two foods in a choice test, and any disruptive effects of the introduction of a new diet. This research provides further justification for the notion of gathering data in-home, using improved technology, to collect these fine-grained measurements to truly understand pet dogs eating behaviors.

Advantages of using an automated system are many. This automation of the specified data collection provides a means of gathering data in a home setting in a standardized manner. The use of an automated system also reduces human error in the application of the test. For example, the system will know that the proper weights of food have been provided to the pet in an in-home setting. The automated feeding station also reduces the human observations that may bias the palatability results through capturing quantitative and reliable intake results. Finally, the automation of capturing intake greatly reduces transcription error of observations.

The topics addressed in this research were to 1) develop and describe a test method for palatability testing of dogs in domestic situations, 2) execute multiple tests to validate the potential for the methodology finding differences in various food choices, 2) evaluate the number of animals and number of days for testing and 4) understand if preference was effected by naïve exposure versus dogs that had been pre-exposed to the foods tested.

Materials and Methods

Subjects: Pets were screened for appropriate age qualifications, i.e. no puppies or super seniors were included, and were to be in good health at the beginning of the study. Companion dogs were to eat only dry foods that were not veterinarian prescribed. Pets that had an aggressive reaction to removal of food also were excluded from consideration.

Households were excluded from consideration if there were children under 5 years old in the home. Human participants had to agree to feed their pets once daily and indoors. They also had to be willing to participate in questionnaires and group discussions about their experiences with the studies.

All dogs were owned by Hill's® Pet Nutrition Center Employees and were housed at the employees' respective homes. Animals were fed once daily and water was available ad libitum. Owners were encouraged to maintain the animals' everyday routine. Exercise and treating was permitted. No health problems were reported throughout the duration of the study.

Thirteen female and 12 male dogs were designated for participation in the study. Nine of the female dogs and ten of the male dogs were between the ages of two and six years of age and classified in the Adult life stage. The remaining four female dogs and two male dogs were over six years old and less than 10 years old.

Size classifications of the dogs were determined by weight of the dogs. According to the Hill's® Key to Clinical Nutrition, small dogs are classified as dogs that weigh less than 26 pounds, medium dogs weigh between 26 and 55 pounds, and large dogs weigh more than 55 pounds at maturity. The 25 dog panel contained seven small and medium sized dogs, four female and three male in each category. The remaining 11 dogs were classified as large, five female and six male. A number of different breeds were represented on the in-home panel. Of the 25 panelists, four were mixed breeds and three were Labradors. One each of the following breeds also was

included on the panel: Shetland Sheepdog, Boxer, Miniature Pinscher, Greyhound, Australian Shepherd, Siberian Husky, Cockapoo, Coonhound, Pit Bull, Golden Retriever, Cocker Spaniel, Rat Terrier, Blue Heeler, English Mastiff, Dachshund, Italian Greyhound and Basset Hound.

Testing Apparatus: A proprietary automated feeding station (US patent # 20120199076) was employed to provide in-home collection of data pertaining to the intake amounts of foods over a specified period of time. Additional data collected included the first food consumed by the pet and rate of consumption of the foods that were provided in each test.

This device uses a two bowl feeding system with each bowl holding a specific amount of food for the pet in the test. Each food amount was calculated for the test subject using the feeding guidelines of the specific products being tested in combination with the age of the pet. The bowls were individually secured by a fabricated stainless steel bowl holder to two scales mounted within the footing of the feeding station.

Two individual bags of food were provided to the pet owner for each day of testing. The test and control foods were individually packaged in Uline® Model Number S-1888 9x12 2 millimeter white block minigrip bags. Attached to each bag was an Avery® White Shipping Label Model 5164, that identified specific information for each individual performing the test. The feeding study number, dog name and sample number were displayed clearly on the label. In order to avoid potential human bias, the product samples were blinded using a three digit numerical code. Feeding session number and food placement, left bowl or right bowl, were also identified on the label.

A barcode was printed at the bottom of the label. This barcode contained specific information that could be interpreted by the barcode scanner that was attached and stored in the computer processor, housed within the feeding station. The computer software was programmed to

understand how much food the dog was allowed to have presented to it in each bowl. If an error in the test information was found; for example, an incorrect amount of food was offered to the bowl, an error message was generated on the computer processor screen to alert the pet owner of the issue and the test was not allowed to proceed until the error was corrected. The computer processor also captured the fine-grained measurements of intake consumptions, with weights of each bowl of food being taken at five second increments. Upon completion of the test, the user was asked to export the data from the computer processor, using the touch screen to prompt the files to be exported to the USB drive.

The home feeding system did not have automated control of animal food intake (i.e. the bowls do not close when allotted amount of food is eaten), so the pet owner must be present during the test in order to observe the animal consume the food. An automatic indicator was visible on the touch screen when the animal had eaten their allotted amount of food for the test. The owner must then remove the animal from the feeding station area and touch the indicator on the screen to stop the data collection on the test. Arujo et al., (2004) noted that one limitation of two pan testing is the large portions provided during the two pan test may prove unhealthy for some animals over time, particularly animals that do not self-limit their food consumption. In this study the computer prompted the per owner to manually remove the food (or pet) when a predetermined weight of food was eaten by the dog.

Laboratory Feeding and In-home Protocols: Table 3.1 illustrates the comparisons of laboratory and in-home panel feeding protocols. Several aspects of the feeding protocols are similar.

