



RESEARCH ARTICLE

# Assessing the Implicit Prices of Health and Wellness Product Attributes in Pet Food: A Hedonic Analysis Approach

Lonnie Hobbs Jr.<sup>1</sup>  and Andrew Anderson<sup>2</sup> 

<sup>1</sup>Department of Agricultural Economics, Kansas State University, Manhattan, KS, USA and <sup>2</sup>Department of Agricultural Economics and Agribusiness, University of Arkansas, Fayetteville, AR, USA

**Corresponding author:** Lonnie Hobbs Jr; Email: [lhobbs@ksu.edu](mailto:lhobbs@ksu.edu)

## Abstract

Here we examine product attributes present in dry dog food to show there exist potential price premiums and discounts associated with health and wellness attributes in dry dog food. The findings indicate price premiums are associated with attributes related to digestion and allergy care. Pricing discounts are found to be associated with immune support and dental attributes. The results of this study are anticipated to be a starting point for more sophisticated and dynamic analysis of pricing and willingness-to-pay studies in the pet food industry.

**Keywords:** Credence attributes; discount; dog food; marketing; premium

**JEL classifications:** Q13; Q110; M31

## 1. Introduction

The pet food industry has seen substantial growth from 2012 to 2022, with global sales rising from \$65.9 billion in 2012 to \$123.6 billion in 2022 (Statista—Sales of Pet Food Worldwide 2024). The U.S. pet food market is the largest global pet food market and contributor to the global sales total, generating \$53.04 billion in revenue in 2022 (Statista—Pet Food—United States, 2023). The factors contributing to the global and U.S. pet food market growth are increasing number of pet owners, rising number of pets per household, higher disposable income, and a growing willingness to pay for pet food products (Marketline—North America Pet Healthcare, 2024). However, the primary drivers behind this sales surge are changing customer preferences for specialized premium products and a heightened concern and awareness among pet owners about the importance of pet health. This is evident from the rising demand of healthier product options in the pet food sector (Coy, Green, and Behler, 2021; Hobbs et al., 2024; Marketline—North America Pet Healthcare, 2024). In 2021, a study of more than 22,000 dogs found that 65.8% of dogs were reported to have at least one health disorder (O'Neill et al., 2021). Similarly, a survey conducted by the Association for Pet Obesity Prevention reported that 59% of the U.S. dogs and 61% of the cats in the sample were overweight or obese (Association for Pet Obesity Prevention, 2022). As pet owners search for healthier product options, the greater the demand for pet food products that can manage, mitigate, and address health-related problems in pets.

In the pet food market, health and wellness products are becoming increasingly important in shaping customer purchasing behaviors. Recent studies underscore the value of these product attributes, emphasizing their role in buying decisions and customers perceived post-purchase

experience (Hobbs et al., 2024). Trends like premiumization and humanization have made pet owners more aware of the health and safety of their pets' food in an attempt to keep their pets healthy and happy (Chen, et al., 2012). Premiumization refers to customers demanding more premium and super-premium products, while humanization involves owners perceiving and treating pets as human family members (Cambridge University Press & Assessment, 2021; Pet Food Industry — Pet Food Premiumization & Consumer Priorities, 2017). In addition to promoting health and well-being amongst their pets, pet owners also look to health and wellness products to target specific health issues, cater to specific breed types, and/or ages of their dogs and cats (van der Velden, 2022). Previous studies have documented that pet owners are willing to pay more for healthier food products for their pets (Cavasos et al., 2023; Pearce et al., 2023). These trends present a potentially lucrative opportunity for pet food companies by offering health and wellness product attributes with an associated premium. To fully capitalize on the profit potential associated with the health and wellness trend, it is essential for pet food decision-makers to identify and promote the health and wellness attributes that are highly valued by customers and have the potential to generate the highest revenue.

Alongside the expanding pet food market, there is an increasing research focus on pet food customer preferences; yet there is a limited academic literature focused on the marketing of health and wellness product attributes in pet food. Specifically, previous studies have explored preferences for sensory product characteristics such as aroma, palatability, product type (kibble vs. wet), and formulation (Koppel, 2014; Samant and Crandall, 2021; Wagoner et al., 2022). More recently, academic researchers have begun exploring marketing related factors in pet food, looking at brand, ingredient, and shopping location (online vs. in-store) preferences, while others have examined the overall value of product attributes based on post-purchase reviews (Coy, Green, and Behler, 2021; Hobbs et al., 2024; Schleicher, Cash, and Freeman, 2019). There is a general consensus among the previous research findings that pet owners value product attributes such as health and wellness, quality ingredients, and palatability. Previous studies also generally agree that health-conscious pet owners are more likely to purchase healthier products for their pets (Boya, 2012; 2014; Chen, Hung, and Peng, 2012; Hobbs, 2023). Despite the growing research about pet food customer preferences, there still exists a need to understand the impact of health and wellness product offerings on product pricing and the amount that owners are willing to pay for those attributes. Specifically, the current literature identifies health and wellness-related attributes as highly valued and in-demand attributes for pet food customers, but it fails to identify the specific attributes within the health and wellness market subsegment that generates the highest profit potential for pet food companies. Consequently, many unanswered questions remain related to the approaches of pet food decision makers to adapt their product innovation, differentiation, and marketing strategies to capitalize on the increasing demand for health and wellness pet food.

The objective of this paper is to address a gap in the existing literature by using hedonic price analysis to evaluate the associated price premium for health and wellness characteristics in pet food. Specifically, the study aims to assess the potential value of health and wellness attributes in dry dog food products by analyzing the implicit prices associated with each attribute. Dry dog food products were chosen for analysis due to their significant market share in the pet food industry and high demand within the dog food market segment (Grey Views—Global Dog Food Market, 2022). The empirical analysis relies on a unique dataset of retail price information web scraped from Chewy.com, one of the leading pet food retailers in 2022. The dataset also includes brand information, product type and form, packaging size, primary ingredients, and health-related attributes for 1,268 dry dog food products listed on Chewy's website on January 3, 2023. The data offers unique benefits as it is readily accessible, low cost, and rich in product information. The findings from the hedonic price estimation are synthesized to provide insights for pet food decision makers, aiding in the development, differentiation, and marketing strategies for dog food products that incorporate health and wellness attributes.

