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Assessing research needs for informing pet food industry decisions

RESEARCH ARTICLE

Lonnie Hobbs, Jr.^a, Aleksan Shanoyan^b and Greg Aldrich^c

^aAssistant Professor, ^bProfessor, Department of Agricultural Economics, Kansas State University, Waters Hall,
Manhattan, KS 66506, USA

^cAssociate Professor, Department of Grain Science and Industry, Kansas State University, 201 Shellenberger Hall,
Manhattan, KS 66506, USA

Abstract

The global pet food industry continues to grow being fueled by increased pet ownership, higher disposable income of pet owners, and a growing demand for premium products. While this growth has attracted increased interest of researchers in animal nutrition and product formulation, the overall body of management and economic literature to guide product innovation and marketing strategies in the pet food industry is still limited. This study aims to identify and highlight the most important, relevant, and current research needs for informing product and marketing decisions in pet food. The methods include a quantitative analysis of primary data from a survey of 76 pet food decision makers involved in the procurement of raw material, production, and marketing. The findings suggest the need for extensive research in various areas pertaining to the quality and availability of raw materials, processing methods, and forecasting consumer preferences. The findings also emphasize high value research areas such as identifying alternative protein sources, enhancing nutrient retention during the extrusion process, identifying opportunities for product innovation that align with customer preferences, and accurately predicting consumer demand.

Keywords: marketing, pet food, production, raw materials, research needs

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[ⓧ]Corresponding author: lhobbs@ksu.edu

1. Introduction

The demand for pet food has increased significantly during the first two decades of the twenty-first century. Valued at less than \$30 billion in 2000, global sales of pet food increased to \$53.9 billion in 2010, and to \$102 billion in 2020 (Bedford, 2022). Fueled by higher disposable income, increased pet ownership, and growing demand for higher priced premium products; the rising pet food demand is creating unprecedented opportunities for pet-food companies to capture the rising profit potential in the market. Therefore, there is a need for innovative product and marketing strategies to enhance competitiveness and ability to capture a share of the growing pet food market. An important pre-condition for designing and implementing effective product and marketing strategies is the availability of evidence-based insights to inform the decision-making process. Conventional channels through which the research is being disseminated and accessed by industry stakeholders include internal reports, trade publications, and academic journals. While there has been recent growth in the publicly available research to guide pet food industry decisions, the overall body of literature in this area is still limited compared to the economic, management, and marketing research needs of the industry stakeholders (Evason *et al.*, 2020; Prata, 2020).

The gap in research to inform pet food economic and marketing decisions is likely the result of three primary factors. First, it is reasonable to assume that most of the research insights generated by in-house capabilities and external consultants are (a) company-specific and (b) not widely available. Second, the research sponsored or generated by industry associations, while generalizable, tends to be limited in scope as such studies are generally designed with a specific focus, limiting the discovery and analysis of topics outside the scope of the research project. For example, a research study sponsored by industry associations examining product demand for sensory product features may fail to identify additional insights such as non-sensory features (e.g., product functionality) that customers demand, customer willingness to pay for specialized attributes, and other valuable insights that decision-makers require to make informed strategic decisions. Third, the research insights generated by university researchers and disseminated through academic journals, while publicly available, tends to be (a) disjointed across disciplines and (b) likely to lag behind the current needs due to extended timelines of the peer-reviewed publication process, and dynamic changes in the pet food industry. Consequently, there is a need for a systematic assessment of the availability and necessity of evidence-based insights and high-priority research required for informing product and marketing decisions and supporting the pet food industry growth.

The purpose of this paper is to identify and highlight the most important, relevant, and current research needs for informing product and marketing decisions in the pet food industry. Specific research questions include: (1) What are the most important research needs of pet food decision makers in the areas of raw materials, production, and marketing/distribution? (2) Do the importance of research needs vary based on pet food company size? In answering the research questions, this study will present and discuss the implications and directions for future research to support the pet food industry growth.

To achieve its objectives, this study utilizes a combination of qualitative and quantitative research methods. Objectives (1) and (2) are accomplished through the design and implementation of a survey targeting decision makers in the pet food industry involved in raw material procurement, production, and marketing. The survey findings reveal the need for research in various areas, such as the quality and availability of raw materials, processing techniques, and predicting consumer taste and preferences. Additionally, the findings highlight several research areas with high potential impact, including exploring alternative protein sources, enhancing nutrient retention during the extrusion process, identifying product innovation opportunities to cater to customer preferences, and accurately forecasting consumer demand.

The contribution of this study is threefold. First, it identifies and describes specific needs for research insights from the perspective of actual industry decision makers. Second, it provides a comparison of the raw material, production, and marketing/distribution research needs based on the pet food company sizes. Third, it identifies and highlights the gaps in available research and the industry needs providing implications

and direction for future research. There are two primary stakeholder groups who stand to benefit from the findings of this study: academics conducting research on the economics and management of pet food, and pet food industry decision makers. The results of this study will help to align future research studies with the needs of pet food decision makers potentially resulting in enhanced economic return on public spending on research and outreach.

2. Literature review

A comprehensive literature review was conducted to assess the current state and identify the gaps in the academic and non-academic literature on pet food. The goal of this review was to identify research gaps in three primary areas: raw materials, production, and marketing/distribution. To achieve this, top journals in both pet food/nutrition and agricultural economics were examined. Keyword combinations such as “pet food,” “dog,” “cat,” “companion animal,” and “animal food” were utilized during the search. Additionally, specific keywords related to each primary area were included. For raw materials, these keywords included “raw material,” “ingredient,” and “protein.” For production, keywords such as “production,” “processing,” and “extrusion” were used. Finally, for marketing/distribution, keywords such as “marketing,” “purchasing,” “distributing,” “distribution,” “consumer,” and “supply chain” were employed. Only research articles and industry reports that included these keywords in their title, abstract, and/or article keywords were selected and reviewed, which constituted over 200 distinct articles. Reading lists of the most directly relevant articles identified during the review process are compiled and presented in Appendix A and Appendix B.

2.1 Pet food raw materials research literature

Among the published academic literature focused on pet food raw materials, there is a general focus on identifying ingredients that enhance the nutritional value offered to pets (G. Aldrich, 2017; Buff *et al.*, 2014; Hill, 2022). There have been several approaches in academic literature to address the issue of nutritious ingredient usage. From examining the benefits of protein sources (both animal and plant protein based) (Alexander *et al.*, 2020; Hill, 2022; Montegiove *et al.*, 2021), highlighting safety of ingredient (such as presence of mycotoxins, sodium, etc.) (Boermans and Leung, 2007; Singh and Chuturgoon, 2017; Soffer *et al.*, 2016), to utilizing specialized ingredients (de Godoy *et al.*, 2009; Hu *et al.*, 2020; Michel, 2006); each of these research articles attempts to address the need for nutritional ingredients to meet the basic needs, and improve the overall health of pets. Recent literature also highlights the rising demand for human grade food usage in pet food due to the humanization trend (i.e., pet owners now seeing and treating their pets like human members of the family), and mirroring of human food and pet food trends. Thus, there is more research needed for understanding the nutritional benefit of popular human food ingredients and identification of alternative protein sources to meet the growing demand for specialized ingredient and high-protein diet (Buff *et al.*, 2014; Hill, 2022; Samant *et al.*, 2021).

Non-academic literature focused on pet food raw materials highlights the rising use of human grade ingredients, ingredient supply chain disruption, and the transparency of plant and animal-based protein sources. In response to pet humanization and premiumization trends, several market reports have suggested the need for pet food companies to increase the use of products made with natural and organic human grade ingredients, alternative protein sources, or those rich in nutritional value (Grand View Research, 2022; Mordor Intelligence, 2022). More recently, non-academic literature have placed a greater emphasis on the low availability of pet food ingredients due to the global pandemic (Diment, 2022; Marketline, 2021; Pet Food Industry, 2022). Therefore, the remaining gaps in non-academic literature include identifying sustainable ingredient procurement/supply, increased ingredient transparency, and identification of alternative protein sources.

2.2 Pet food production research literature

Current academic literature in the area of pet food production is largely focused on enhancing production techniques. More specifically, there is a consensus among pet food production literature to address improved

nutrient retention, product functionality, quality and palatability of pet food during the extrusion process (Baller *et al.*, 2021; Koppel *et al.*, 2014; Morin *et al.*, 2021; Tran *et al.*, 2008). Several recent studies assessing the pet food production process suggests the need for identification and use of palatability and nutrient enhancers to increase the nutritional value of the final pet food products. (Baller *et al.*, 2021; Hu *et al.*, 2020; Morin *et al.*, 2021). Other studies highlight the need to improve the efficiency, effectiveness, and safety of pet food production, while lowering production cost (Craig, 2021; Leiva *et al.*, 2019; Soffer *et al.*, 2016). Overall, the remaining gaps in pet food production academic literature include approaches to improve the production process for increased nutrient retention and product safety (Aldrich and Koppel, 2015; Leiva *et al.*, 2019; Samant *et al.*, 2021).

The publicly available non-academic literature in the area of pet food production has a current focus on identifying sustainable production practices, nutrient retention production practices, and solutions to labor shortages. Similar to the academic literature, industry publications and reports emphasized the need to improve the nutritional benefits and product safety to meet the needs of pets, while accommodating the changing demands of customers (Mordor Intelligence, 2022; Statista, 2021). Recently, several industry articles and reports emphasize the need to address Covid related production disruptions, such as ingredient and labor shortages (Beaton, 2022; Calderwood, 2022; Tyler, 2021; Vennetti, 2022). However, the remaining gaps expressed in the non-academic literature are centered around ways for pet companies to improve nutrient retention, product safety, and ingredient transparency during the production process (Grand View Research, 2022; Statista, 2017, 2021).