Twenty-five dogs were used in both feeding tests. The laboratory and in-home protocols used a once daily, 45 minute feeding duration. Both procedures provide the individual dogs with two

choices of foods, in two separate bowls. In each protocol the food bowls are mounted on two scales, which communicate to a computer system.

Differences in the protocols were the calibration diets, the basis in which feeding amount was calculated and the duration of the test. In-home panelists were only fed commercially produced kibble, thus Science Diet® Adult was tested versus Science Diet Light® instead of the traditional coated kibble versus uncoated kibble calibration test. Feeding amounts were calculated on a kilocalorie basis using two factors, weight and activity level for the laboratory panel while the in-home panels food calculations were based solely on body weight. The panel at the Hill's Pet Nutrition Center tested foods for 2 days, while perceived potential variation on the in-home panel influenced the decision to increase the number of test days to from 2 to 7 days.

Adaptation Phase: Because this was an unfamiliar protocol, an adaptation period of seven days was used to introduce the pet to the apparatus. Owners were encouraged to continue to feed the dog's current diet, but divide the daily food amount by half. One half was then presented to the animal in the left bowl and the remaining half of the food was presented in the right bowl. This step not only helped the pet get used to the notion of a two bowl serving option, but also helped identify dogs that might be prone to a sided bias. Owners were urged to monitor their dog's reaction to the apparatus and report any stressful reactions to the apparatus or feeding procedure. Upon completion of the adaptation phase, dogs were evaluated for their ability to continue on the panel. If the dogs or owners were uncomfortable with the study, replacement panelists were identified and began the adaptation process.

Food Comparisons: A total of seven diet comparisons tested, with four additional tests being replicated at the end of the study for a total of 11 individual, seven day tests. The initial test run was a calibration test. This calibration test was performed to understand the ability of the

panelists to make a consistent choice. The in-home panel was presented with Science Diet® Adult Advanced Fitness Original Dry and Science Diet® Adult Light Dry. The null hypothesis of the calibration of this test was that the intake ratio of the test diet, (Science Diet® Adult Light Dry) would be greater than or equal to 0.50. The alternate hypothesis stated that the intake ratio of the test diet would be less than 0.50. The calibration phase was repeated mid study to ensure that dogs were still making consistent choices.

The additional diets were a variety of products available in the Science Diet® commercial line. All Science Diet® products were labeled as test diets. The identified test diets were Science Diet® Oral Care Dry, Science Diet® Adult Advanced Fitness Original Dry, Science Diet® Adult Healthy Mobility™ Dry, Science Diet® Puppy Healthy Development Original Dry, Science Diet® Mature Adult Active Longevity™ Original Dry, and Science Diet® Adult Light Dry. For the tests, comparison diets were selected from commercially available competitive benchmarks. Table 3.2 illustrates the number of in-home panelists which were consuming the identified test products at the launch of the study.

Data Analysis: The only bias-free method of quantifying and expressing preference results is based on the Intake Ratio (IR) (Griffin, 1995). $IR = A \div (A + B)$, where A and B are in individual animal's daily food consumption of each of two different foods. The intake ratio of A was labeled as the intake ratio of the test diet. In this research, the intake ratio was calculated for each individual dog using Microsoft Excel 2010.

A Student's t-test was then used to understand the statistical significance, using a 95% confidence interval, of the calculated intake ratio of the overall panel. The null hypothesis for this test was that intake ratio was greater than or equal to 0.50. Conversely, the alternate hypothesis for this test was the intake ratio was less than 0.50. SAS Software version 9.2

(Copyright 2002-2008 SAS Institute Inc., Cary, NC, USA) was employed to perform the Student's t-test on the feeding data collected for each test.

Hand et al., (2010) state that this intake ratio can be summarized for a group of animals in two ways; first any animal with a ratio greater than 0.51 can be classified as preferring Food A, where animals with a ratio less than 0.49 are classified as preferring Food B. Any animal that falls between 0.49 and 0.51 would be classified as having no preference. The result for the group can then be expressed as the percentage of animals preferring Food A, Food B and having no preference. This ratio can also be summarized for a group of animals by reporting the average intake ratio.

Preference was similarly calculated in this experiment by judging amount of food consumed of Food A as compared to Food B. If a dog consumed more of Food A than of Food B over the duration of the seven day test, then they were judged to have preferred Food A. Conversely, if a dog consumed more of Food B than of Food A over the duration of the seven day test, they were judged to have preferred Food B. If the dog consumed the exact same amount of Food A and of Food B, over the duration of the seven day test, they were judged to have no preference.

In-home panel members were deemed invalid for a number of reasons. Some examples of invalidation of data were missing data for at least one of the test days over the seven day test duration and inadequate total consumption in the forty-five minute test time. Overall panel test results were deemed invalid if over twenty-five percent of the panel was ruled invalid. None of the tests performed in this study resulted in invalid results.

Results and Discussion

Calibration Studies: The in-home panel initial calibration test resulted in parity, meaning that there was no difference between Science Diet® Adult Advanced Fitness Original Dry and

Science Diet® Adult Light Dry. The hypothesis of this particular test was that dogs would prefer Adult Original Dry product over the Adult Light Dry product as there is more fat coated on the outside of the Adult Original Dry Product. Careful interpretation of the data made sure that each individual dog was making a consistent choice, be it preferring Adult Original or Adult Light products over the seven day test duration.