This study makes three key contributions. First, it is the first study of its kind to introduce the use of hedonic pricing analysis in the pet food industry to assess product attribute premiums based on the implicit pricing of product attributes. Second, it is the first study to focus specifically on the pricing of health and wellness attributes in pet food. The current literature in this area has limitations in informing pet food decision makers due to its limited focus on health and wellness product attributes and limited availability of pet food pricing data. Third, this study serves as a starting point for research generating insights to assist pet food decision-makers with enhancing product positioning and differentiation strategies for health and wellness products. This insight can be used to potentially maximize profitability and gain a competitive edge in the health and wellness product market.

## 2. Background of the dry dog food market and product labeling

### 2.1. The dog food market

The dog food market has the highest market share among all other pet food markets globally and in the U.S. In 2021, dog food sales totaled \$63.05 billion globally, and 45.52% (\$28.7 billion) of the market share coming from the North American dog food market (Grey Views — Global Dog Food Market, 2022). Of the variety in the types of dog food, dry dog food has the highest demand and sales totaling 46.09% (\$13.2 billion) of the global dog food market in 2021 in comparison with wet dog food market totaling less than 40% in 2021 (Grey Views — Global Dog Food Market, 2022). Although the demand for wet dog food has increased over the past decade as pet owners associate wet dog food as a healthier feeding option, the convenience of dry dog food still remains as primary driver for the purchase of dry dog food (Schleicher, Cash & Freeman, 2019).

Along with the desire for premium and specialized product offerings, pet owners' purchasing behavior is guided by factors such as price, product ingredients, and attribute offerings (Nielsen Consumer—The Human Pet Trends Driving Pet Food Purchases, 2021; Schleicher, Cash, and Freeman, 2019). Regarding product attributes, product characteristics such as aroma, kibble size and texture, palatability, and functionality have been found as key attributes determining customer purchasing behavior and post-purchase experience (Baquero, 2018; Koppel, 2014; Koppel et al., 2018). However, with the rise in the “health-conscious” pet owner and human pet trends, health and wellness attributes and product ingredients have been the top attributes observed and desired by pet owners (Hobbs et al., 2024).

### 2.2. Labeling regulations in dog food

The regulatory landscape for pet food health claims presents a complex and delicate framework overseen primarily by the Food and Drug Administration (FDA) and the Association of American Feed Control Officials (AAFCO). While AAFCO establishes comprehensive guidelines for nutritional profiles, guaranteed analysis, and labeling requirements, the FDA's approach to health-related claims remains notably ambiguous. This regulatory environment creates a challenging interpretive space for manufacturers, veterinary professionals, and consumers alike. The FDA's regulatory strategy emphasizes truthfulness and scientific substantiation without providing explicit, standardized definitions for health-related product attributes. Pet food companies are therefore required to navigate a complex self-regulatory landscape that demands careful language and scientific precision when marketing. Claims such as “supports digestive health” or “alleviates allergy symptoms” must be communicated with careful qualification, utilizing language that suggests potential benefit without declaring definitive medical intervention.

Unlike pharmaceutical or human nutritional regulations, pet food health claims exist within a remarkably flexible regulatory framework. The absence of pre-approval processes and the primarily reactive enforcement approach create a unique marketplace where scientific evidence

and marketing strategies intersect. Pet food companies must validate claims through peer-reviewed research, documented physiological mechanisms, and verifiable ingredient efficacy, yet face minimal regulatory constraints. This regulatory approach fundamentally transforms health claims into a complex negotiation between scientific possibility and marketing rhetoric. The FDA's primary enforcement mechanism relies on preventing blatantly fraudulent or potentially harmful statements, rather than establishing precise definitional boundaries for health-related attributes. Consequently, similar health claims can consist of substantially different interpretations across various pet food brands, creating significant variability in definitions on claims.

The effects of this regulatory framework extend beyond mere marketing strategies. Consumers are ultimately positioned as critical interpreters, required to navigate a complex informational market where scientific validation and marketing narrative remain in continuous negotiation. Given that most health claims are credence in nature (cannot be visually verified), the perceived value associated with the health claims are under the discretion of consumers. Consequently, proper marketing of these variables can enhance customer perception of value, leading to higher willingness to pay and sales of these attributes.

### **2.3. Dog owners health and wellness attribute preferences**

Among the health and wellness attributes, "low calorie" and "diabetic support" were two of the top five most-search pet food attributes on Amazon.com between 2020 and 2021 (Nielsen Consumer — The Human Pet Trends Driving Pet Food Purchases, 2021). In 2022, a survey provided by IQI Petfood Innovation indicated that healthy digestion, muscle joint and bone health, skin/coat care, immune system support, and heart/cardiovascular health are the top health and wellness attributes indicated by the 1,400 North American survey respondents included in their study (van der Velden, 2022). One would assume that the five most popular health and wellness attributes would be the most valued and purchased health and wellness related attributes among pet owners, and the highest revenue generating attributes related to health and wellness product claims in pet food. However, due to sales and purchasing data limitations, the current academic and industry literature does not provide enough evidence to support this claim. Therefore, questions remain regarding the top revenue generating health and wellness attributes for pet food companies. This study seeks to systematically address this question using pet food pricing data. Specific data characteristics and analytical approaches are provided below in the data and methods sections.