2.3 Pet food marketing and distribution research literature

Pet food marketing/distribution academic literature has a primary focus on understanding customer purchase behavior and factors affecting purchasing decisions. Originally, these studies were designed to identify external forces motivating pet purchasing decisions, such as relationship with pets, family and demographic differences, and brand loyalty (McNicholas *et al.*, 2005; Purewal *et al.*, 2019; Schwarz *et al.*, 2007). More recently, the specialized focus on purchasing decision factors has evolved into identifying specific product attributes and product perceptions of customers to understand demand preferences (Hobbs *et al.*, 2023; Koppel, 2014; Koppel *et al.*, 2018; Kwak and Cha, 2021). Many of the pet owners' purchasing decisions are aligned with their personal dietary and ingredient preferences. Consequently, there has also been a push in pet food marketing academic literature to increase the effectiveness of product labeling, transparency, and regulations to inform marketing strategies that capitalize on the similarities of human and pet food demand (Antúnez *et al.*, 2013; Hobbs, Jr., 2019; Lemke *et al.*, 2015). However, many unanswered questions remain about how to predict and meet future customer preferences efficiently and effectively.

There is a wide array of non-academic literature centered around marketing and distribution of pet food. More specifically, a large portion of the pet food industry market reports provide insight into customer behavior, preferences, industry sales, and market forces guiding future industry forecast. The consensus of this body of literature identified the need for research on how to communicate product value to customers. In addition, non-academic literature has consistently expressed the need of pet food companies to market specific product attributes desired by customers, and adapt to changing purchasing habits (i.e. online shopping, automatic purchasing, etc.) to increase product sales (Statista, 2021; Waters, 2021). Accordingly, remaining information gaps in non-academic literature includes promotion of clean labelling, understanding purchasing decisions, and predicting future customer behavior.

Overall, there is a general alignment between academic and non-academic literature regarding the research needs in the areas of raw materials, production, and marketing/distribution in pet food. The research gaps in raw materials include the increased and improved use of human-grade ingredients in pet food, as well as the identification of alternative protein sources to meet the rising protein demand by pet owners. The available literature agrees that improving extrusion processes and production safety is an area that constitutes a research

gap in pet food production literature. Forecasting customer demand is another area of a significant research gap expressed in both academic and non-academic literature. While the review of academic and non-academic literature is necessary for identifying research gaps, it is not sufficient. A more comprehensive assessment of research needs in pet food economics and management requires a concurrent analysis of pet food decision makers' perceptions about ongoing needs for research-based insights to inform their decisions. This study aims to provide a comprehensive assessment of research needs in pet food economics and management by comparing and contrasting the research gaps identified in the literature with the research needs expressed by decision makers.

3. Methods and data

3.1 Needs assessment methodology

Literature suggests that surveying industry representatives can identify challenges faced by companies and provide insights into decision-makers' actual needs (Depken and Zeman, 2018; Gilbert *et al.*, 2010; Malavolta *et al.*, 2013). Researchers find it beneficial to periodically survey stakeholders to track new developments and ensure research addresses the primary concerns of their target audience. Needs assessment surveys help determine industry requirements to develop effective strategies and offer technical assistance, particularly by land grant universities. More specifically, these assessments identify which groups are in need, the types of needs, and their severity (Barron, 2009). This method is utilized across various fields, including business, education, and extension (Delgado *et al.*, 2023; Depken and Zeman, 2018; Ealing *et al.*, 2023). However, no published studies have used this approach in the pet food industry. Therefore, this study is the first of its kind to apply a needs assessment to the pet food industry to identify the research needs of industry decision makers.

To analyze and draw conclusions from a needs assessment, previous studies have utilized Likert scale approach to indicate the degree of importance of the need and generate quantitative data for statistical analysis (Kaufman and English, 1979). The degree of the Likert scale varies depending on desired degree of variability, granularity, and precision (Alabi and Jelili, 2023). Once the Likert scale data has been collected, the common approach to analyzing the data is descriptive statistics, analysis of variance (ANOVA), and t testing to identify statistical differences between groups. Likewise, this study will follow a similar approach in using t-testing and ANOVA analysis of Likert-scaled data to establish importance rankings among the various research needs based on statistical significance.

3.2 Survey data sources and study items

An electronic survey was administered to pet food industry professionals using the Qualtrics survey system to identify industry decision maker needs. The survey sample included professional attendees of the three of the top U.S. pet food events from 2021–2022 (2021 Pet Food R&D Showcase, 2021 Pet Food Formulation for Commercial Production Course hosted by the Kansas State University (KSU) Pet Food Program, and 2022 Petfood Forum hosted by Watt Global Media, the largest annual gathering of pet food professionals in the US. In addition to the conference attendees, the Qualtrics survey link was distributed through social media pet food groups, and through an article written by Watt Global media and published online. The combination of these outlets allowed access to a large and diverse group of decision makers in the US pet food industry. The survey participants consist of a variety of pet food industry professionals and stakeholders from small, medium, and large companies who are decision makers in the areas of raw materials, production, and/or marketing. The details on the sample size and summary statistics are presented in the first part of the results section.

The survey instrument consisted of six sections. The first section comprised of basic demographic information, including education, company size, job function, and frequency of decision making in the areas of raw

materials, production, and marketing. Respondents that are not involved in decision making in the primary areas (raw materials, production, and marketing) are removed from the sample to ensure the results reflect the needs of actual industry decision makers. Sections 2–4 identified the need for research insight, primary sources for obtaining research insights, important challenges, and key information gaps in the respective areas of raw materials, production, and marketing/distribution. The research areas specified in the survey (raw materials, production, and marketing/distribution), the specific topics of research needs in each area, and the keywords used in the literature review and qualitative analysis have been identified through a focus group and a pilot survey of pet food stakeholders, including academic researchers and industry professionals from small, medium, and large companies. Questions concerning external research utilization were included in Section 5. The last section of the survey instrument comprised of open-ended questions to explore the most important current and future market trends in the pet food industry.

3.3 Method of analysis

The analysis of survey data is based on a combined quantitative and qualitative approach for identifying the research needs and key information gaps within three primary areas: (a) raw materials, (b) production, and (c) marketing and distribution. The survey participants were asked to individually rate four raw material research topics, seven production topics, and six marketing/distribution topics from low research need (0) to high research need (10). This approach allows to obtain insights on the magnitude of importance of each topic and the relative importance compared to others, in an efficient manner (e.g., without overloading respondents with multiple repetitive questions required by alternative measures such as Best-Worst-Scaling). It is assumed that factors with the highest mean rating reflect the highest research need. The analysis is structured to identify most important research needs going from broad to specific. The first step aims to identify the most important area of research (i.e., raw materials, production, and marketing/distribution), the second steps aim to identify most important topic within each area, and the third step aims to identify the most important topic across all areas of research. Following this structure, the statistical analysis is conducted, and the results are discussed for the total sample and three sub-samples based on company size (i.e., small, medium, and large).

To complement the statistical analysis, a qualitative analysis of responses to open-ended questions is conducted using keyword frequency analysis technique following the approaches utilized in Hobbs *et al.* (2023). First, all open-ended responses are reviewed to identify keywords related to each of the seventeen research topics within three research areas. Second, a binary variable is created indicating whether a specific topic-related keyword is present in a particular open-ended response. Third, the number of open-ended responses related to each research topic is identified using the binary variable. The final step of the qualitative analysis involves comparing the number of open-ended responses across seventeen research topics. The goal is to identify the research topics mentioned in most open-ended responses. The results present the number of open-ended responses related to each topic in a descending order. The most important research needs based on the combination of statistical and qualitative analysis are then compared and discussed in relation to the key gaps found in the current academic and non-academic literature.

Statistical means of research topics are evaluated independently to assess the overall importance of the research topic. It is important to note, the level of importance indicated by the rating on the 0 to 10 scale likely varies based on the respondent's subjective perception, however it is reasonable to assume that the perception of the midpoint (e.g., 5 on a scale from 0 to 10) will likely be consistent across respondents. To test the assumption of consist midpoint across the respondents and reliability of the survey instrument, a Cronbach Alpha test was conducted for each research area in the total sample and sub-samples based on company size. The Cronbach alpha serves as an indicator of a survey or scale's internal consistency (Cronbach, 1951). It has been used in various studies to evaluate whether all items in a survey measure the same concept and if a unidimensional measurement scale exists within the survey items (Green *et al.*, 1977; Tavakol and Dennick, 2011). More specifically, the Cronbach alpha provides an indicator of whether a group of items (questions) in a survey can be used to measure a latent variable, based on the correlation between the items

(Cronbach, 1951). If the answers to the questions are highly correlated, they are said to have high internal consistency. Cronbach alpha values range between 0 (indicating low correlation among the survey items) and 1 (indicating high correlation). Past studies suggest that an acceptable alpha value falls between 0.70 and 0.95 (Barbera *et al.*, 2021; Schrepp, 2020; Tavakol and Dennick, 2011).

4. Results

This section presents (i) the characteristics of the sample and summary statistics, (ii) the results of the statistical analysis that reflect the most important areas and topics of research for the whole sample and sub-samples based on company size, and (iii) the results of the qualitative analysis of open-ended responses. Table 1 presents the results of the Cronbach Alpha test. As shown in Table 1, all Cronbach Alpha measurements in this study range from 0.79 to 0.89, indicating statistical reliability and uniformity in the measurement scale. This provides a reasonable basis for assuming consistent midpoint perception across respondents. Therefore, to gauge the independent importance of each research topic, it is assumed that topics with statistical mean above 5.0 are perceived to be of higher magnitude of importance compared to that of under 5.0. Additionally, research topics will be assessed relative to the other topics to identify the most important research topics based on the statistical mean analysis.