One possible explanation for the resulting parity of the foods in this initial study is the products are, in fact, at parity and there is no actual preference among the products. An alternative explanation is that the adaptation period to the feeding apparatus was insufficient. Perhaps a longer warm up period for the dogs to get used to the station would have resulted in the expected outcome. Nine dogs on the in-home panel were consuming Science Diet® Adult Advanced Fitness Original Dry, Science Diet® Adult Advanced Fitness Original Dry Large Breed or Science Diet® Adult Small & Toy Breed Dry at the onset of the study. Of these nine dogs who were previously consumed a version of a commercial Science Diet® Adult product, only three dogs preferred the Adult product over the Light product. Two dogs who consumed an Adult type product had data that was considered invalid.

Two dogs on the in-home panel were consuming Science Diet® Adult Light Dry or Science Diet® Adult Light Dry Large breed. Both dogs preferred the Light product in this initial calibration study.

According to Larose (2004), dietary history can greatly influence an animal's response to palatability tests, specifically when comparing an accustomed product to a less known product. Neophobia is defined as rejection of the novel diet, while neophilia is defined as preference of the novel diet. This initial test suggests a neophilic response in the case of the dogs consuming Adult products, meaning there was a preference for the novel diet. Bradshaw (2006) and

Waterhouse and Fritsch (1967) stated that dogs fed the same diet for long periods often display enhanced preferences for other diets, an example of the so called novelty effect.

Conversely the two animals eating Light products exhibited neophobic tendencies, as neither dog switched to the Adult product. This is an unexpected result, as the assumption was that higher fat foods are more palatable. Therefore dogs were neither universally neophobic nor neophilic and the conclusion for this panel was there was no preference for adult over light.

This calibration study was replicated in Week 8 of the eleven week study. This test resulted in a rejection of the null hypothesis, meaning the Science Diet® Adult Advanced Fitness Original Dry was preferred over Science Diet® Adult Light Dry. Again, 3 of the dogs who were eating an Adult product preferred this product over the Light product. Dog 6 and 8 were two dogs whose choices were consistent over the two tests. Dog 7 and 18 both reversed their preferences by preferring the Light product in the initial test and the Adult product in the replicate test.

One of the dogs (Dog 4) who had been previously eating Light Products showed a preference for the Adult product in the replicate test, as did most of the dogs in this test. Dog 13 remained consistent in his choices as he preferred the Light product in both tests.

While dogs switched their preferences over the two tests, the hypothesized significant difference in intake of the two diets in the second test provides further justification that a longer adaptation is necessary and should be taken into account when qualifying a new in-home panel in future studies.

Another objective of this test was to identify animals that may have a side bias for the testing apparatus. Waterhouse and Fritsch (1967) reported that only five percent of the dogs tested had a preference for a particular bowl position in their palatability studies. This initial calibration

study resulted in one dog (Dog 10) of the 19 valid results that was perceived to have a sided bias. This results in 5% of the panel, which is in agreement with previous published research.

The sided bias was again investigated in the second calibration study, with Dog 4 showing sided tendencies. Hypothesized reasons for this phenomenon were that the dog did not exhibit a true preference for the test or control diet or that it was bored by the products offered and chose to eat out of one bowl for the duration of the test. Because this dog does go on to make choices throughout the duration of the study, both of the explanations may be a direct cause of lack of motivation of the dog to actually make a choice.

Dog 10 appeared to be sampling food from both bowls, although he did not make a decisive choice over the seven day duration of the test. Again this could be due to a lack of motivation to make a distinct choice between the two foods as it pertains to palatability.

Dental Studies: The first palatability test presented to the panel was Science Diet® Oral Care Dry versus a super-premium competitive product with similar dental claims. The initial test resulted in no significant difference. Intake ratio was calculated at 0.5366 (p-value 0.1336). Preference for this test was 44% preferring the Science Diet® product and 40% of the panel preferring the competitive diet. Four dogs had invalid data for this test.

Two dogs on the panel were eating the Science Diet® Oral Care Dry product at the inception of the study. Dog 2 preferred the competitive diet, while Dog 12 was ruled invalid. In this study, Dog 14 showed tendencies of a left bowl sided bias. While the test food was positioned in the left bowl 6 of the 7 days she chose to eat from the left bowl all 7 days, resulting in a sided judgment. This one dog of twenty-one valid results accounted for 4.76% of the panel.

The dental study was repeated, with different batches of food, in Week 9 of the 11 week study. This replicate test resulted in a significant difference in intake of the products with the Science

Diet® product resulting in an intake ratio of 0.6529 (p-value 0.0001). Preference was reported as 64% of the panel preferring the Science Diet® product and 28% of the panel preferring the competitive diet. There were two dogs with invalid data for this test.

Dog 2 once again preferred the competitive diet, exhibiting neophillia, while Dog 12 showed a preference for the Science Diet® product, which exhibited neophobia.

The difference between the two tests could be the result of random variation, slight batch to batch variations in palatability, or a growing comfort with the apparatus by the animals which allowed real differences to be determined.

Adult Studies: Science Diet® Adult Advanced Fitness Original Dry was tested versus a super-premium adult competitive product. The first test resulted in a significant difference in the products with the Science Diet® product resulting in an intake ratio of 0.3447 (p-value 0.0001). Science Diet® Adult Advanced Fitness Original Dry was preferred by 12% of the panel and the competitive product was preferred by 68% of the panel. Five dogs resulted in invalid data for this test.