## **3. Model specification and empirical framework**

To assess the effects of the health and wellness related product attributes on dog food prices, a hedonic pricing model is adopted following Rosen (1974). According to hedonic pricing theory, a good is comprised of a set of attributes that provides consumers with utility received post-purchase (Rosen, 1974). Variations in the attribute offerings allows for customization of product offerings to match the preferences of the customers, contributing to the welfare of the customer and potential opportunity to maximize the customer's utility. In a heavily competitive market, the various combinations of product attributes allow companies to differentiate their product offerings if marketed and priced properly. Rosen (1974) indicates the observed market equilibrium price of a good is comprised of implicit prices of each product attribute. However, this approach embodies underlying assumptions that (a) all customers are aware of all available combinations of attribute offerings, (b) there is no switching cost between products, and (c) the differentiated products are bought and sold by a large number of producers and consumers with no market power (Lusk et al., 2011). These assumptions are reasonable to assume in this study due to the data source being an online outlet (Chewy.com) and the nature of the dry dog food industry. First, it has been documented that purchasing products online allows customers to easily compare

product pricing, attributes, and benefits (Sarkar and Das, 2017). On Chewy.com, customers are provided with options to filter products, allowing them to see various product offerings with their desired attribute, providing customers with the opportunity to make themselves aware of the available attribute combinations. Second, given that the online website provides pricing information for all products, and there is no cost or penalty from interchanging products in the online cart before purchasing, it is reasonable to assume that customers do not encounter a switching cost between products. Third, the products offer product reviews to communicate customers purchasing and product use experience. With the products in this study, all had product review numbers ranging from 39 to 3,000+, potentially signaling that many consumers purchase these products. Also, there were more than 60 brands analyzed in the study, signaling that many producers sell these products. Given the nature of the data described above, all underlying assumptions are reasonable to assume, meaning that it is practical to examine online pet food prices as being comprised of implicit prices of each product attribute.

Following a similar modeling approach to Botta et al. (2023), the price of dry dog food products are expressed as a function of  $k$  attributes plus health-related product features, product packaging weight, and additional product attributes (food flavor, life stage, breed size, and processing location). As suggested in Butler (1982), a regression equation that includes only the attributes that yield utility and incurs significant production cost suffices to estimate the hedonic prices of attributes, while reducing the potential misspecification problem. Therefore, the price of dry dog food is defined as follows:

$$\text{Price}(x) = f(x_1, x_2, \dots, x_k, \text{product weight, health} - \text{related attribute}) \quad (1)$$

Where price ( $x$ ) indicates the price per pound of a dry dog food product, and  $x$  represents a vector of product attributes. The specific hedonic model used in this study is specified as:

$$\ln P_i = \alpha + \beta \text{Weight}_i + \sum_{j=1}^n \gamma_j \text{HealthFeature}_{ji} + \sum_{k=1}^m \delta_k \text{Attribute}_{ki} + \sum_{v=1}^s \tau_v \text{Brand}_{vi} + \varepsilon_i. \quad (2)$$

Where  $\ln P_i$  is the log price (\$/lb.) of dog food  $i$ ,  $\text{Weight}_i$  is the packaged weight,  $\text{HealthFeature}_{ji}$  is a dummy variable for the  $j$ th health and wellness attribute included in dog food  $i$ ,  $\text{Attribute}_{ki}$  is a dummy variable for the  $k$ th other attribute included in dog food  $i$ ,  $\text{Brand}_{vi}$  is a dummy variable for the  $v$ th brand of dog food  $i$ , and  $\varepsilon_i$  is a normally distributed error term. The coefficients for the health and wellness attributes are indicated by  $\gamma_j$  where  $j$  ranges from 1 to 16, representing the sixteen health attributes examined. Similarly,  $\delta_{ki}$  indicates the additional attributes fixed effects for attribute  $k$ . The additional attributes include features related to special diets, food flavor (protein), life stage, breed size, and sourcing. Summary statistics of all variables are also found in Tables 3 and 4.

The brand level fixed effect coefficient for dog food  $i$  is represented as  $\tau_v$  where  $v$  ranges from 1 to 60. A list of the brands examined is provided in Appendix C. However, the brand level results will not be disclosed to maintain the focus on the broader implications related to the implicit prices of the health-features in dog food. Disclosing specific brand-level data could inadvertently lead to undue emphasis on differences in brand pricing, which is not the primary focus of this study. According to Wooldridge, log prices are utilized to capture the potential non-linear relationship between price and independent variables and to ensure data normality. Variations of the model with additional groups of control variables are estimated in this study as a robustness check and presented in Appendix B. The primary specification used in this study models hedonic pricing while controlling product weight, brand level fixed effects, and the non-health related attribute control variables.

**Table 1.** Results of statistical testing for normality of price per pound

Test	Statistic	P-Value
Shapiro-Wilk (Raw)	0.976	0.000***
Shapiro-Wilk (Log)	0.986	0.000***
Kolmogorov-Smirnov (Raw)	0.054	0.001***
Kolmogorov-Smirnov (Log)	0.048	0.006***

Significance: \*10% level; \*\*5% level; \*\*\*1% level. Raw indicates the test results for the non-log price per pound and log indicates the log-transformed prices.

**Table 2.** Statistical comparison of data with and without outliers

Dataset	N	Mean Price	Median Price	SD Price	Min Price	Max Price
With Outliers	1602	3.16	2.87	1.53	0.59	17.48
Without Outliers	1540	2.97	2.81	1.15	0.59	6.25

Note: The prices shown in this table were calculated before completing all data filtering steps. As a result, the above prices differ from those in Table 3 because they include observations that were removed through filtering.

4. Data

4.1. Data collection, preparation and initial filtering

The analysis began with a systematic approach to data cleaning and sample selection in the dry dog food market. Using Relenium and Rvest packages in R statistical software, pet food product information was collected from Chewy.com in January 2023. Specifically, product name, attributes/labeling claims, price, and package size were extracted for all dog food, dog treat, cat food, and cat treat products to create a comprehensive dataset. To test for external validity of the prices listed on Chewy.com, a visual examination of prices listed on Walmart.com and Petco.com, two of the top five online sites for pet food purchasing, which confirmed that the prices listed on each of the three websites were similar. Initial data filtering criteria isolated the target market segment. The sample was restricted to products explicitly categorized as dog food, specifically dry food formulations, excluding supplements, treats, and food toppings that operate in distinct market segments.

4.2. Distribution analysis and outlier detection

Following initial filtering, extensive distribution analysis of price per pound was conducted. Initial visual analysis indicates non-normal distribution for neither raw prices nor log-transformed prices. Statistical tests for normality, including both Shapiro-Wilk ( $W = 0.976, p < 0.001$ ) and Kolmogorov-Smirnov tests ( $D = 0.054, p = 0.001$ ), confirmed significant deviations from normality in the price distribution. Results of the normality and outlier testing are reported below in Table 1.