4.1. Summary statistics

The total sample includes 76 pet food industry decision makers. The sample includes respondents from three broadly defined company size categories reflected by the number of employees. The small company category reflects a pet food company with less than 100 employees, medium company category includes businesses with 100–1000 employees, and a large company category includes businesses that employ more than 1000 people. Figure 1 presents a percentage distribution of the survey respondents by company size. Although there are slightly more respondents from medium sized companies, the representation by company size is comparable as the small, medium, and large company respondents represented 32, 37 and 31%, respectively. The primary area of decision-making is also examined for each respondent to assess the extent to which the sample is reflective of decision makers in the three focus areas (raw materials, production, and marketing). As shown in Figure 2, there are relatively more primary decision makers in raw materials represented in the sample for all company sizes. Overall, there is a similar proportional representation of primary decision makers in each area. Some respondents are primary decision makers in more than one area, hence the total number of responses in Figure 2 exceeding our total sample size.

4.2 Relative importance of research needs in areas of raw material, production, and marketing and distribution

Table 2 reflects the relative importance of research needs in the areas of raw material, production, and marketing/distribution, as expressed by respondents from small, medium, and large companies. The values represent the difference in the average ratings of importance of each topic area, with the sign indicating the relative importance of the topic areas. The statistical significance of the difference in mean values is indicated by the stars. For example, 1.627*** in the first row of the second column indicates the difference

Table 1. Cronbach alpha results.

Research area	Total sample	Small comp.	Medium comp.	Large comp.	Number of items in the scale
Raw materials	0.8325	0.8914	0.8022	0.7928	4
Production	0.8355	0.8408	0.8427	0.8431	7
Marketing and distribution	0.8456	0.8336	0.8036	0.8956	6

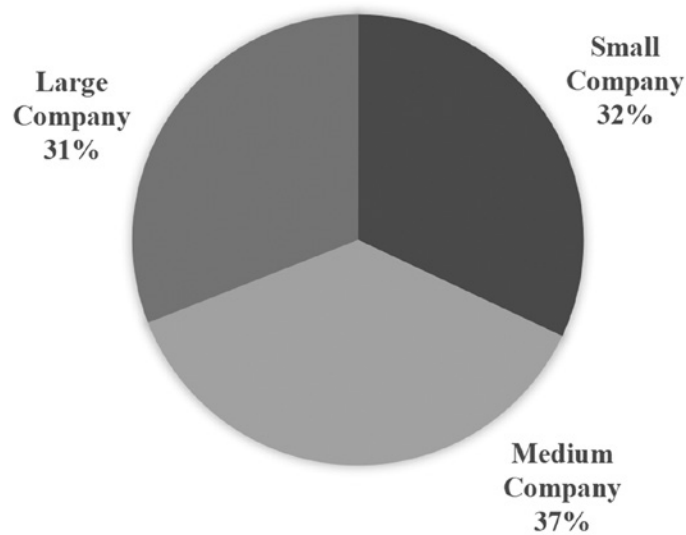


Figure 1. Relative proportion of responses based on company size.

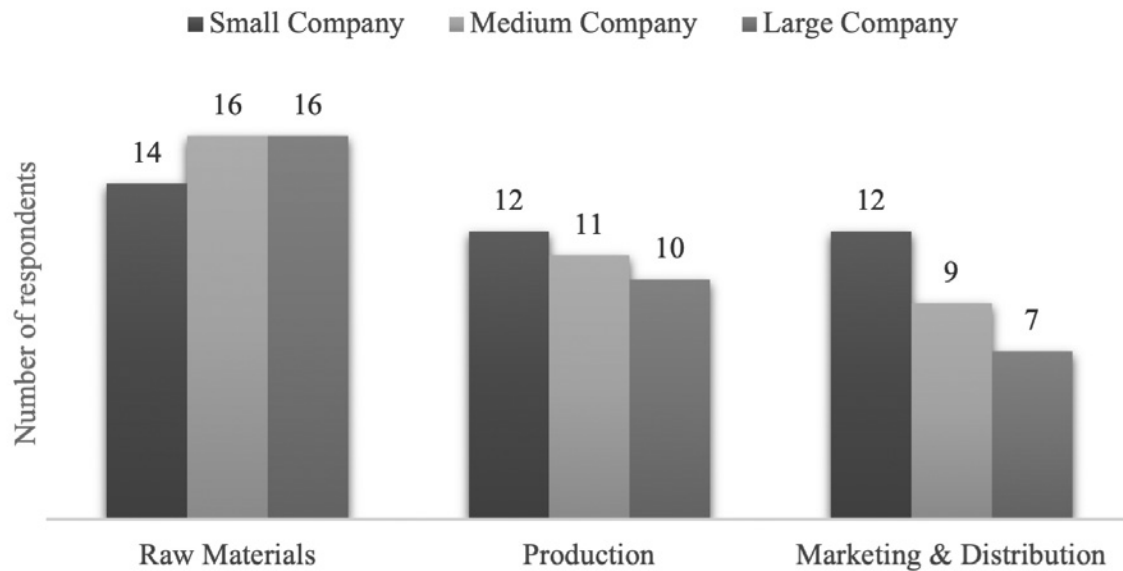


Figure 2. Respondents' primary decision area by company size.

Table 2. Relative importance of research need across topic areas by company size (as reflected by the difference in mean ratings)

Research area	Mean diff.			
	Total sample	Small comp.	Medium comp.	Large comp.
Raw material research vs Production research	1.627*** (0.262)	1.443** (0.647)	2.030*** (0.489)	1.240** (0.577)
Raw material research vs Marketing and distribution research	0.352* (0.224)	0.325 (0.657)	0.822** (0.475)	-0.189 (0.593)
Production research vs Marketing and distribution research	-1.125*** (0.185)	-1.118 (0.610)	-1.207** (0.514)	-1.429*** (0.543)

Mean difference, mean rating of research area. Standard errors are reported in parentheses: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$.

in the average rating of the importance of raw materials research and production research. The positive sign indicates that the research need in the area of raw material is perceived by the respondents to be, on average, more important than the research need in the area of production. The difference in average importance is statistically significant at 0.01 level. The results in Table 2 indicate that the research need in the area of raw materials is perceived to be greater than the research need in the area of production across firms of all sizes. The results also indicate that the respondents from medium-sized firms perceive the research need in the area of raw materials to be greater than the research need in the area of marketing and distribution. However, research need in the area of marketing and distribution is perceived to be greater than the research need in the area of production by the respondents in both large- and medium-sized firms.

4.3. Relative importance of research topics within each area of research

4.3.1. Relative importance of research needs on four research topics in the area of raw materials

The relative importance of research topics in the area of raw materials is reflected in Table 3. The results indicate that the need for research related to the quality of raw materials is perceived to be greater than the need for research on the topics of availability/consistent supply of raw materials, cost of raw materials, and governmental regulations of raw materials for the total sample of respondents and respondents in the sample from small-sized companies. The results also indicate that for respondents in the sample from medium-sized companies, the need for research related to quality of raw materials and availability/consistent supply of raw materials is perceived to be greater than the need for research related to the cost of raw materials and governmental regulations of raw materials, as indicated by the positive difference in means value.

Table 3. Relative importance of research need in the area of raw materials by company size (as reflected by the difference in mean ratings)

Research topics in the area of raw materials	Mean diff.			
	Total sample	Small comp.	Medium comp.	Large comp.
Quality of raw materials research vs Availability/consistent supply of raw materials research	0.737** (0.399)	1.217* (0.753)	0.571 (0.493)	0.445 (0.806)
Quality of raw materials research vs Cost of raw materials research	1.240*** (0.412)	1.174* (0.774)	1.464*** (0.540)	1.042 (0.824)
Quality of raw materials research vs Governmental regulations of raw materials research	1.243*** (0.405)	1.713*** (0.716)	1.571*** (0.598)	0.417 (0.796)
Availability/consistent supply of raw materials research vs Cost of raw materials research	0.503 (0.412)	-0.043 (0.820)	0.893** (0.548)	0.597 (0.781)
Availability/consistent supply of raw materials research vs Governmental regulations of raw materials research	0.506 (0.405)	0.496 (0.768)	1.000** (0.604)	-0.028 (0.753)
Cost of raw materials research vs Governmental regulations of raw materials research	0.003 (0.419)	0.540 (0.790)	0.107 (0.643)	-0.625 (0.769)

Mean difference, mean rating of research topic. Standard errors are reported in parentheses: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$.

4.3.2 Relative importance of research needs on seven research topics in the area of production

The relative importance of research topics in the area of production is summarized in Table 4. The results indicate that the research need related to the topic of processing methods/technology is statistically significantly greater than all production-related topics as perceived by the total sample, excluding risk management. The results also indicate that the need for research related to the topic of geography/location is perceived to be less important than all other production-related topics for the total sample, and for the three sub-samples based on company size. For respondents included in the sample from small-sized companies, the need for research related to processing methods/technology and risk management are perceived to be greater than the need for research related to approaches for attracting talent, management methods/processes, and geography/location. The results also indicate that the need for research related to facilities is perceived to be greater than the need for research related to the approaches for attracting talent, as expressed by the respondents from small-sized companies. The results in Table 4 also indicate the medium-sized company respondents research need related to processing methods/technology and risk management topics are perceived to be greater than the research need related to approaches for attracting talent, facilities, management methods/processes, and geography/location. The research needs related to risk management is perceived to be greater than the need for research related to governmental regulations/compliance, as expressed by the respondents from medium-sized companies. Additionally, the results indicate that for sample of respondents from large-sized companies, processing methods/technology, governmental regulations/compliance, and approaches for attracting talent related research are perceived to be greater than the need for research related to the topics of facilities and geography/location. However, the respondents in the large-sized firms research need related to processing methods/technology is also perceived to be greater than the research need related to risk management.

4.3.3 Relative importance of research needs on six research topics in the area of marketing/distribution

The relative importance of research topics in the area of marketing/distribution is presented in Table 5. The results of the statistical analysis indicate that the six marketing/distribution-related research topics are equally important for the total sample. The results also indicate that for the respondents in the sample from small-sized companies, the need for research related to market and competitor intelligence is perceived to be greater than the need for research related to coordinating the supply chain and distribution. It is important to note that for the respondents included in the sample from large-sized companies perceive the need for research related to the validation of claims is greater than the need for research related to attracting and retaining customers.