The adult product category represented the product with the greatest previous exposure by the in-home panel. Nine of the 25 dogs on the panel were eating this diet at the beginning of the feeding study. Two of the dogs (Dog 6 and Dog 10) showed neophobic tendencies and preferred the Hill's® Science Diet® product that they were accustomed too. Six of the dogs (Dogs 7, 8, 9, 11, 14 and 23) all preferred the competitive product, exhibiting neophilic propensities. Dog 18 had invalid data for this test, and was not included in the analysis.

No sidedness was observed in this test. There are two possible explanations for this result. The first being that the dogs had two weeks prior to this test to become familiar with the feeding

apparatus and the notion of being presented with a food choice. Further studies would be necessary to understand adaptation time to the apparatus and the protocol for pet dogs.

The most likely explanation for this perceived difference is that the foods are differentiated enough in taste that there was legitimate reason for a dog to prefer one product over another. Arujo et al., (2004) outlined the limitations of two pan tests as; inability to control for food interactions, inability to control for the satiating effects of a test food, the inability to deal with the dynamic aspects of palatability over time. Test sensitivity was also addressed in this study, as the degree of difference between the two tests feeds must be determined to ensure reliable results.

While calibration studies were designed to evaluate this precise point, these diets were not a similar category comparison. Because the control product was a competitive product, there was no way to reasonably compare, the impacts of different ingredients and formulations to understand their particular impacts on flavor. No human studies of dog food flavor as suggested recently by DiDonfrancesco et al., (2012) were conducted on these samples to allow actual comparison of flavor.

The adult products were tested again in Week 10. The test again resulted in significant difference in the products intake ratio with the Science Diet® Adult Advanced Fitness Original Dry product resulting in an intake ratio of 0.3371 (p -value < 0.0001). Science Diet® Adult Advanced Fitness Original Dry was preferred by 28% of the panel while the competitive product was preferred by 68% of the panel. One dog resulted in invalid data for this test.

Mobility Studies: Science Diet® Adult Healthy Mobility™ Dry was tested versus a super-premium mobility type competitive product. This comparative feeding study resulted in a significant difference in the products with Science Diet® Adult Healthy Mobility™ Dry

resulting in an intake ratio of 0.6572 (p-value < 0.0001). Science Diet® Adult Healthy Mobility™ Dry was preferred by 60% of the panel, while 28% of the panel preferred the competitive product. Three dogs resulted in invalid data for this test.

Of the seven dogs with valid data that had previous exposure to the Science Diet® Adult Healthy Mobility™ Dry product line, only one dog (Dog 25) presented neophilic tendencies, thus preferring the competitive product. The remaining six dogs (Dogs 1, 4, 10, 12, 17, 20 and 25) all preferred the food they were familiar with, Science Diet® Adult Healthy Mobility™ Dry.

Mobility products were tested for a second time in Week 11, the final test of the study. The result of this test was no significant difference in intake for the two diets, with an observed intake of 0.5681 (p-value 0.4825). Science Diet® Adult Healthy Mobility™ Dry was preferred by 40% of the dogs and 44% of the panel preferred the competitive product.

Of the seven dogs with previous exposure to Science Diet® Adult Healthy Mobility™ Dry, two dogs (Dog 1 and 17) demonstrated different preferences in the replicate test. These two dogs joined Dog 25 in their preference for the competitive product. Dog 10, 12, and 20 remained neophobic in their preferences and chose the Science Diet® Adult Healthy Mobility™ Dry product. Dog 4 who had previously preferred Science Diet® Adult Healthy Mobility™ Dry had invalid data for this test.

No dogs exhibited a preference for a particular bowl side in either of the tests.

Additional Tests: Weeks 5-7 were tests across additional product categories and were not replicated later in the study. These tests included Science Diet® Puppy Healthy Development Original Dry, Science Diet® Mature Adult Active Longevity™ Original Dry and Science Diet® Adult Light Dry.

Science Diet® Puppy Healthy Development Original Dry was tested versus a super-premium puppy type competitive product. The result of this test was no significant difference in products. Intake ratio was calculated to be 0.4514 (p-value 0.0608) with 32% of the panel preferring the Science Diet® product and 56% of the panel preferring the competitive product. Three dogs resulted in invalid data for this test.

Because the panel was selected from dogs that were older than 1 year old, no dogs were eating this product at the onset of the study.

Science Diet® Mature Adult Active Longevity™ Original Dry was the next product to be tested against a super-premium mature adult type competitive product. The result of this test was no significant difference between the two diets with a calculated intake ratio reported of 0.4602 (p-value 0.1171). Science Diet® Mature Adult Active Longevity™ Original Dry was preferred by 40% of the panel, while 52% preferred the competitive product. Three dogs resulted in invalid data for this test.

Five dogs on the panel were eating Science Diet® Mature Adult Active Longevity™ Original Dry at the onset of this study. Of these five dogs, Dog 15 preferred the Science Diet® product while the additional four dogs (Dogs 11, 19, 20 and 24) displayed neophilic tendencies and preferred the competitive product.

The final non-replicated study was Science Diet® Adult Light Dry versus a light type competitive product. This test resulted in significant difference between the two products with the Science Diet® Adult Light Dry resulting in an intake ratio of 0.3664 (p-value < 0.0001).