Given the non-normal nature indicated by the results of the statistical testing shown in Table 1, which is typical in retail price data, the interquartile range (IQR) method was employed for outlier detection rather than approaches assuming normal distribution (Vinutha, Poornima, and Sagar, 2018). Using the initially filtered dataset, key distribution parameters were calculated including the first quartile (Q1), third quartile (Q3), and the interquartile range ( $Q3 - Q1$ ). Outlier boundaries were then established using the standard IQR formula, identifying



observations as outliers if they fell below  $Q1 - 1.5IQR$  or above  $Q3 + 1.5IQR$ . This approach provided a statistically robust method for identifying extreme prices while accounting for the natural skewness in pet food pricing. When accounting for the IQR thresholds, there were 62 (3.87% of observations) total outliers above the IQR threshold and 0 outliers below the threshold. All outliers were removed from the data. Table 2 provides the results of the comparison statistics of the data with and without outliers.

#### 4.3. Brand and market structure analysis

To ensure reliable brand-level analysis, additional filtering criteria for manufacturers were implemented. Only brands with at least 10 products in the dataset were retained, ensuring sufficient observations for meaningful comparisons while avoiding potential bias from small-sample manufacturers. This filtering step was crucial for subsequent brand-level analyses and the investigation of brand fixed effects in the hedonic models.

#### 4.4. Feature categorization and variable creation

A comprehensive categorization scheme was developed for product features across multiple dimensions based on the product classification claims provided by Chewy.com. For health claims, binary indicators were created for distinct health-related features including digestive health, skin and coat health, immune support, and others, based on product descriptions and marketing claims. Key dietary attributes were identified including grain-free formulations, high-protein content, and natural ingredients. Products were categorized across primary flavor categories including poultry, chicken, meat, and seafood. Indicators were created for life stages (adult, puppy, senior) and breed sizes (small, medium, large, extra small, giant breeds), as well as manufacturing characteristics, particularly noting products made in the USA. Each categorical variable underwent careful cleaning, with missing values systematically coded as 'none' to ensure comprehensive coverage and avoid potential bias from missing data. All categories were determined based on classification by Chewy.com.

#### 4.5. Correlation and multicollinearity analysis

Prior to estimating the hedonic pricing models, correlation analysis and variance inflation factors (VIF) tests were conducted to identify potential multicollinearity issues among the explanatory variables. Using a correlation threshold of 0.7 to identify problematic relationships, three variables exhibited high correlations with other variables that warranted further investigation. For instance, the 'adult' life stage variable showed strong negative correlations with both 'puppy' ( $-0.766$ ) and 'senior' ( $-0.552$ ) categories, while 'poultry' demonstrated high correlation with other flavor indicators, particularly 'chicken' (0.752). Similarly, 'sweet potato' displayed strong relationships with the 'fruits and vegetables' variable (0.814). Based on these statistical results and theoretical considerations about variable redundancy, several variables including 'adult', 'poultry', and 'sweet potato' were removed from the final specification. This variable selection process helped ensure model stability and reliable coefficient estimates while maintaining comprehensive coverage of product characteristics in the hedonic analysis. Results of the correlation and VIF test are reported in Appendix D.

Based on the correlation analysis and VIF test results, the premium variable warranted careful consideration but did not necessarily require modification before model estimation. Specifically, the premium variable's VIF of 10.113 (reported in Table D.1 in Appendix D) is only marginally above the traditional threshold of 10, while its highest correlations with other variables (reported in Table D.2 in Appendix D) are moderate: gluten free (0.439), natural (0.366), price per pound (0.379), and chicken free (0.310). None of these correlations exceed 0.5, suggesting that while there is some relationship between these variables, they are not severely collinear. Given that premium is

theoretically important for understanding price structures in the pet food market and likely captures unique pricing information not captured by other variables, retaining it in the model without modification is justifiable.

#### 4.6. Comparative analysis and validation

To validate the outlier removal process, detailed comparative analyses between the original and cleaned datasets were conducted. This included examining changes in key statistical measures including mean, median, and standard deviation, as well as distribution characteristics. Comprehensive documentation of all observations removed through the cleaning process was maintained, ensuring transparency and reproducibility in the methodology. Throughout the data preparation process, quality control measures were implemented through systematic verification of created variables against source data, cross-validation of categorical assignments, documentation of all data transformations and filtering decisions, and regular checks for consistency in categorical assignments. This methodological approach provided a robust foundation for subsequent hedonic pricing analysis, ensuring the results reflect typical market conditions while maintaining the integrity of the underlying price relationships and product characteristics.

#### 4.7. Summary statistics for health-related product attributes

Descriptive statistics for all health-related product attributes are presented in Table 3. It is important to note that all health-related variables, excluding the price, are binary indicators. There is no reference category as the variables are interpreted individually as having versus not having each health claim or attribute. All product attributes are mutually inclusive, indicating that a product can include various combinations of features in each category. Therefore, the percentages presented for each category in Table 3 will not sum to 100 percent. It is important to note that only the attributes explicitly labeled on products were analyzed. When a product is labeled with an ingredient, this does not mean other products lack that ingredient, only that they do not display the ingredient label. For instance, while “with-grain” and “grain-free” are theoretically mutually exclusive, a product containing grain is not required to carry a “with-grain” label. Additionally, if the product does not include the “with-grain” label, it does not imply that the product is “grain-free.” The same principle applies to meat and poultry labels: chicken and turkey products may not carry a poultry label, and meat products may not display a meat label, even though they contain these ingredients.

There are nine health-related product attribute groups examined in this study: digestion, skin and coat, immune support, muscle and joint, dental, internal organ support, weight control, energy, and vitamins. Within the product attribute groups, there is a combined total of sixteen health-related product features examined for 1,268 dry dog food products. The three most common health related features include *digestive health* (52%), *skin coat health* (41%), and *immune support* (37%). On the other hand, *allergy relief* (2%), *itch redness remedy* (2%), and *appetite stimulation* (2%) were the three least common health-related attributes present in the products examined. When examining the proportion of health-related attributes found in the data, a pattern emerges where the general health related attributes (e.g., digestive health, skin and coat, immune support, etc.) are included in a large portion of the responses, whereas the more specialized and targeted health-related attributes (e.g., allergy, appetite stimulation, itch remedy, etc.) have a lower representation within the data. The average price per pound for all products included in the sample is \$3.03.