4.4 Relative importance of research topics across three research areas

The relative importance of seventeen research topics across three research areas (raw materials, production, and marketing/distribution) is summarized in Table 6. The superscript numbers beside the reported means indicate that the reported mean for the research topic is statistically significantly larger than the mean for the topics denoted by the number at or above the number indicated by the superscript when the items are listed in the descending order based on the sample mean. For example, the superscript number 2 indicates that the reported mean is greater than the means for topic from 2 (availability and consistent supply of raw materials) to 17 (geography/location). The results of the statistical analysis indicate that the need for research related to the topic of quality of raw materials is perceived to be greater than the need for research compared to the other 16 research topics for the total sample and for the small company sub-sample. The results also indicate that availability/consistent supply of raw materials is statistically significantly more important than governmental regulations of raw materials and all research topics listed thereafter (topics 8–17). It is also important to note that need for research related to market competitor intelligence, forecasting consumer tastes and preferences, and cost of raw materials is perceived to be greater than the need for research topics related to risk management, governmental regulations/compliance, approaches for attracting talent, facilities, management methods/processes, and geography/location as indicated by the respondents included in the

Table 4. Relative importance of research need in the area of production by company size (as reflected by the difference in mean ratings)

Research topics in the area of production	Mean diff.			
	Total sample	Small comp.	Medium comp.	Large comp.
Processing methods/technology research vs Risk management research	0.372 (0.404)	0.136 (0.684)	-0.111 (0.686)	1.204** (0.717)
Processing methods/technology research vs Governmental regulations/compliance research	0.696** (0.431)	0.727 (0.735)	0.852 (0.756)	0.476 (0.767)
Processing methods/technology research vs Approaches for attracting talent research	0.960** (0.437)	1.539** (0.824)	1.074* (0.784)	0.236 (0.645)
Processing methods/technology research vs Facilities research	1.012*** (0.410)	0.364 (0.723)	1.111* (0.693)	1.569** (0.713)
Processing methods/technology research vs Management methods/processes research	1.090*** (0.398)	1.182** (0.690)	1.111* (0.709)	0.976* (0.679)
Processing methods/technology research vs Geography/location research	2.626*** (0.412)	2.955*** (0.722)	2.323*** (0.701)	2.658*** (0.745)
Risk management research vs Governmental regulations/compliance	0.324 (0.449)	0.591 (0.779)	0.963* (0.727)	-0.727 (0.834)
Risk management research vs Approaches for attracting talent research	0.588* (0.455)	1.403* (0.866)	1.185* (0.755)	-0.098* (0.721)
Risk management research vs Facilities research	0.640* (0.428)	0.227 (0.768)	1.222** (0.661)	0.366 (0.785)
Risk management research vs Management methods/processes research	0.718** (0.416)	1.045* (0.737)	1.222** (0.678)	0.227 (0.751)
Risk management research vs Geography/location research	2.254*** (0.431)	2.818*** (0.767)	2.434*** (0.667)	1.455** (0.813)
Governmental regulations/compliance vs Approaches for attracting talent research	0.264 (0.481)	0.812 (0.908)	0.222 (0.820)	-0.240 (0.776)
Governmental regulations/compliance vs Facilities research	0.316 (0.455)	-0.364 (0.813)	0.259 (0.734)	1.093* (0.836)
Governmental regulations/compliance vs Management methods/processes research	0.394 (0.443)	0.455 (0.785)	0.259 (0.749)	0.500 (0.801)
Governmental regulations/compliance vs Geography/location research	1.930*** (0.457)	2.227*** (0.813)	1.472** (0.742)	2.182*** (0.860)
Approaches for attracting talent research vs Facilities research	0.052 (0.461)	-1.175* (0.898)	0.037 (0.762)	1.333** (0.716)
Approaches for attracting talent research vs Management methods/processes research	0.131 (0.450)	-0.357 (0.871)	0.037 (0.777)	0.740 (0.680)
Approaches for attracting talent research vs Geography/location research	1.666*** (0.464)	1.416* (0.898)	1.249** (0.771)	2.422*** (0.752)
Facilities research vs Management methods/processes research	0.079 (0.422)	0.818 (0.773)	0.000 (0.685)	-0.593 (0.748)
Facilities research vs Geography/location research	1.614*** (0.437)	2.591*** (0.802)	1.212** (0.675)	1.089* (0.814)
Management methods/processes research vs Geography/location research	1.536*** (0.425)	1.773** (0.773)	1.212** (0.692)	1.682** (0.779)

Mean difference, mean rating of research topic. Standard errors are reported in parentheses: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$.

Table 5. Relative importance of research need in the area of marketing and distribution by company size (as reflected by the difference in mean ratings)

Research topics in the area of marketing and distribution	Mean diff.			
	Total sample	Total sample	Total sample	Total sample
Forecasting consumer tastes and preferences research vs Market and competitor intelligence research	-0.014 (0.415)	-0.323 (0.814)	0.280 (0.628)	-0.055 (0.756)
Forecasting consumer tastes and preferences research vs Validation of claims research	0.050 (0.450)	0.535 (0.901)	0.080 (0.707)	-0.463 (0.759)
Forecasting consumer tastes and preferences research vs Forecasting consumer demand research	0.175 (0.451)	0.487 (0.894)	0.002 (0.656)	0.061 (0.832)
Forecasting consumer tastes and preferences research vs Attracting and retaining customers research	0.304 (0.442)	-0.136 (0.862)	0.440 (0.672)	0.591 (0.796)
Forecasting consumer tastes and preferences research vs Coordinating supply chain and distribution research	0.326 (0.452)	0.909 (0.871)	0.127 (0.635)	-0.045 (0.866)
Market and competitor intelligence research vs Validation of claims research	0.064 (0.421)	0.857 (0.801)	-0.200 (0.700)	-0.408 (0.711)
Market and competitor intelligence research vs Forecasting consumer demand research	0.189 (0.422)	0.810 (0.793)	-0.278 (0.649)	0.116 (0.786)
Market and competitor intelligence research vs Attracting and retaining customers research	0.319 (0.414)	0.186 (0.762)	0.160 (0.665)	0.646 (0.751)
Market and competitor intelligence research vs Coordinating supply chain and distribution research	0.341 (0.424)	1.232* (0.772)	-0.153 (0.628)	0.010 (0.821)
Validation of claims research vs Forecasting consumer demand research	0.125 (0.458)	-0.048 (0.887)	-0.078 (0.729)	0.524 (0.790)
Validation of claims research vs Attracting and retaining customers research	0.254 (0.449)	-0.671 (0.854)	0.360 (0.740)	1.054* (0.753)
Validation of claims research vs Coordinating supply chain and distribution research	0.276 (0.459)	0.374 (0.863)	0.047 (0.710)	0.418 (0.829)
Forecasting consumer demand research vs Attracting and retaining customers research	0.130 (0.449)	-0.623 (0.847)	0.438 (0.694)	0.530 (0.827)
Forecasting consumer demand research vs Coordinating supply chain and distribution research	0.152 (0.460)	0.422 (0.856)	0.125 (0.657)	-0.106 (0.897)
Attracting and retaining customers research vs Coordinating supply chain and distribution research	0.022 (0.450)	1.045 (0.825)	-0.313 (0.674)	-0.636 (0.861)

Mean difference, mean rating of research topic. Standard errors are reported in parentheses: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$.

sample. The results also indicate that geography/location is statistically significantly less important than all research topics across the research areas of raw materials, production, and marketing/distribution for the total sample, and for all sub-samples based on company size. For the respondents from medium-sized companies, the need for research related to the quality of raw materials and availability/consistent supply of raw materials is perceived to be greater than the need for research related to the other 15 topics. For the respondents included in the sample from large-sized companies, research related to the validation of claims is perceived to be greater than the need for research related to approaches for attracting talent, facilities, management methods/processes, and geography/location. In summary, the results presented in Table 6 indicate that the need for research related to the quality of raw materials is perceived to be greater than the need for research of all topics across all three research areas as expressed by the sample of pet food industry decision makers.

Table 6. Survey results of research needs for informing pet food marketing and distribution decisions

Research topic	Area	Mean				Obs. total sample
		Total sample	Small comp.	Medium comp.	Large comp.	
1. Quality of raw materials	RM	8.013 ^{2**} (2.441)	8.304 ^{2*} (2.382)	8.536 ^{3***} (1.815)	7.125 ^{15***} (2.939)	75
2. Availability/Consistent supply of raw materials	RM	7.276 ^{7*} (2.464)	7.087 ^{16**} (2.712)	7.964 ^{3*} (1.875)	6.680 ^{15*} (2.704)	76
3. Market and competitor intelligence	M&D	6.841 ^{12*} (2.260)	7.095 ^{16**} (2.256)	6.680 ^{15*} (2.193)	6.783 ^{15*} (2.411)	69
4. Forecasting consumer tastes and preferences	M&D	6.826 ^{12*} (2.601)	6.773 ^{16*} (3.007)	6.960 ^{13*} (2.244)	6.727 ^{15*} (2.658)	69
5. Validation of claims	M&D	6.776 ^{13*} (2.645)	6.238 ^{16*} (2.897)	6.880 ^{13*} (2.728)	7.190 ^{14*} (2.294)	67
6. Cost of raw materials	RM	6.773 ^{12*} (2.607)	7.130 ^{16**} (2.849)	7.071 ^{13**} (2.210)	6.083 ^{15*} (2.765)	75
7. Governmental regulations of raw materials	RM	6.770 ^{13*} (2.50)	6.591 ^{16*} (2.423)	6.964 ^{13*} (2.589)	6.708 ^{15*} (2.562)	74
8. Forecasting consumer demand	M&D	6.652 ^{13*} (2.634)	6.286 ^{16*} (2.849)	6.958 ^{13*} (2.349)	6.667 ^{15*} (2.799)	66
9. Attracting and retaining customers	M&D	6.522 ^{13*} (2.587)	6.909 ^{16**} (2.706)	6.520 ^{15*} (2.502)	6.136 ^{15*} (2.62)	69
10. Coordinating supply chain and distribution	M&D	6.500 ^{14**} (2.685)	5.864 ^{17***} (2.765)	6.833 ^{13*} (2.200)	6.773 ^{15*} (3.070)	68
11. Processing methods/technology	PD	6.597 ^{13*} (2.311)	6.682 ^{16*} (2.102)	6.593 ^{15*} (2.635)	6.522 ^{15*} (2.192)	72
12. Risk management	PD	6.225 ^{14*} (2.514)	6.545 ^{16*} (2.425)	6.704 ^{14*} (2.399)	5.318 ^{17***} (2.607)	71
13. Governmental regulations/compliance	PD	5.901 ^{17***} (2.824)	5.955 ^{17***} (2.734)	5.741 ^{17***} (2.917)	6.045 ^{17***} (2.919)	71
14. Approaches for attracting talent	PD	5.638 ^{17***} (2.864)	5.143 ^{17***} (3.214)	5.519 ^{17***} (3.105)	6.286 ^{17***} (2.077)	69
15. Facilities	PD	5.586 ^{17***} (2.568)	6.318 ^{17***} (2.662)	5.481 ^{17***} (2.455)	4.952 ^{17***} (2.539)	70
16. Management methods/processes	PD	5.507 ^{17***} (2.443)	5.500 ^{17***} (2.464)	5.481 ^{17***} (2.578)	5.545 ^{17***} (2.365)	71
17. Geography/Location	PD	3.971 (2.599)	3.727 (2.658)	4.269 (2.459)	3.864 (2.783)	70