Science Diet® Adult Light Dry was preferred by 32% of the panel while 52% of the panel preferred the competitive product. Four dogs resulted in invalid results for this test.

Two dogs were accustomed to eating this diet at the start of the study. Both Dog 4 and Dog 13 exhibited neophilic inclinations and preferred the control product over the test product.

Table 3.3 provides a comprehensive summary of all test results run in this study.

Statistical Analysis: Power of Test

Waterhouse and Fritsch (1967) recommended that due to the inherent biological variations, several animals are required for precision in testing and provides the best method of determining average values. The number of dogs and number of test days required to determine palatability depend on desired accuracy of the test results, variation of the measurement and true differences between the foods. In the cited study, 20 dogs and two days were found to provide adequate ability to find a difference in foods with a reasonable true difference in palatability.

Based on the anticipated variance in feeding choices of the dogs being fed on the in-home panel, the initial approach included longer test duration than the typical two day laboratory palatability test. The seven day palatability test could produce up to 175 total intake data points, if all 25 dogs completed the test with no invalid data. This generates a much larger data set when compared to the 50 observations obtained in a typical two day palatability test. This higher number of observations were expected to compensate for the inherent variations, both biological and situational, and helped to build confidence in the data.

Of course, using this data it is possible to determine an answer to the question “Do we need all seven days in the test protocol?” A reduction of test time would not only be more cost effective, but would also increase the productivity of the panel.

Power of the test was then employed to understand how the preference of the food changed over the duration of the seven day test. The power of the test represents the probability of rejecting H_0 when it is in fact false (Brase et al., 2003). In order to calculate power it is necessary to

specify the sample size, α -level, sampling variance and the effect size (Thomas, 1997). Beta must also be identified. Beta is defined as the long term probability of missing a true difference, or a Type II error is committed (Lawless and Heyman, 1999). The power of the test is then calculated as:

$$\text{Power of Test} = 1 - \beta$$

Effect size is defined as the difference between the null and alternative hypothesis. Many measures of effect size are available (Cohen, 1990). Two major classes of effect size can be defined as 1) standardized, dimensionless measures such as correlation coefficients or d -values and 2) raw measures such as slope in the regression analysis or difference between means (Thomas, 1997).

According to Murphy and Myors (1998), the power of a statistical test is a function of its sensitivity, the size of the effect in the population and, as mentioned above, the criteria used to test statistical hypothesis (α -level). Ways to improve power of test were suggested as 1) increasing the sample size in order to increase the sensitivity of the study 2) using large effect size measurement, thus there is a true difference between the null and alternative hypothesis and finally 3) set standards that are easy to reject the null hypothesis perhaps by using a larger α to define the significance of the result.

Murphy and Myors (1998) also state that research in the social and behavioral science often shows low levels of power. Cohen (1962) published a review which stated that studies in psychology, education, communication, journalism and other related fields have routinely documented power in the range of .20 to .50 for detecting small to medium treatment effects (Sedlmeier and Gigerenzer, 1989).

The statistical application incorporated in this research used the difference between the mean of the intake ratio of the test food provided to the panel in order to evaluate the power of each test. Figure 3.1 illustrates the conclusion of a minimum of ± 0.20 difference between the hypothesized intake ratios of 0.50 of the test product was needed in order to achieve a power of test of 0.80 or higher, thus providing a test result aligned with true palatability difference in the test product from the control. This is a direct indication of the effect size of the test shown in real life application. More specifically, if the mean intake of the test food was in fact 0.20 different than the hypothesized 0.50 test intake ratio the panel determined that the foods were either preferred or not preferred to the control food. Thus the effect of the treatment needed to be large, and power of the test indicated as such.

If a relaxed standard of power is acceptable, the difference in hypothesized intake ratio of 0.50 of the test product decreases to ± 0.15 to see power of tests drop to 0.60. This lower power of test may be acceptable for the tests where a higher probability of finding the true difference is not required.

Power of test indicates no significant difference between Day 1 of testing through Day 7 of testing (Table 3.4). These data suggest that the dogs on this panel made their food choice on the first day of testing. The overall palatability result, and power of test, did not change over the remaining six days of testing. This reduction in overall duration of the test results in an improved capacity allowance. Seven tests could be performed in a week, versus one test over the same time period, which drastically improves the productivity of the panel.

This data allow us to conclude that for in-home testing, one day is all that is needed for the testing as compared to existing research that usually uses two day testing (Waterhouse and Fritsch, 1967). In order to understand how the data is reflected in a two day test, average intake

for every test was plotted (Figure 3.2) versus days of the test (Day 1, Day 1-2, Day 1-3, etc.). . These data exhibited small changes in intake ratios of the test foods and a decreasing intake ratio of test food for the remaining five days of the test. This observation indicates that the dogs on this panel made a similar choice in one day of testing when compared to 2nd, 3rd, 4th, 5th, 6th or 7th days. This provides justification for the duration of the test length to be shortened from seven days to one day.

The conclusion of this statistical analysis was that this panel reported no significant difference in intake of test foods from day one through day seven, thus reducing the test time 85.7%. This translates to the possibility of performing seven tests versus one test per week.

Statistical Analysis: Previous Exposure to Food

Because each dog used in the study was familiar with one or multiple types of Science Diet® foods, an investigation of the effect of previous exposure to the food tested was undertaken to determine if exposure affected the palatability results of each test.