There were notable differences in the average price per pound for health-related product attributes. The health-related attributes with the highest average price per pound were *allergy relief* (\$3.89), *weight-management* (\$3.52), and *sensitive skin* (\$3.19), and *sensitive digestion* (\$3.19). Excluding *weight-management*, it is likely that the attributes with the highest average price per



**Table 3.** Summary statistics for health-related variables included in each dog food product

Variable	N	Proportion	Mean price (\$/lb.)	SD price (\$/lb.)	Min price (\$/lb.)	Max price(\$/lb.)
Price per lb.	1268	100%	3.03	1.11	0.63	6.25
Digestion						
Digestive health	663	52%	3.01	1.07	0.63	6.25
Sensitive digestion	306	24%	3.19	0.97	1.14	6.23
Skin and coat						
Skin coat health	522	41%	2.94	1.11	0.63	6.18
Sensitive skin	79	6%	3.19	0.87	1.48	5.91
Itch redness remedy	22	2%	2.92	0.83	1.55	5.22
Immune care						
Immune support	467	37%	2.74	0.97	0.93	6.25
Allergy relief	20	2%	3.89	0.85	2.18	5.91
Muscle and joint						
Hip joint support	198	16%	2.94	1.1	0.97	6.02
Muscle care	102	8%	2.72	1.09	1.23	5.56
Dental						
Dental breath care	114	9%	2.63	1.25	0.63	6.18
Internal organ support						
Brain health	113	9%	2.89	1.00	1.21	6.18
Heart care	47	4%	3.16	1.29	1.31	6.18
Weight control						
Weight management	54	4%	3.52	1.11	1.41	6.22
Appetite stimulation	24	2%	3.07	1.34	1.41	5.73
Energy						
High energy	98	8%	2.76	1.01	0.84	5.52
Vitamins						
Vitamins minerals	449	35%	3.06	1.01	1.21	6.18

pound is due to low number of observations as each of them are present in 6% or less of the products respectively. On the other hand, products that include *dental breath care* (\$2.63), *muscle care* (\$2.72), and *immune support* (\$2.74) attribute claims have the lowest per pound average price among all health-related product claims.

Figure 1 provides a visual representation of the distribution of the price per pound for the products that includes each health-related product attributes (indicated as “yes”) and those that do not include the health-related product attribute claim (indicated as “no”). The mean price of the products with the health-related product claim and excluding the health-related product claim is indicated by the horizontal black bar inside of the respective color bars. A detailed table of the descriptive statistics of Figure 1 are provided in Appendix A.

As indicated above, the relationship between the average price of products that included the health-related product claim and those that did not include these claims varied. Specifically, the

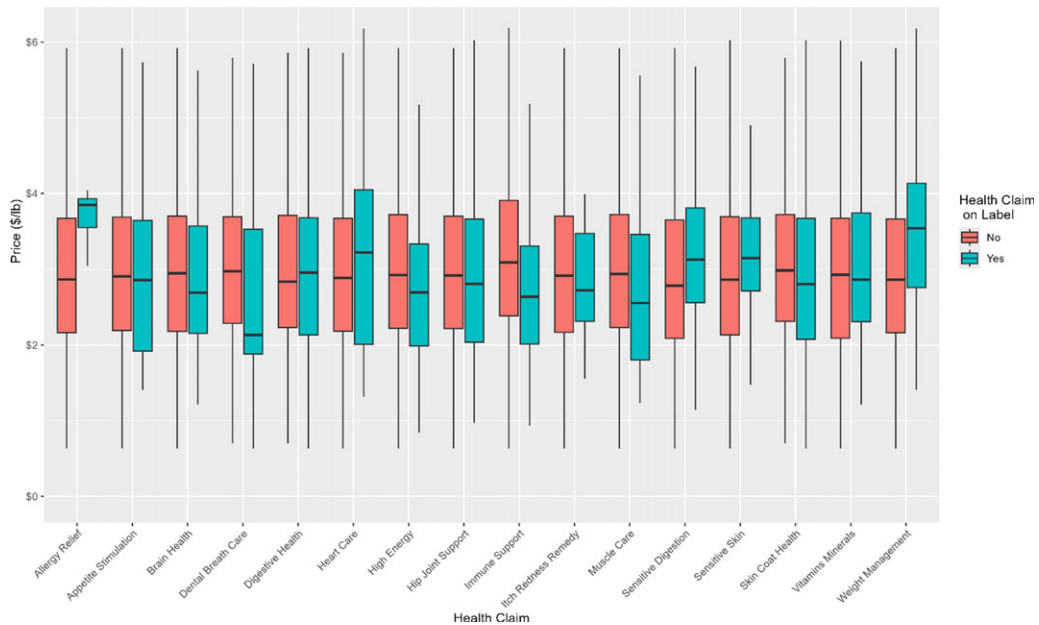


Figure 1. Distribution of price (\$/lb.) by health-related product claim.

average price per pound is higher for products that include claims such as *allergy relief*, *appetite stimulation*, *digestive health*, *heart care*, *sensitive digestion*, *sensitive skin*, and *weight management* than for the products that do not include these claims. Products that include *brain health*, *dental breath care*, *high energy*, *hip joint support*, *immune support*, *itch redness remedy*, *muscle care*, *skin and coat health*, and *vitamins minerals* have a lower average price per pound than the products that do not include these attributes. Overall, Figure 1 and Table 3 provide the naïve effect on price for each health and wellness attribute, without controlling for other factors. The hedonic price models in later sections identify these same effects while controlling for other factors that could potentially confound the naïve effects.

#### 4.8 Summary statistics for non-health-related product attributes

Table 4 reports the summary statistics for all non-health related product attributes. Additional product features varied by diet, food flavor, life stage (adult, puppy, or senior), breed size, package size, and product location (e.g. Made in the U.S.). The most common specialty diets included in the dog food products were “with grain,” “grain-free,” and “high protein.” Non-GMO, chicken free, and premium were the least frequent specialty diet related product attributes included in the product description. Regarding food flavors, poultry, chicken, and meat were the most common food flavors; while sweet potato, fruits/vegetables, and beef were the least common food flavor offerings. The majority of the product offerings were for dogs in the adult life stage, accounting for 80% of the product offerings. Puppy and senior focused products accounted for 13 and 7% respectively. Regarding the breed size, small, medium, and large breeds products accounted for 84, 72%, and 81% of the product offerings respectively. The average package weight was 23.53 pounds.