Standard deviations are reported in parentheses; superscript numbers indicate that the reported mean is greater than the mean of the superscript number and all reported means following the superscript: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$.

4.5 Analysis of open-ended responses on most important challenges in pet food

This section presents the results of the key word frequency analysis of open-ended responses. Table 7 presents the ranking of research topics based on the number of key words used in open-ended responses. The results of the frequency analysis indicate that words related to the topic of availability/consistent supply of raw materials are used in more open-ended responses compared to words related to all other topics. The results also indicate that processing methods/technology research topic is the second most frequently referenced

Table 7. Results of open-ended response frequencies by research topic

Research topic	Research area	Frequency			
		Total sample	Small comp.	Medium comp.	Large comp.
1. Availability/Consistent supply of raw materials	RM	50	15	21	15
2. Processing methods/technology	PD	26	11	8	7
3. Cost of raw materials	RM	17	7	7	3
4. Approaches for attracting talent	PD	17	3	9	5
5. Quality of raw materials	RM	11	3	3	5
6. Market and competitor intelligence	M&D	9	4	5	0
7. Validation of claims	M&D	9	2	5	2
8. Facilities	PD	8	3	1	4
9. Management methods/processes	PD	8	0	3	5
10. Forecasting consumer tastes and preferences	M&D	6	2	1	3
11. Coordinating supply chain and distribution	M&D	6	3	0	3
12. Forecasting consumer demand	M&D	5	1	2	2
13. Attracting and retaining customers	M&D	4	1	2	1
14. Governmental regulations/compliance	PD	2	2	0	0
15. Governmental regulations of raw materials	RM	2	0	0	2
16. Risk management	PD	1	0	0	1
17. Geography/Location	PD	0	0	0	0
No. of observations		76	23	28	25

topic in open-ended responses for the total sample, and the small and large company sub-samples. Approaches for attracting talent is the second most frequently mentioned research topic in open-ended responses by respondents in the medium company sub-sample. It is notable that the words related to availability/consistent supply of raw materials, processing methods/technology, cost of raw materials, approaches for attracting talent, and quality of raw materials research topics are frequently mentioned in open-ended responses in the context of industry disruptions caused by the global pandemic.

5. Discussion and conclusion

Despite the recent growth in the pet food industry, the literature on pet food economics and management still lags behind the growing needs of industry decision-makers. This study contributes to defining that gap by utilizing primary data from actual industry decision makers and executives to identify most important research needs in the area of raw materials, production, and marketing of pet food.

Although there is general alignment between the available non-academic literature and the needs expressed by industry decision makers, there is an apparent disconnect in the areas of research needs based on the gaps described in the current academic literature and those expressed by industry decision makers. Specifically, the industry decision makers included in the survey expressed a similar level of need for research, on average, in the areas of raw materials and marketing and distribution as shown in Table 2. While the review of publicly available academic literature suggests a greater need for research related to marketing and distribution than raw materials. This disconnect can potentially be attributed to the time lag associated with academic research going from problem identification stage to a final publication. The effect of such time lags is likely to be particularly pronounced for fast-evolving industries. This issue is addressed by shortening publication timeline for academic research in fields associated with fast-evolving industries such as Information and Communication, Biomedical, etc. However, while the rate of growth and change in the pet food industry

has been exponential, the publication timeline of academic research in related fields (e.g. economics and management in pet food industry) continue to stay at historical levels. In the case of non-academic literature there is not much time lag as the news articles and association reports tend to get published faster and follow closely the industry trends. The results of this study confirm this notion as reflected in the general alignment between the research needs highlighted in the non-academic literature and those expressed by industry decision makers in the survey sample. Specifically, the needs expressed in both sources are in direct response to key market trends such as increased demand for premium products due to the humanization trend, and the rise in demand for specialized diet formulations and ingredients currently observed in pet food. The term “humanization” refers to pet owners viewing and treating their pets as human members of the family (Cambridge Dictionary, 2021). Given the current economic landscape (i.e. rising pet ownership, more health-conscious customers, rising demand for specialized premium products) and factors in the pet food industry, it is not surprising that the industry decision makers in the sample expressed greater need for research related to raw materials, and marketing and distribution of products. The mere presence of such disconnect between the research needs identified by the academic literature, non-academic literature, and the decision makers in the sample further highlights the value of this and similar studies aimed at need identification and mapping. Table 8 summarizes the common and unique pet food research gaps expressed in academic and non-academic literature, and by the industry decision makers.

Table 8. Common and unique research gaps in pet food

	Academic	Non-academic	Industry decision makers
Raw materials			
Common gaps	<ul style="list-style-type: none"> • Use of human-grade ingredients • Identify alternative protein sources 	<ul style="list-style-type: none"> • Use of human-grade ingredients • Identify alternative protein sources 	<ul style="list-style-type: none"> • Use of human-grade ingredients • Identify alternative protein sources
Unique gaps		<ul style="list-style-type: none"> • Sustainable supply of proteins • Traceability of protein ingredient sources 	<ul style="list-style-type: none"> • Improved ingredient nutrient profiles • Sustainable supply of natural ingredients
Production			
Common gaps	<ul style="list-style-type: none"> • Nutrient retention during extrusion • Improve production safety 	<ul style="list-style-type: none"> • Nutrient retention during extrusion • Improve production safety 	<ul style="list-style-type: none"> • Nutrient retention during extrusion • Improve production safety
Unique gaps	<ul style="list-style-type: none"> • Identifying natural nutrient and palatability enhancers 	<ul style="list-style-type: none"> • Addressing labor shortages 	<ul style="list-style-type: none"> • Addressing labor shortages • Production strategy insight/literature • Production risk management
Marketing and Distribution			
Common gaps	<ul style="list-style-type: none"> • Forecasting customer demand and preferences 	<ul style="list-style-type: none"> • Forecasting customer demand and preferences 	<ul style="list-style-type: none"> • Forecasting customer demand and preferences
Unique gaps	<ul style="list-style-type: none"> • Marketing strategies to benefit from humanization trends 	<ul style="list-style-type: none"> • Clean labelling promotion • Online purchase decision factors 	<ul style="list-style-type: none"> • Validation of labelling claims • Market and competitor intelligence • Attracting and retaining customers • Coordination of supply chain and distribution

There is a consensus amongst the three sources regarding the need to improve the quality and supply of raw materials, increase ingredient transparency and traceability, and identify alternative proteins available for use in pet food. The results of this study point out three potential high-value areas for future academic research related to pet food ingredients. First, researchers should examine the drivers and impediments for establishing supply of alternative protein sources to use in pet food products. Currently, the animal-based proteins used in pet food are largely derived from by-products of human food production. With the growing demand for animal-based proteins in pet food production the supply chain is experiencing significant challenges (Hill, 2022). Thus, research studies aimed at identifying alternative protein sources and establishing consistent and reliable supply for use in pet food can help inform one of the most pressing management decisions related to the pet food industry. Second, future research should examine the use and safety of human grade ingredients to help improve the quality of raw materials. Use of human grade ingredients has potential to affect not only the nutritional profile of finished pet food products, but also product positioning and differentiation in the context of the humanization trend. However, many questions still remain about the regulatory aspects, production processes, packaging and handling measures, as well as marketing of human grade pet food products. Research studies in these areas are more demanded by industry stakeholders and are likely to have greater impact. Lastly, a concerted research effort should be directed at studying issues related to safety and traceability of pet food ingredients. The humanization trend is also fueling the increase in health-conscious pet owners, which in turn drives the need for transparency in pet food ingredient sourcing and use (Bloom, 2020). Research efforts aimed at supply chain management and traceability of raw materials can help address the need for research-based insights in this area.

The analysis of the literature and the survey of pet food decision makers indicates that there is a potential for high-impact academic research focused on processing methods and product functionality. First, there is a continuous need for research focused on enhancements to extrusion process for increase nutrient retention. During the extrusion process, pet food undergoes extensive heat for baking and drying; resulting in vitamin loss, protein denaturation, and loss of other nutritional factors (Tran *et al.*, 2008). There is a need for research aimed at identifying alternative processing methods and/or natural nutrient enhancers to increase nutrient retention during the extrusion process. Second, there is a consistent need for technical research aimed at developing and testing natural palatability-enhancing agents to improve the palatability and functionality of pet food. Product functionality and palatability depends on product formulation, heat processing, raw material freshness and stability, and product packaging. Thus, identification of effective agents to improve product formulation, design, and packaging have potential to improve perceived product appeal and benefits by pet food customers. Third, there is a lack of literature focused on talent acquisition and development in the pet food industry. Labor shortages in pet food have become problematic due to the recent pandemic and labor market trends (Beaton, 2022; Tyler, 2021). Therefore, research effort should be directed at identifying more effective recruitment and training techniques to increase the supply of qualified labor to meet the operational needs of pet food companies in a fast changing economic and political-legal environment.