In order to gain better insight into this question, the status of each individual as to the exposure to the food was used as an independent variable.

Least squares means (LSM) were then generated using SAS Software version 9.2 (Copyright 2002-2008 SAS Institute Inc., Cary, NC, USA) using the MIXED procedure. Least squares means in the PROC MIXED procedure takes into account the non-balanced animal number of exposures to the various foods.

Table 3.5 illustrates that least squares means for dogs that did not have previous exposure to a diet in a test were estimated to be 0.4815 intake ratio of the test food. Using the same analysis dogs that did have previous exposure to a diet in a test had an estimated 0.4853. These data

show (Figure 3.3) that there was no effect on palatability results when a dog on this panel had been pre-fed a diet in a study.

Eating Behavior

After review of the data, a trend in eating behavior surfaced for some of the dogs on the in-home panel. The notion of decisive eating became apparent when studying some individual dog's food intakes. Decisive eating was defined by consuming the same food throughout the duration of the seven day test, regardless of which side of the feeding apparatus the food was placed on.

Five of the 25 dogs, exhibited this type of behavior in over 50% of the tests. Of these five decisive eaters, one dog in particular displayed this particular behavior on eight of the 11 tests. That is to say he made his food choice consistently throughout the duration of the test 72.7% of the time. That dog was an 85 pound Black Labrador, who consistently and aggressively made his food choices. Because of the dog's size and aggressive food behavior this phenomena was coined this the "Rambo Principle" (based on an American film character who can be characterized as a militant or an aggressive person) to describe any dog that decisively makes the same food choice when presented with different options, regardless of bowl position.

Conclusions

The scope of this research was fundamental, yet broad. The first objective of the study was to evaluate the experimental methods including the apparatus and software as to their functionality in in-home palatability tests. Feeders and food were distributed to homes and data was successfully collected.

The second objective was to statistically analyze the data and evaluate if palatability results can find taste differences in the products tested. Data was analyzed using standard methods and

palatability result conclusions were drawn showing that this method can effectively find differences between foods.

The third objective was to evaluate if the number of animals and number of days needed in testing for the most efficient use of resources. This resulted in a 25 animal test for maintaining a 0.80 power and an ability to find differences between foods.

The fourth objective was to determine if a reduction of recommended test days from seven to one day was reasonable. Investigation of the average mean of test food intake over all 11 tests provided compelling evidence that the one day test would also be acceptable.

The final objective was to understand if previous exposure of the food in the study affected palatability. The estimated least squares means of approximately 0.48 intake ratio of the test food for both pre-exposed and naïve dogs show that palatability results were not affected by the dogs having consumed the food in previous feeding sessions.

Future studies of in-home palatability tests should include how owners perceive the food. Smith, Kronfeld and Banta (1983) studied the owners' perception of food flavor preferences of pet dogs in relation to measured preferences of laboratory dogs. Given the technological advances realized in this research, it would behoove pet food manufacturers to understand how to effectively capture the pet owner impressions of the dog food and compare these data to palatability of the individual dog and the panel as a whole.

Table 3.1 Protocol Comparison

	Laboratory Panel Protocol	In-home Panel Protocol
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Number of dogs on panel	25	25
Minutes per session	45	45
Calibration Diets	Coated v. Uncoated	Adult v. Light
Feeding amount	Kcal (considers activity)	Kcal (based solely on body weight)
Number of days/ test	2	7

Table 3.2 Panel Dog Diet Consumption at Launch of Study

Diet Name	Number of Panelists Consuming at Launch of Study
Science Diet® Adult Advanced Fitness Original Dry	7*
Science Diet® Adult Advanced Fitness Original Dry Large Breed Dry	1
Science Diet® Adult Light Dry	1*
Science Diet® Adult Light Large Breed Dry	1
Science Diet® Adult Healthy Mobility™ Dry	6*
Science Diet® Adult Healthy Mobility™ Large Breed Dry	2
Science Diet® Mature Adult Active Longevity™ Original Dry	5*
Science Diet® Oral Care Dry	2*
Science Diet® Adult Small & Toy Breed Dry	1
*Indicates multiple number of diets consumed	

Table 3.3 In-home Panel Test Results

Test Product	Result	IR	Preference Test / Preference Control / Invalid / No Preference	p-value (1-tailed)
Science Diet® Adult Light Dry *	No Significant Difference	0.5811	48/28/6	0.4945
Science Diet® Oral Care Dry	No Significant Difference	0.5366	44/40/4	0.1336
Science Diet® Adult Advanced Fitness Original Dry	Significant Difference	0.3447	12/64/6	0.0001
Science Diet® Adult Healthy Mobility™ Dry	Significant Difference	0.6572	60/28/3	0.0001
Science Diet® Puppy Healthy Development Original Dry	No Significant Difference	0.4478	32/56/3	0.0608
Science Diet® Mature Adult Active Longevity™ Original Dry	No Significant Difference	0.4602	40/52/3	0.1171
Science Diet® Adult Light Dry	Significant Difference	0.3664	32/52/4	0.0001
Science Diet® Adult Light Dry *	Significant Difference	0.4138	32/56/1/1	0.0020
Science Diet® Oral Care Dry	Significant Difference	0.6529	64/28/2	0.0001
Science Diet® Adult Advanced Fitness Original Dry	Significant Difference	0.3371	28/68/1	0.0001
Science Diet® Adult Healthy Mobility™ Dry	Significant Difference	0.5717	40/44/4	0.0285