### 5. Empirical results and discussion

The estimated parameters for the health-related product attributes and other control variables are reported in Table 5. Price premiums for each attribute are discussed based on the approaches of

**Table 4.** Summary statistics for non-health related variables included in each dog food product

Variable	N	Proportion	Mean price (\$/lb.)	SD price (\$/lb.)	Min price (\$/lb.)	Max price(\$/lb.)
Special Diets						
With Grain	712	56%	2.89	1.15	0.63	6.25
Grain Free	693	55%	2.93	0.96	1.04	6.22
High Protein	388	31%	2.91	1.04	0.94	6.22
Natural	360	28%	3.22	1.02	1.23	6.22
Gluten Free	341	27%	3.29	1.03	1.16	6.22
Pea Free	283	22%	3.26	1.14	0.97	6.23
Premium	235	19%	3.91	0.86	2.36	6.22
Chicken Free	201	16%	3.58	0.9	1.44	6.18
Non-GMO	185	15%	3.38	1.12	1.65	6.19
Food Flavor						
Chicken	631	50%	2.92	1.13	0.63	6.25
Meat	320	25%	2.87	1.07	0.63	6.22
Seafood Fish	263	21%	3.21	0.99	1.12	6.18
Lamb	183	14%	2.88	1.02	1.09	6.13
Salmon	148	12%	3.08	0.92	1.41	6.18
Turkey	134	11%	3.41	0.97	1.39	6.22
Beef	109	9%	2.73	1.26	0.63	6.22
Fruits Vegetables	97	8%	2.89	0.98	0.63	5.54
Puppy	164	13%	2.94	1.06	0.85	6.25
Senior	93	7%	2.99	1.08	1.24	6.12
Breed Size						
Small Breeds	1060	84%	3.1	1.14	0.63	6.25
Medium Breeds	914	72%	2.96	1.08	0.63	6.23
Large Breeds	1028	81%	2.88	1.07	0.63	6.23
Extra Small Breeds	179	14%	3.89	1.11	1.47	6.25
Giant Breeds	149	12%	3	1.14	1.04	6.23
Other Variables						
Packaged Weight	1268	–	23.53 lbs.	9.25 lbs.	1.05 lbs.	51.1 lbs.
Made In USA	610	48%	3.03	1.21	0.63	6.23

Note: All variables are binary variables, excluding the packaged weight. All means, standard deviation, min, and max amounts reported above are reported in \$/lb., excluding packaged weight. Summary statistics for packaged weight are reported in lbs.

Halvorsen and Palmquist (1980) and Botta et al. (2023). Specifically, the price premiums are computed as  $(e^c - 1) \times 100$ , where  $c$  is the estimated parameter. The statistically significant parameter estimates are compared and discussed across the variables of interest and control

Table 5. Regression results

	Parameter Estimate	Associated Premium / Discount
<b>Digestion</b>		
Digestive Health	0.014 (0.011)	1.41%
Sensitive Digestion	<b>0.037***</b> (0.011)	<b>3.77%</b>
<b>Skin and Coat</b>		
Skin Coat Health	−0.010 (0.012)	−1.00%
Sensitive Skin	0.037 (0.025)	3.77%
Itch Redness Remedy	−0.039 (0.035)	−3.82%
<b>Immune Care</b>		
Immune Support	− <b>0.027**</b> (0.013)	− <b>2.66%</b>
Allergy Relief	<b>0.164***</b> (0.046)	<b>17.82%</b>
<b>Muscle and Joint</b>		
Muscle Care	−0.027 (0.018)	−2.66%
Hip Joint Support	−0.024 (0.013)	−2.37%
<b>Dental</b>		
Dental Breath Care	− <b>0.077***</b> (0.017)	− <b>7.41%</b>
<b>Internal Organ Support</b>		
Brain Health	0.021 (0.015)	2.12%
Heart Care	−0.024 (0.028)	−2.37%
<b>Weight Control</b>		
Weight Management	−0.015 (0.016)	−1.49%
Appetite Stimulation	−0.025 (0.032)	−2.47%
<b>Vitamins</b>		
Vitamins Minerals	−0.020 (0.014)	−1.98%
<b>Energy</b>		
High Energy	−0.007 (0.018)	−0.70%
<b>Special Diets</b>		
With Grain	− <b>0.087***</b> (0.010)	− <b>8.33%</b>
Grain Free	−0.023 (0.015)	−2.27%
High Protein	0.003 (0.012)	0.30%
Natural	−0.012 (0.017)	−1.19%
Gluten Free	0.002 (0.012)	0.20%
Pea Free	−0.001 (0.016)	−0.10%
Premium	<b>0.141***</b> (0.024)	<b>15.14%</b>
Chicken Free	<b>0.032**</b> (0.013)	<b>3.25%</b>
Non-GMO	<b>0.046**</b> (0.019)	<b>4.71%</b>

(Continued)

Table 5. (Continued)

	Parameter Estimate	Associated Premium / Discount
<b>Food Flavor (Protein)</b>		
Chicken	−0.032*** (0.011)	−3.15%
Meat	0.023 (0.016)	2.33%
Seafood Fish	0.017 (0.014)	1.71%
Lamb	−0.004 (0.016)	−0.40%
Salmon	0.010 (0.016)	1.01%
Turkey	0.013 (0.013)	1.31%
Beef	−0.016 (0.018)	−1.59%
Fruits Vegetables	0.027** (0.013)	2.74%
<b>Life Stage</b>		
Puppy	−0.010 (0.011)	−1.00%
Senior	−0.020 (0.013)	−1.98%
<b>Breed Size</b>		
Extra Small Breeds	0.004 (0.021)	0.40%
Small Breeds	−0.008 (0.022)	−0.80%
Medium Breeds	0.015 (0.020)	1.51%
Large Breeds	−0.048 (0.033)	4.69%
Giant Breeds	0.012 (0.018)	1.21%
<b>Packaging</b>		
Packaged Weight	−0.021*** (0.001)	−2.08%
<b>Sourcing</b>		
Made In USA	0.021 (0.017)	2.12%
<b>Constant</b>		
1.479*** (0.053)		
Observations	1,268	
R <sup>2</sup>	0.919	
Adjusted R <sup>2</sup>	0.912	

Robust standard errors in parentheses. Significance: \*10% level; \*\*5% level; \*\*\*1% level. Brand level fixed effects are included in this model. However, the brand level results are not disclosed to maintain the focus on the broader implications related to the implicit prices of the health-features in dog food.

variables. As detailed in Table 5, the adjusted R-square indicates that 92% of the variation in the dependent variable is explained by the model.