This study also highlights directions for potentially high-impact research aimed at addressing the primary marketing/distribution research needs of pet food decision makers. First, there is a distinct need expressed by the total sample of pet food decision makers for research to assist with forecasting consumer demand and preferences. The demand for pet food is expected to continue to rise and evolve over the next decade due to current industry forces (i.e. growing pet ownership, humanization, etc.) (Imarc Group, 2022). Thus, proper understanding of pet food demand structure and purchasing decisions can help managers and policymakers to predict customer responses to external and internal industry forces. Second, the findings suggest a need for research aimed at improved validation of product claims. There are several credence attributes (e.g. natural, sustainable, etc.) currently marketed in the pet food industry that do not have clearly defined qualifications to indicate that the product claim meets the requirements of the American Animal Feed Control Organization (AAFCO), U.S. Food and Drug Administration (FDA), and/or other product claim validating organizations, unlike other well-defined claims (e.g. organic, human-grade, etc.). With the growing humanization trend, preferences for specialized product attributes have increased. As companies seek to differentiate through

various claims and product attributes, there is a need to have not only an up-to-date understanding of customer preferences, but also the ability to establish industry standards and requirements needed to meet and market the desired product attributes claims demand by customers. to validate Lastly, the results highlighted a need for research-based insights to inform marketing and distribution strategies aimed at emerging e-commerce trends in pet food. The reliance on online shopping in pet food have increased significantly since global pandemic, resulting in shift towards e-commerce including subscription and automatic order models (Mordor Intelligence, 2022; Pet Food Industry, 2022). Due to the ease of product comparison and increased competition in the e-commerce space, research in this area is likely to be in high demand by industry decision makers in the near future.

The limitations of this study are related to the relatively low sample size of industry respondents. Although the sample provided adequate information regarding the needs of pet food decision makers, increasing the sample size of respondents can potentially increase the representation of decision maker needs and will allow for more nuanced statistical analysis. Nevertheless, considering the relatively small size of the population of inference – the US pet food manufacturers, the insights gained from the sample are sufficiently informative. This paper provides the most comprehensive and well-rounded overview of the research needs in the area of pet food economics and management based on the combined analysis of evidence in literature and a survey of pet food industry decision makers.

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Appendix A

Table A1. A reading list of academic literature on pet food.

Title	Author	Year	Primary area	Open gaps	URL
Raw materials					
Evaluating the supply chain of animal protein-based pet food ingredients and international trade of pet food	Hill	2022	Raw materials	Estimation of the value of animal-based protein ingredients in pet food and factors affecting pet food trade.	https://krex.k-state.edu/dspace/handle/2097/42387
An alternative approach to evaluate the quality of protein-based raw materials for dry pet food	Motegoive <i>et al.</i>	2021	Raw materials	Identification of digestibility indexes of the different raw materials used for dry pet food production	https://www.mdpi.com/2076-2615/11/2/458

Table A1. Continued.

The global environment paw print of pet food	Alexander <i>et al.</i>	2020	Raw materials Production	There is a lack of research and data surrounding environmental paw prints from pet food. Adoption of human plant-based diets should be extended into companion animals.	https://www.sciencedirect.com/science/article/pii/S0959378020307366
A dog food recommendation system based on nutrient suitability	Song and Kim	2020	Raw materials Marketing/ Distribution	Further evaluation and improvements of content-based dog food recommendation algorithms are needed to assist pet owners in determining suitable pet food to improve pet health conditions.	https://onlinelibrary.wiley.com/doi/full/10.1111/exsy.12623
Antioxidant performances of corn gluten meal and DDGS protein hydrolysates in food, pet food, and feed systems	Hu <i>et al.</i>	2020	Raw materials	Improved product storage stability.	https://www.sciencedirect.com/science/article/pii/S2666154320300119
Special topic: The association between pulse ingredients and canine dilated cardiomyopathy: Addressing the knowledge gaps before establishing causation	Mansilla <i>et al.</i>	2019	Raw materials	Increased knowledge of processing methodologies and nutrient interactions among ingredient combinations.	https://academic.oup.com/jas/article/97/3/983/5279069
Bacteriophages safely reduce Salmonella contamination in pet food and raw pet food ingredients	Soffer <i>et al.</i>	2016	Raw materials	Improved safety of raw pet food ingredients and production.	https://www.tandfonline.com/doi/full/10.1080/21597081.2016.1220347

Table A1. Continued.

Natural pet food: a review of natural diets and their impact on canine and feline physiology	Buff, Carter, and Kersey	2014	Raw materials	Understanding of natural pet food diets and their effect on growth and performance, nutrient availability, digestibility, and product safety	https://academic.oup.com/jas/article/92/9/3781/4702209
Myths and misperceptions about ingredients used in commercial pet foods	Laflamme <i>et al.</i>	2014	Raw materials	Indicators of ingredient quality cannot be included on product labels. Therefore, true food quality indicators such as nutrient profile and digestibility are only known by companies.	https://www.vetsmall.theclinics.com/article/S0195-5616(14)00047-3/fulltext
Select corn coproducts from the ethanol industry and their potential as ingredients in pet foods	de Godoy <i>et al.</i>	2009	Raw materials	Increased nutritional information on novel ingredients and product claims.	https://academic.oup.com/jas/article/87/1/189/4731181
Mycotoxins and the pet food industry: toxicological evidence and risk assessment	Boermans and Leung	2007	Raw materials	Address and assess of risk and safety of mycotoxins in pet food.	https://www.sciencedirect.com/science/article/pii/S0168160507003935?casa_token=SmG_xu0rR3wAAAAA:0677ad5UCrMbJjSBPSj5Cau35p9PADzrsRNm65TeyKERMp5lepS8gLgV7oEqKup0iawOY_ipyIw
Production Dry pet food flavor enhancers and their impact on palatability: A review	Samant <i>et al.</i>	2021	Production	Use of aromas commonly related to human foods and traditional palatability-enhancing agents can be potentially valuable in pet food acceptance.	https://www.mdpi.com/2304-8158/10/11/2599

Table A1. Continued.

Additives in pet food: Are they safe?	Craig	2021	Production Raw materials	Updated processing strategies and technologies are needed to establish and ensure product safety processed food production.	https://onlinelibrary.wiley.com/doi/full/10.1111/jsap.13375
Dry pet food flavor enhancers and their impact on palatability: A review	Samant <i>et al.</i>	2021	Production	Use of aromas commonly related to human foods and traditional palatability-enhancing agents can be potentially valuable in pet food acceptance.	https://www.mdpi.com/2304-8158/10/11/2599
Sustainability and pet food: Is there a role for veterinarians?	Acuff <i>et al.</i>	2021	Production	Pet owners do not fully understand the impacts purchasing decisions have on sustainability.	https://www.vetsmall.theclinics.com/article/S0195-5616(21)00020-6/fulltext
A literature review on vitamin retention during the extrusion of dry pet food	Morin <i>et al.</i>	2021	Production	Improved retention of vitamins during extrusion process.	https://www.sciencedirect.com/science/article/pii/S0377840121001619?casa_token=D3TFs5BnmbcAAA:0aAfNthGYalkQa31kJVMJNo4TizUJE85L9HkcMnrbrGnXNfswGeO0jaKX29UEVnTOBWvEqANnIM
Effects of thermal energy on extrusion characteristics, digestibility and palatability of a dry pet food for cats	Baller <i>et al.</i>	2021	Production	Improved nutrient retention through generalizable extrusion process among manufacturers.	https://onlinelibrary.wiley.com/doi/full/10.1111/jpn.13606?casa_token=fIOSZIE9UTMAAAAA%3AVz722HpjkhxkPF3tKUIql4upaCyxVN_yGQJnKrz8wSQZ_UL00n7BhFmsqJdkYZTfExxqvojWpf4i--s
Pet food quality assurance and safety and quality assurance survey within the Costa Rican pet food industry	Leiva <i>et al.</i>	2019	Production	Improved pet food formulations to account for the loss of nutrients during extrusion process.	https://www.mdpi.com/2076-2615/9/11/980

Table A1. Continued.

A comparative analysis of mycotoxin contamination of super market and premium brand pelleted dog food in Durban, South Africa	Singh and Chutu	2017	Production	Improved processing and packaging technology can potentially reduce the presence of mycotoxins in pet food.	https://journals.co.za/doi/abs/10.4102/jsava.v88i0.1488
Pet food palatability evaluation: A review of standard assay techniques and interpretation of results with primary focus on limitations	Aldrich and Koppel	2015	Production	There is a need to develop methods that would help understand and improve palatability related issues or provide better models to predict cat and dog food selection.	https://www.mdpi.com/2076-2615/5/1/43
The effects of cooking process and meat inclusion on pet food flavor and texture characteristics	Koppel <i>et al.</i>	2014	Production	Assessment of flavor, odor, and texture characteristics associations with palatability.	https://www.mdpi.com/2076-2615/4/2/254
Pet food safety: A shared concern	Buchanan <i>et al.</i>	2011	Production	Identification of new sources of nutrients to enhance nutritional well-being of pets.	https://www.cambridge.org/core/journals/british-journal-of-nutrition/article/pet-food-safety-a-shared-concern/A2BBC59F8ABFE6280F7A36249CE0DB14
Marketing/ Distribution					
The pet exposure effect: exploring the differential impact of dogs versus cats on consumer mindset	Jia <i>et al.</i>	2022	Marketing/ Distribution	Need for understanding the strength of influence of pets versus people on consumer behavior.	https://journals.sagepub.com/doi/full/10.1177/00222429221078036
Is there a market for upcycled pet food?	Ye <i>et al.</i>	2022	Marketing/ Distribution	Identifying consumer purchasing behavior and price response to branding when accounting for political ideology of pet owners.	https://www.sciencedirect.com/science/article/pii/S0959652622005960?casa_token=Q8RzbG3_IIMAAA:dKy2wAI3BM-xOp2_UDs69jdkfjHn-NxebvBqEM-xed79aBGSqvYvjJ5DhIVWvYsKjG1_Swzq-X4

Table A1. Continued.