**Indicates Calibration Test*

Table 3.4 Comparison of Test Food Mean Intake, Standard Error and Power of Test of All Tests with Day of Test as Independent Variable

	Test Food Mean Intake	Standard Error	Power of Test
Day 1	0.485	0.084	0.453
Day 2	0.493	0.080	0.476
Day 3	0.484	0.078	0.465
Day 4	0.485	0.075	0.475
Day 5	0.483	0.076	0.470
Day 6	0.480	0.075	0.425
Day 7	0.476	0.073	0.483

Table 3.5 Previous Exposure to Food Does Not Influence Choice: Least Squares Means

Previous	Estimated Intake Ratio	Standard Error	DF	t Value	p-value
Naïve	0.4815	0.01074	21	44.83	<0.0001
Pre-fed	0.4853	0.01839	21	26.39	<0.0001

Figure 3.1 Palatability Change from 0.5 Intake Ratio as Compared to Power

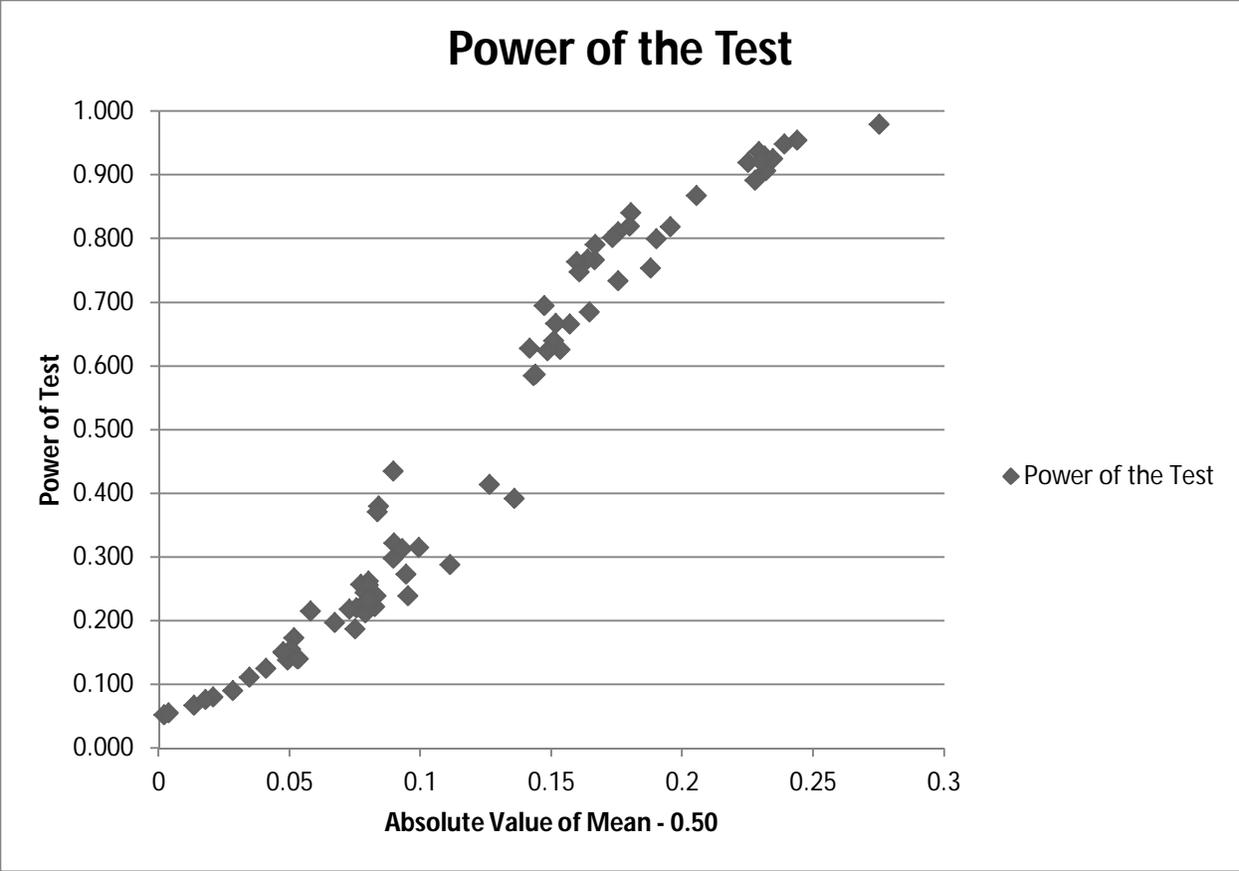


Figure 3.2 Mean Average Intake Ratio of Test Food

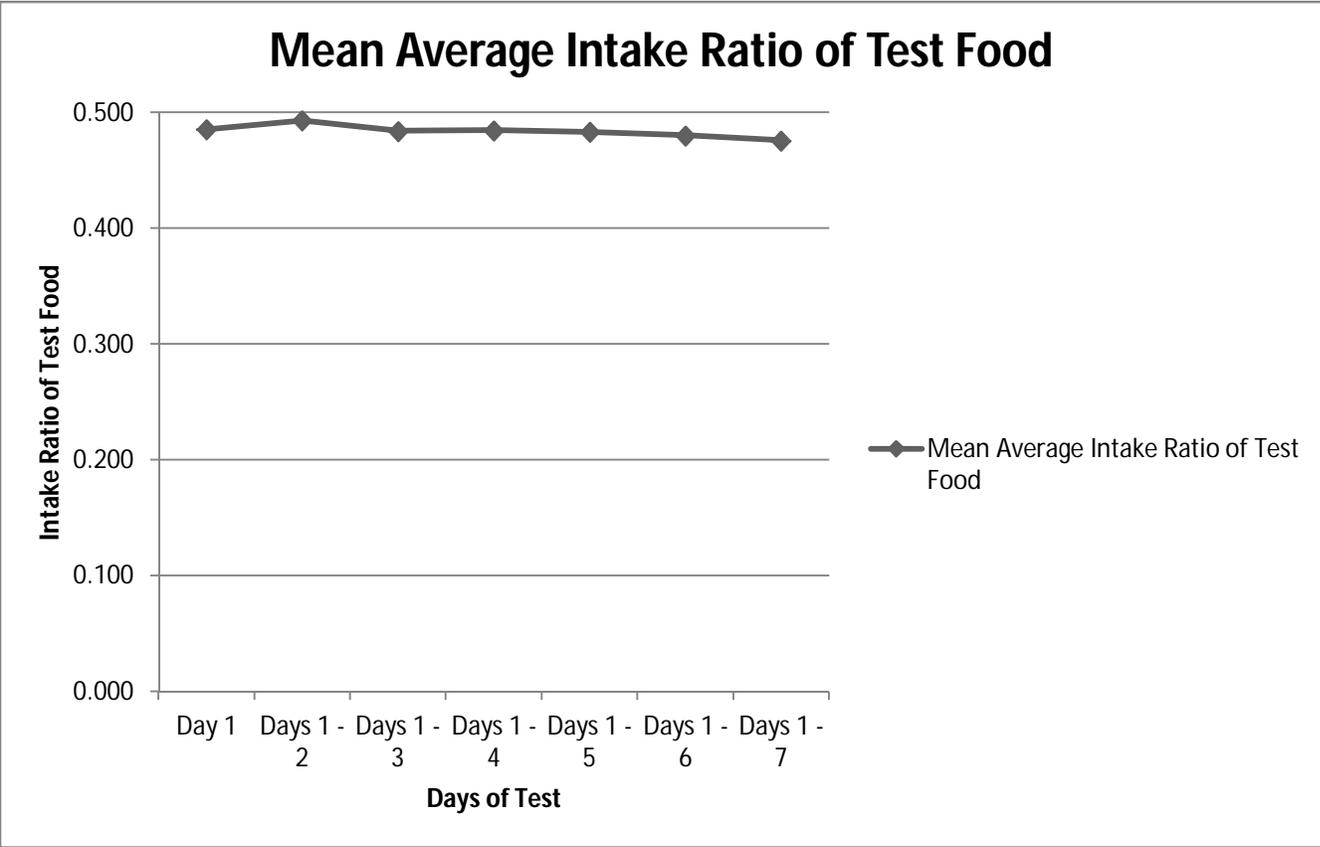
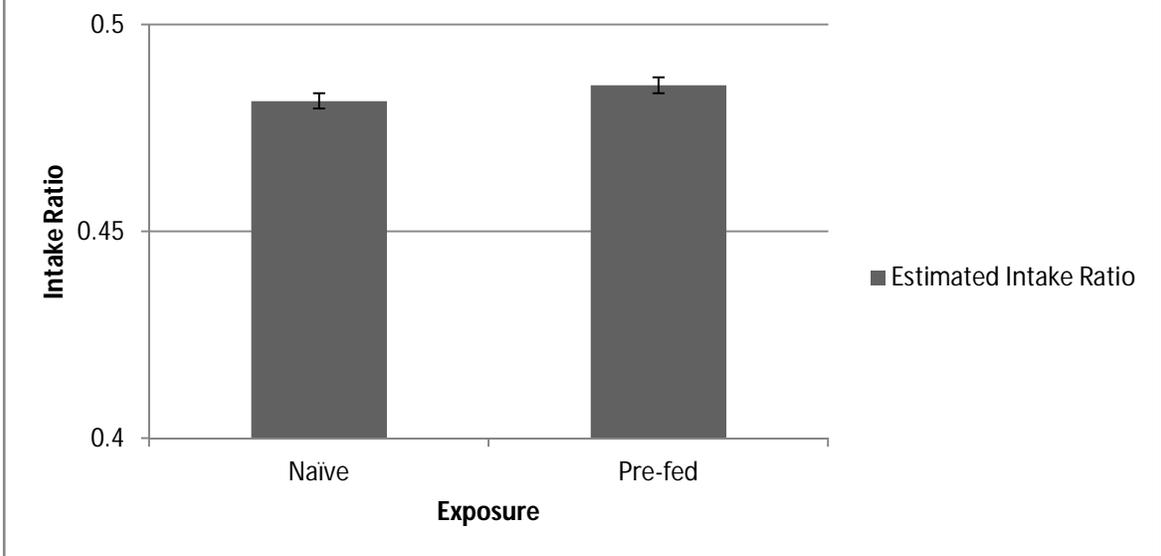


Figure 3.3 Estimated Intake Ratio vs. Exposure to Test Food

Estimated Intake Ratio vs. Exposure to Test Food



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