Parameter estimates and associated premiums and discounts are discussed below for the variables with statistically significant parameter estimates. It warrants emphasis that statistically insignificant coefficients should not be interpreted as definitive evidence of the absence of price premiums or discounts associated with these attributes. Rather, such findings indicate that the present analysis, given the available data, cannot establish with statistical confidence whether these attributes command market premiums or discounts. This limitation in statistical inference does

not preclude the possibility of economically meaningful relationships that might be detected with alternative data or methodological approaches.

The statistical significance and estimated effect of the health-related product attribute groups vary when controlling for additional product features and brand fixed effects. The signs of the coefficients in Table 5 match those of the robustness check model results in Table B.2 (Appendix B). While the variables showing statistical significance differ between models, this consistent alignment of signs confirms the uniform directional relationship between the independent variables and the log price per pound.

### 5.1. Associated premiums and discounts for the health-related product attributes

The hedonic pricing analysis reveals several statistically significant relationships between health-related product attributes and price premiums in the dry dog food market. Among the digestion related attributes, *sensitive digestion* claims command a 3.77% premium as suggested by the results in Table 5. However, the coefficient related to *digestive health* was statistically insignificant, indicating the analysis cannot confirm an associated premium or discount with statistical confidence. Similarly, the analysis fails to confirm a premium or discount for the three skin and coat attributes as all coefficients related to skin and coat health claims are statistically insignificant.

All immune care related product attributes were statistically significant in Table 5. The substantial premium associated with *allergy relief* (17.82%) represents the largest health-related premium, suggesting significant market value for specialized formulations addressing pet allergies. Conversely, *immune support* claims are associated with a price discount of 2.66%. Interestingly, the findings also show significant discounts (−7.41%) related to *dental care*. Coefficients for muscle and joint, internal organ support, weight control, vitamins, and energy health-related claims are statistically insignificant, indicating that the analysis fails to statistically confirm associated premiums and/or discounts related these attributes based on the sample data used in this study.

### 5.2. Associated premiums and discounts for the non-health-related product attributes

The special diets and food flavor (protein) categories provide insight into pricing patterns in the dog food market, as shown by the results in Table 5. Products labeled as *premium* command a 15.14% price premium, while those marketed as *with grain* show an 8.33% discount. The results also indicate statistical significance regarding certain dietary restrictions, with *chicken free* and *non-GMO* products commanding price premiums of 3.25% and 4.71% respectively. Regarding protein sources, *chicken*-based products show a 3.15% discount, while products containing *fruits and vegetables* labeling command a 2.74% premium. As suspected, packaging weight is negatively correlated with price per unit, indicating that increased packaging size reduces the price per lb. The analysis does not statistically confirm associated premiums or discounts for life stage, breed size, and sourcing related product attributes as indicated by the statistically insignificant results.

### 5.3. Strategic implications for pet food companies

Understanding the implicit prices of pet food attributes provide pet food decision makers with insights about market pricing structures and product positioning. In the pet food market, products are differentiated through various nutritional features and price points. The ability of a company to effectively position their offerings requires an understanding of how different health-related attributes correlate with market prices. This hedonic analysis approach presents insights into implicit prices associated with health and wellness product attributes in pet food by utilizing readily available online product description and pricing data.



The findings indicate significant price differences associated with various health attributes. Attributes related to *allergy relief*, *sensitive digestion*, and *non-GMO* ingredients are associated with higher market prices, while features such as *dental care* and *immune support* correlate with lower prices. These differentials suggest several strategic considerations for pet food companies. For example, the varying price levels associated with different attributes potentially suggest the need for strategic production planning. Companies might evaluate their manufacturing capabilities and ingredient sourcing to efficiently produce products with premium-associated attributes while managing cost. The significant premiums for specialized formulations like *allergy relief* suggest potential opportunities for dedicated production lines or facilities focusing on premium segments.

Manufacturers might also evaluate product development strategies that combine multiple premium-associated attributes. For instance, the significant premiums associated with both *allergy relief* and *sensitive digestion* suggest potential opportunities in specialized formulations addressing multiple health concerns. Specifically, the higher premiums suggest potential opportunities to place higher focus to offer product bundles that include the higher premium attributes, while carefully evaluating ingredient costs and production complexities. However, the price discounts associated with certain health claims like *dental care* suggest these features may be better positioned as complementary attributes rather than primary product attributes.

The substantial premium associated *premium* labeled products combined with specific health claims suggests potential opportunities for strategic upper-market positioning. More specifically, companies might evaluate their brand portfolio to ensure clear differentiation across price tiers. The significant discount for *with grain* products indicates distinct market segments with different price sensitivities. Companies could potentially develop targeted strategies for each segment, recognizing that price differences may reflect varying production costs and positioning strategies rather than just consumer preferences.

The negative relationship between package weight and price warrants careful consideration of package size strategy. Companies might evaluate their package size portfolio to balance production efficiencies with market positioning. Larger packages can be potentially positioned for value-oriented segments, while smaller packages might target premium or convenience-oriented segments. This relationship also suggests opportunities for strategic price tiering across packaging sizes (e.g., smaller packaging sizes command the highest price per pound and larger packaging size offer lowest price per pound while maintaining the highest total package price). This tiering structure can serve multiple purposes, including offering accessible entry price points with smaller packages, providing bulk discounts on larger packages while maintaining higher absolute margins, and meeting diverse consumer needs ranging from apartment residents to multiple-dog households.

The price discount associated with *chicken* compared to the premium for *fruit and vegetables* suggests potential opportunities for strategic ingredient selection. Specifically, companies may evaluate their protein and ingredient sourcing strategies, balancing cost considerations with market positioning opportunities. Additionally, the *chicken-free* premium indicates potential opportunities in alternative protein formulations, though production cost differences must be considered.