Analysing the impact of COVID 19 and firm performance: A case study of pet foods firms in Malaysia	Cherz and Rahman	2022	Marketing/ Distribution	Improved marketing and business strategy tools to evaluate pet food company performance.	http://eprints.utar.edu.my/4448/1/1900651__hazel_chua.pdf
A new market for pet food in China: Online consumer preferences and consumption	Xiao <i>et al.</i>	2021	Marketing/ Distribution	Identify if there is a difference in online versus offline pet food purchasing behavior.	https://www.tandfonline.com/doi/abs/10.1080/10971475.2021.1890360
Profiling Italian cat and dog owners' perceptions of pet food quality traits	Vinassa <i>et al.</i>	2020	Marketing/ Distribution	Identification of factors that influence dog and cat owners' perceptions of pet food quality.	https://link.springer.com/content/pdf/10.1186/s12917-020-02357-9.pdf
Determinants of pet food purchasing decisions	Schleicher <i>et al.</i>	2019	Marketing/ Distribution	Improved understanding of the underlying motivations of pet food purchases and pet diet selections.	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6515811/
Analysis of customer perception of product attributes in pet food: Implications for marketing and product strategy	Hobbs, Jr.	2019	Marketing/ Distribution	Improved understanding of customer perceptions of product attributes, attribute category classifications, and customer purchasing behavior.	https://krex.k-state.edu/dspace/handle/2097/40076
An analysis of pet food label usage	Lemke <i>et al.</i>	2015	Marketing/ Distribution	Improvement pet food labeling and education of pet owners about benefits of label	https://www.cabdirect.org/cabdirect/abstract/20153441457
Feeding Fido: Changing consumer food preferences bring pets to the table	Kumcu and Woolverton	2014	Marketing/ Distribution	Improved understanding of customer purchasing behaviors and ways to leverage technology to reach younger age pet owners.	https://www.tandfonline.com/doi/full/10.1080/10454446.2012.715575?casa_token=LPAKtZII_wYAAA%3AjE2rVunPOpp_pBphKPGBskU9JKy3d1dopzdcgOba-0CcyW3ssk0WE6E9Ja5IJcnnZnZqd_XN--vyaA

Table A1. Continued.

Sensory analysis of pet foods	Koppel	2014	Marketing/ Distribution	Improved analysis and understanding of personality and environmental factor to further understand customer acceptance to pet food.	https://onlinelibrary.wiley.com/doi/abs/10.1002/jsfa.6597?casa_token=t5nsJMHARzMAAAAA:Wv6OhrsmtwPKH-TFATel-KSbLDQc9M_8-uPVsQdcKkJg56dGzR-LaSg07rVDTptDYrhU8YK_HC0XvNE
Do they buy for their dogs the way they buy for themselves?	Tesform and Birch	2010	Marketing/ Distribution	Need for research to understand why dog owners choose certain brands over others, and how behavioral connection influences purchasing decisions.	https://onlinelibrary.wiley.com/doi/full/10.1002/mar.20364
Animal house: economics of pets and the household	Schwarz <i>et al.</i>	2007	Marketing/ Distribution	Improved understanding of pet owner spending habits and factors driving spending over time.	https://faanalytics.org/wp-content/uploads/2015/05/Citation421.pdf

Appendix B

Table B1. A reading list of non-academic literature on pet food.

Title	Source	Year	Open Gaps	URL
Global pet food market size & share report	Grand View Research	2022	Need for insight to address supply issues, flow of raw materials, and forecast product demand.	https://www.grandviewresearch.com/industry-analysis/pet-food-industry
North America – pet healthcare	Marketline	2022	Need for product innovation to meet customer demands and increase competitive advantage.	https://advantage-marketline-com.er.lib.k-state.edu/Analysis/ViewasPDF/north-america-pet-health-care-155740
Pet Food Market Share, Trends, Report 2022–27	Mordor Intelligence	2022	Need for insight to address supply issues, use of human grade ingredients, online purchasing behavior, and forecast product demand.	https://www.mordorintelligence.com/industry-reports/global-pet-food-market-industry
Challenges continue to keep pet food manufacturers on their toes pet food processing	Petfood Processing	2022	Need for insight to address supply issues, flow of raw materials, and labor shortages.	https://www.petfoodprocessing.net/articles/15947-challenges-continue-to-keep-pet-food-manufacturers-on-their-toes

Table B1. Continued.

Pet food labor challenges and automation solutions	Petfood Industry.com	2022	Need for insight to address labor shortages, supply chain issues, and processing innovations.	https://www.petfoodindustry.com/articles/11148-pet-food-labor-challenges-and-automation-solutions
Pet food institute explains food shortages, inflation impacts	Pet Food Institute	2022	Need for insight to address supply issues, labor shortages, raw materials shortages, and forecast product demand.	https://www.ktre.com/2022/07/25/pet-food-institute-explains-food-shortages-inflation-impacts/
Pet food market trends	PetfoodIndustry.com	2022	Need for insight to address supply issues, use of human grade ingredients, identify alternative protein sources, and forecast product demand.	https://www.petfoodindustry.com/topics/222-pet-food-market-trends
Industry at a glance – OD4347 pet food production	IBIS World	2021	Need for product innovation to increase nutritional benefits, identify raw material alternatives, and forecast and meet future demand.	https://my-ibisworld-com.er.lib.k-state.edu/us/en/industry-specialized/od4347/industry-at-a-glance
Baby, children, and pet products: Consumer behaviour is driving innovation in key sectors	Marketline	2021	Need for increased for increased human grade ingredients, product transparency, ingredient quality, and sustainable packaging.	https://advantage-marketline-com.er.lib.k-state.edu/Analysis/ViewasPDF/baby-children-and-pet-products-consumer-behaviour-is-driving-innovation-in-key-sectors-137681
Pet supplies – US – 2021	Mintel Group Ltd.	2021	Need for insight to improve product and ingredient quality, increase safety standards, product transparency, and forecast customer purchasing behavior.	https://reports-mintel-com.er.lib.k-state.edu/display/1086999/?fromSearch=%3Ffreetext%3Dpet%2520food&highlight#hit1
Pet food report 2021	Statista	2021	Need for insight to address supply issues and forecast future product demand.	https://www-statista-com.er.lib.k-state.edu/study/48838/pet-food-report/
What you need to know about the pet food shortage	Animal Health Clinic of Funkstown	2021	Need for insight to address supply issues, flow of raw materials, and meet rising demand.	https://funkstownvet.com/blog/what-you-need-to-know-about-the-pet-food-shortage/
Pet food processors cope with labor shortages amid growing product demand	Petfood Processing	2021	Need for insight to address labor shortages, supply chain issues, and meet rising demand.	https://www.petfoodprocessing.net/articles/15323-pet-food-processors-cope-with-labor-shortages-amid-growing-product-demand
Global pet food sales	Statista	2017	Need for product innovation to meet customer demands and increase competitive advantage.	https://www-statista-com.er.lib.k-state.edu/statistics/253953/global-pet-food-sales/

Appendix C. ANOVA testing of mean values by company size

Table C1. One-way ANOVA results to test difference in mean values by company size

Research need	SS	Degrees of Freedom	MS	F statistic	P value
Raw materials					
Availability/Consistent supply of raw materials	22.97 (432.23)	2 (73)	11.48 (5.92)	1.94	0.151
Cost of raw materials	16.85 (486.30)	2 (72)	8.42 (6.75)	1.25	0.293
Quality of raw materials	28.53 (412.46)	2 (72)	14.26 (5.73)	2.49	0.09*
Governmental regulations of raw materials	1.85 (455.24)	2 (71)	0.93 (6.41)	0.14	0.866
Production					
Processing methods/technology	0.29 (379.03)	2 (69)	0.14 (5.49)	0.03	0.974
Management methods/processes	0.051 (417.70)	2 (68)	0.026 (6.14)	0.00	0.996
Approaches for attracting talent	14.34 (543.60)	2 (66)	7.17 (8.24)	0.87	0.423
Risk management	26.54 (415.86)	2 (68)	13.27 (6.12)	2.17	0.122
Governmental regulations/compliance	1.22 (557.09)	2 (68)	0.61 (8.19)	0.07	0.929
Facilities	20.52 (434.47)	2 (67)	10.26 (6.48)	1.58	0.213
Geography / Location	3.87 (462.07)	2 (67)	1.94 (6.90)	0.28	0.756
Marketing & Distribution					
Market and competitor intelligence	2.08 (345.16)	2 (66)	1.04 (5.23)	0.20	0.820
Attracting and retaining customers	6.57 (448.65)	2 (66)	3.28 (6.80)	0.48	0.62
Forecasting consumer demand	5.07 (445.91)	2 (63)	2.54 (7.08)	0.36	0.70
Forecasting consumer tastes and preferences	0.73 (459.19)	2 (66)	0.36 (6.96)	0.05	0.95
Coordinating supply chain and distribution	13.21 (469.79)	2 (65)	6.61 (7.23)	0.91	0.41
Validation of claims	9.95 (451.69)	2 (64)	4.98 (7.06)	0.71	0.50

The standard errors are reported in parentheses. *** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$.

Appendix D. Open-ended survey responses

Raw materials important challenge

Small company

- Availability
- Supply, cost
- supply levels
- availability of stable, safe, reliable sources
- Covid related shipping disruptions.
- sourcing of, quality check, price outlook
- We have so few in vivo studies in companion animal nutrition
- Currently it is the rising cost related to short supply
- Rising costs which often lead to specification adjustments to mitigate said costs.
- Costs are going up faster than inflation and faster than we are able to increase prices at retail.
- sourcing consistent supply that meets internal standards
- competition with other pet food companies and human food companies
- Consistency of supply - specifically with quality balanced around this.
- Consistency
- Trustable suppliers
- Currently it is simply availability and cost. Previously it was functionality and quality.
- Processing
- Rising costs
- Supply of organ meat
- We deal in wild venison as our hero ingredient in a range of raw food and treats. Whilst production is year-round it was heavily interrupted by Covid and the impact on associated edible venison demand for food service. We want to prove that our raw material supply chain is sustainable both commercially and environmentally.
- Right ingredients
- I faced with the volume of slaughter each slaughter houses and this is the most important issue
- Availability

Medium company

- The availability of some raw materials in the pandemic cost
- Constant supply
- Matching raw material specs and current supply
- Availability—most people do not set out to make the raw material my company uses.
- we are a newbie in petfood and we tend to be dependent on imported raw materials. it is important for us to develop a strong supplier base for high quality imported petfood ingredients and it is important for us to figure out which locally available ingredients can be part of our petfood formulas
- Homogeneity in different batches
- Getting a consistent supply that meets our required specifications and are not outrageously priced.
- Consistency of raw materials between suppliers and finding relevant research on digestibility and palatability.
- The time-consuming, complicated process of vetting new suppliers
- Supply
- Transportation/Availability
- Continued supply
- Price and availability
- Obtaining raw materials from suppliers that have high quality and food safety standards.

- Consistent supply, variability in nutrient profile.
- Cost and rapid inflation
- Consistent and quality supply source
- Consistent supply, especially of animal derivatives
- Cost
- Inflation has had an incredible impact on availability as well as cost of materials. It has cut our EBITDA in half
- Freight costs
- Price and availability.
- Availability
- Sustainability

Large company

- Consistent availability
- Quality of raw material
- Limitation of approved aafco natural ingredients
- Approval for use in exotic species
- AAFCO Natural Status
- Availability
- Supply chain impacts disrupting raw material availability. Also labor shortages and their impact on the process.
- Stable global supply; consistent supply; raw material safety; raw material functionality
- Precise reliable data confirming absence of unwanted protein, for ingredients to include in formulas for allergic pets (aromas, etc.)
- Sourcing during supply challenges while maintaining fair pricing.
- Cost of renewable fuels in the supply chain of fat and oils.
- Supply.
- Lack of consistency in quality and supply
- Constant supply; Contingency Suppliers
- ingredient storages
- Availability, delivery against quality standards, inflation/cost pressures, and innovation enablers.
- Availability and consistency of Material
- Supply chain issues.
- Constantly shifting supply chains / availability of high volume quality raw materials
- Unknown - do not work with raw material procurement. Assume consistent supply is current challenge driven by industry supply chain issues.
- Availability of natural kraft and a fc free print ply.

Production important challenge

Small Company

- Employees
- Staying current with new technologies
- NA
- Staffing
- Production capacities utilization, availability, legislation
- Ingredients, processing, final product research is lacking in dogs and cats
- Finding quality focused manufacturers.
- Quality and service levels
- Getting enough product produced in time for our customer's orders.
- Increasing efficiencies

- We are a raw manufacturer and need to find a faster more efficient way of doing our exclusive way of production.
- Staffing
- Capacity
- Time and commitment
- Regulatory interpretation. Marketing and Operations always want to push the envelope in the area of claims and verbiage, this needs to be clearer, and make more sense to lay personnel.
- Energy cost
- Form and freezing. We sell a raw product in cube form that is presently formed as a block and cut by bandsaw. Its a messy, dangerous and low-yielding way to make what we want.
- Volume
- The most important challenge is in the oven I need to kill any pathology with the heat and not dehydrate so much the product
- Lead time/capacity

Medium Company

- When there is a new line for extrusion and then stabilize the process.
- Consistency of product quality
- Personnel recruitment
- Time in production facilities! we ebb and flow; when we're stacked, finding places to make test products is crucial.
- The learning curve to get used to running an extruder since we are a newby in petfood production, our engineers/manufacturing personnel are coming from a livestock/poultry feed production experience
- I haven't this information
- Hesitancy to change how it's been done in the past. Unique challenges requiring custom machinery and novel solutions (cost and time associated with this). Labor
- Operational efficiency and retaining talent.
- Hiring qualified production workers that will stay on long-term
- Ingredient supply
- Transportation
- Finding production facilities that can meet our strict food safety and quality requirements.
- Growing needs of consumers resulting in growing needs of company
- Innovation and new product forms are difficult to source with existing co-manufacturing plants.
- Consistent product production and quality
- Short of people
- Measuring Actual negative affects of Rendering and high temperature processing of proteins and enzymes on health of animal.
- Not enough general laborers, machine operators, material handlers or mechanics. People are hired and hard to keep around
- Supply chain issues and labor market
- Finding skilled labor

Large Company

- Scaling production/ capabilities to fit our customer's needs.
- Hiring and retaining employees
- Innovation
- Post-extrusion spray on technology
- Rising costs, ingredient consistency and data collection and using the data to make good decisions.
- Keeping pace with new technologies
- Labor and equipment/processing challenges
- Developing viable forecasting models for justifying additional capacity

- Absence of gold standard on methods for factory cleaning & analyses on finished products
- Maintaining workforce
- Human resources
- Adaptation
- Ability to maintain staffing, currently. Lack of trending food safety related technology-newest transition best practices, sanitizers, sanitizing technology, etc
- Staffing
- Making enough with the ingredient and equipment limitations
- Delivering the schedule with raw material availability challenges.
- Capacity
- Limited production capacity across industry.

Marketing and distribution important challenge

Small company

- Staying ahead of the curve
- NA
- Trend outlook, impact of covid on behaviour and expenditure willingness
- Actually I find the emphasis on marketing in PFI is a MAJOR obstacle to quality research and development -companies are spending so much on marketing they are not investing in studies, R&D, etc.
- The high cost of obtaining shelf space in grocery and mass markets
- We are a small fish in a gigantic pond
- Increased costs of freight and transportation are putting unforeseen pressure on the financial viability of the business.
- Understanding the needs of very specific demographics
- Distribution is being hammered by the crazy high cost of fuel and the shortage of drivers.
- Getting reliable data
- Customer Positive Reviews
- Level of risk when it comes to product claims and litigation, e.g. Canada Dry and ginger, or the various vanilla suits.
- There are many competing claims and determining which are most relevant to our customer base or which can deliver a premium.
- Knowing who
- The experience with the product
- Attracting general practice veterinarians

Medium company

- Development of new products claiming Grain Free
- How to grow our market share quickly on market segments that we are weak at, while we simultaneously protect/grow our dominant market share on market segments that have shrunk or have been on flat growth
- Ingredient naming on the label
- Learning the best approach to reaching new customers
- Growing our market share as a late entrant in the local petfood industry which is dominated by many imported products and a few strong local manufacturers
- Information not available
- Convincing our core customers to try new products/move them from our chews to kibble/food. Keeping up with demand.
- Making legally sound marketing claims
- Turnover with folks we sell too

- Getting back into traveling post-COVID
- Lack of research in the small animal, pet bird and wild bird industries without having to pay a tremendous amount of money.
- N/A. do not deal with marketing
- “Claims substantiation”
- Too many AFFCO restrictions
- Forecasting because hard to get good retail, consumer, sales data/information
- Validation of claims

Large company

- Understanding the needs of our customers/ industry in the future and not just currently.
- Fluffy marketing claims
- I might need a definition of why marketing and distribution are together. they seem different but can both be lumped into supply chain, so i will assume that is the meaning for my answer. cost of producing in one location, marketing to another and tying in the logistics of material to transformation location to distribution. Highly complex
- Not my primary role, so I can’t provide good insight here.
- Planning for consumer preference changes and adjusting production to meet the needs.
- “telling our product story” with databased product proposition
- Local claims from competition
- Covid constrains have posed challenges to keep distribution flowing
- Economy of sales, development and management of them accounts
- The ever flowing change of customer demand.
- Not involved much, so unsure
- Ever changing consumer
- Future proofing the organization.
- Current challenges are driven by supply chain issues and limited product availability.
- When supply becomes consistent, challenge will shift to understanding consumer and retailer needs as the landscape shifts.

Appendix E.

Table E1. Research topic related words

Research topic	Related words
RM	
Quality of raw materials	quality
Availability/Consistent supply of raw materials	availability, supply, shipping, sourcing, sustainable, volume, suppliers
Cost of raw materials	cost, price
Governmental regulations of raw materials	regulations, government, AAFCO
PD	
Processing methods/technology	technologies, technology, production, capacity, processing, efficient, efficiencies, produced, quality, product, volume, oven, extrusion, machinery, innovation, rendering, equipment
Risk management	risk, forecasting
Governmental regulations/ compliance	legislation, regulatory, regulation, compliance, government
Approaches for attracting talent	employee, staff, staffing, personnel, recruit, labor, retain, talent, hiring, workers, people, laborers, workforce, human resources

Table E1. Continued.

Facilities	capacity, energy, factory
Management methods/ processes	manufacturer, operation, needs of company, standard, adaption, making enough, schedule
Geography/Location	location, geography
MD	
Forecasting consumer tastes and preferences	willingness, demographics, reviews, try new product, needs of our customer, preference, changing consumer, taste
Market and competitor intelligence	ahead of the curve, trend, research, data, market share
Validation of claims	claim, label
Forecasting consumer demand	premium, demand, sales
Attracting and retaining customers	attracting, reaching, new customers turnover, telling our product story
Coordinating supply chain and distribution	shelf space, freight, transportation, drivers, distribution, fuel, logistics, location

The words identified in this list are based on the words used in the open-ended survey responses reported in Appendix D. Therefore, keyword analysis using this word list is specific to the data set used in this study.