#### 5.4. Implications and considerations for pet food buyers

The findings can potentially provide benefit to pet food buyers during price-value assessment of health claims, package size efficiency, ingredient considerations, and product market positioning. Specifically, pet food buyers should note the higher prices associated with certain attributes may reflect factors beyond product quality, including production costs and marketing strategies. For example, while *allergy relief* products command significant premiums, pet food buyers should evaluate whether these specialized formulations address their pets' specific needs. On the other

hand, products with *dental care* features can potentially offer higher value opportunities despite their benefits. Regarding package size efficiency, the negative relationship between package size and price suggests potential cost savings with larger packages, though storage requirements and product freshness should be considered.

When considering ingredients, *chicken-based* products tend to be more economically priced (based on the  $-3.15\%$  discount shown in Table 5), while alternative proteins and specialized formulations command premiums. Thus, pet food buyers should evaluate whether these price differences align with their pets' dietary needs, and their budget constraints. Additionally, the premium associated with *premium* labeled products suggests significant price differentiation in this segment. Pet food buyers should carefully evaluate whether premium-positioned products offer additional benefits that justify their higher prices.

The findings also suggest several strategies for value-conscious pet food buyers. Larger package sizes generally offer better value per pound, though this benefit should be weighed against storage capacity and usage patterns to prevent spoilage from nonuse. Additionally, products with certain health features (like dental care) can potentially offer good value despite their benefits, as these features appear more commonly in lower-priced products. However, pet food buyers should note that price differences may potentially reflect various factors beyond product quality. Purchasing decisions should prioritize their pets' specific nutritional needs and health requirements over price considerations alone.

### 5.5. Considerations when interpreting empirical results

The findings indicate significant price differences associated with various health attributes, though the interpretation of these differences must consider the frequency of each attribute in the data sample (highlighted in Table 3). For *allergy relief*, while showing the highest premium ( $17.82\%$ ), this attribute appears in only 2% of products with a relatively high mean price of  $\$3.89/\text{lb.}$  as shown in Table 3. This limited presence suggests the associated premium might reflect a highly specialized market segment, though the small sample size warrants cautious interpretation despite statistical significance. In contrast, digestive health claims demonstrate different patterns across subcategories. The findings in Table 5 indicate that a  $3.77\%$  premium is associated with the *sensitive digestion* health claim. Since *sensitive digestion* appears in 24% of products, with a mean price of  $\$3.19/\text{lb.}$ , the substantial sample size and consistent premium suggest a well-established market position. General *digestive health* claims, although appearing in 52% of products, show no significant premium, potentially indicating this has become a standard feature across price points.

The negative relationship between *immune support* claims and price ( $2.66\%$ ) warrants particular attention given its presence in 37% of products with a notably lower mean prices of  $\$2.74/\text{lb.}$  This widespread presence combined with lower prices might suggest this feature has become standardized in lower-priced market segments. Similarly, *dental and breath care* claims show a substantial discount ( $-7.41\%$ ) while appearing in 9% of products with the lowest mean price of  $\$2.63/\text{lb.}$ , suggesting consistent positioning in lower-price segments.

Some attributes show interesting price differences but lack statistical significance, possibly due to limited observations. *Heart care* and *weight management* claims show higher mean prices ( $\$3.16/\text{lb.}$  and  $\$3.52/\text{lb.}$  respectively) but show no statistically significant premiums, potentially indicating insufficient sample size to detect true price effects. Similarly, *itch and redness remedy* claims also show no significant premium or discount despite specialized positioning ( $\$2.92/\text{lb.}$ ), possibly due to limited observations (present in 2% of products in the sample).

It is also important to note that the signs of the coefficients reported in Table 5 align with the signs of the robustness check model results reported in Table B.2 in Appendix B. Although the statistically significant variables vary, the alignment of signs indicates uniformity in the predicted relationship between the independent variables and the log price per pound.

Overall, these findings suggest strategic considerations should account for both the price effects and market presence. Attributes with significant premiums and substantial market presence (relatively high presence in products in the sample), like *sensitive digestion*, might offer more reliable opportunities for product differentiation compared to those with high premiums but limited presence, like *allergy relief*. The widespread presence of certain features showing discounts, such as *immune support* and *dental care*, potentially suggests these attributes have become baseline features rather than premium differentiators.

## 6. Conclusion

The increasing diversity of health and wellness attributes in pet food products creates a need to understand their associated market prices. This study addresses this need by applying hedonic price analysis to various health and wellness attributes in dry dog food, identifying the implicit prices associated with each attribute. The findings contribute to both practical industry insights and academic literature in agribusiness management and applied economics.

The analysis reveals significant price variations associated with different health attributes in the dry dog food market. Notable findings include substantial price premiums associated with certain digestive and immune care attributes. The allergy relief attribute demonstrates the highest premium among health-related attributes, with products carrying this claim priced 17.82% higher than those without. Conversely, significant price discounts are observed for products with immune support (−2.66%) and dental breath care (−7.41%) claims. These price differentials suggest distinct market positioning strategies across different health attribute categories.

Several important limitations warrant consideration. The hedonic approach captures market equilibrium prices but cannot distinguish whether price differences stem from consumer demand, manufacturing costs, or strategic positioning decisions. While the analysis controls for brand fixed effects, quality differences may confound results if certain attributes appear predominantly in higher or lower quality products. Additionally, there is potential endogeneity due to the correlation between health-related attributes and unobserved quality factors. As a result, consumer choices may be influenced by external factors like marketing intensity and distribution channels. These limitations suggest the need for careful interpretation when considering product development and marketing strategies based on these findings.

This research establishes a foundation for future investigation into pet food pricing structures. Further research could examine consumer willingness to pay for specific attributes, providing clearer insights into demand-side effects. Additional studies might explore price variations across different product formats (wet food, freeze-dried, etc.) and pet categories (cat food, exotic pets). Given the growing pet food market, such analyses could provide valuable insights for product differentiation strategies. Future research might also examine non-health attributes to identify optimal combinations of product features that align with market pricing structures. This comprehensive understanding could help manufacturers develop more effective product portfolios while considering both health-related and non-health attributes in their pricing strategies.

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