Animal Protein-Based Ingredients in Pet Food: Analysis of Supply Chain and Market Drivers

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Abstract

This paper evaluates the supply chain of animal protein-based ingredients used in pet food and how they flow from human food production to pet food manufacturers. This creates the opportunity to understand the major players and transaction characteristics to identify constraints and potential growth areas in the supply chain. It is important to understand the supply chain of pet food ingredients as the demand for animal protein-based pet food ingredients grow. Currently, literature covering a detailed analysis of this supply chain is unavailable. This paper contributes to filling this gap on pet food analysis in agribusiness and economics literature.

1. Introduction

The pet food industry is rapidly growing in the US and globally as evidenced by the increase in the volume and value of pet food sold over the last decade. In the US, expenditure on pet food and treats has increased 122% from 2011 to 2021 (Bedford using US APPA, 2021). A similar trend can be seen globally with a 61.6% increase in dollar sales of pet food and a 45.1% increase in volume sold from 2012 to 2020 (Frimpong, 2021). This growth is fueled by humanization trends (e.g. pet is treated as a member of a family) and is expected to continue into the future (Frimpong, 2021). In order to meet this increasing demand for pet food, the availability of pet food ingredients will have to increase (Million Insights, 2020). According to data from Decision Innovation Solutions (DIS) using Nielsen (2020), animal-based protein ingredients made up 38% of the ingredients used in US pet food from the 52-week period before June 2019 by volume and 52% by value. The importance of animal-based protein ingredients is expected to grow in the future with trends towards higher protein diets and pet foods with protein as the first ingredient (Tyler & Semple, 2019; Phillips-Donaldson, 2020).

While the demand for pet food ingredients is driven by increasing pet food sales and pet-owner preferences, the supply of animal-based protein in pet food continues to be predominantly derived from animal slaughter for human consumption. The challenges associated with identifying and relying on novel protein sources for pet food production include inadequate or

underdeveloped supply chains that pet food can fit alongside (Aldrich, 2018). As a result, pet food industry decision makers are in search of approaches for ensuring a consistent and reliable supply of animal-based protein.

The purpose of this paper is to present a comprehensive analysis of animal-based protein supply for the pet food industry. Specific objectives include: (i) mapping out the supply chain and describing the flow of animal protein from the human food supply chain to use in pet food manufacturing, (ii) estimate the total volumes and historical trends of animal-based protein supply for the pet food industry based on trends in animal slaughter for human consumption, and (iii) highlight and discuss potential supply chain constraints and bottlenecks as well as the areas of untapped potential and growth opportunities.

The results of this study will contribute to filling that gap in three ways: (i) the detailed supply chain analysis will provide a complete overview of pet food supply chain structure, main stages, and key players, (ii) the findings highlighting supply chain inefficiencies, major constraints, and key bottlenecks, as well as the untapped supply potential and opportunities for growth can be used to inform industry decisions on input procurement, product, and marketing strategies, (iii) the findings and propositions generated by this study will help highlight the gaps in the literature and the need for agribusiness research insights in pet food.

2. Literature Review

2.1 Academic Literature

A thorough review of academic literature in agribusiness and agricultural economics journals shows a gap over animal-based protein used in pet food. The American Journal of Agricultural Economics (AJAE), Applied Economics Perspectives and Policy (AEPP), Journal of Agricultural Economics (JAE), Agribusiness, and International Food and Agribusiness

Management Review (IFAMR) journals were evaluated by searching each journal from 2000 to 2021 for keywords, such as pet, pet food, animal protein, and animal byproducts.

There is some literature available that covers how byproducts from human food production are being used in pet food (Reithmayer et al, 2020; Mathews & McConnell, 2012). Martinez-Garmenda & Anderson (2005) and ShalekBriski et al (2020) give examples of less common animal protein ingredients being used in pet food. However, these articles do not go into detail on the supply chain transactions involved with this movement of ingredients. Kimle (2010) provides some insight on the transaction costs between one pet food manufacturer and their ingredient supplier, but outside of this article, the literature available on transaction characteristics between ingredient suppliers and pet food manufacturers is very limited.

There are a few papers that cover information on the volumes of ingredients being used in pet food. Bernstein & Skully (2003) mentioned that 5% of beef offal imports go into pet food production in the EU. Mathews & McConnell (2012) estimate that 25% of meat and bone meal was used for pet food in 2000. Pet food was mentioned in a handful of articles, however, none of these articles were focused on pet food or animal-based protein used in pet food. For example, Houser, et al (2018) and Henson & Mazzocchi (2002) look at pet food in relation to BSE.

2.2 Disciplinary Literature

Disciplinary journals were evaluated for information on how animal protein is sourced for pet food. There are a few papers that briefly cover how pet food is using the same ingredient streams as human food supply and provide simplified pet food ingredient supply chains (Acuff, et al, 2021; Carrion & Thompson, 2014; Swanson, 2013). However, these are very general evaluations and do not go into detail on the specific players, ingredient processing, and interactions involved in the movement of animal protein from the human supply chain into pet

food. IBISWorld has a report on pet food production that provides an overview of the supply chain and players involved. However, this report only provides generalized information on ingredients and does not go into the specific steps involved in moving animal protein from human food to pet food (Diment, a2021).

This field primarily focuses on scientific aspects of animal protein-based pet food ingredients, such as how processing affects animal proteins (Chang, 2014; Perez-Calvo, 2010; Spitze, 2003), quality of different animal protein ingredients in pet food (Tjernsbekk, 2017; Hervera, 2009), and animal protein in pet food's impact on the environment (Acuff et al, 2021; Kim, et al, 2019; Alexander et al, 2020; Mosna et al, 2021).

2.3 Non-Academic Literature

Nonacademic literature, such as industry and company websites, provides a source of information on pet food and the animal-based protein being used. The three main segments of information in this literature evaluate pet food formulation (AAFCO, n.d., Aldrich, n.d.), consumer trends (Avis, 2020; Wethal, 2021; Wall, 2021; Wall, 2018; Martin, 2019), and players in pet food manufacturing (WATT Global Media, a n.d.; WATT Global Media, b n.d.; Pet Food Institute; 2020; NARA, 2021). However, this literature is missing information on the supply chain of pet food ingredients, such as the interaction between major players, how the ingredients move through each stage of production, the volumes of ingredients used, and the market structure of each supply chain sector.

2.4 Literature Gap

There is an abundance of literature available through academic and nonacademic sources that covers information on the animal protein ingredients that make up pet food and their scientific properties, pet food trends, and players involved in pet food production. However,

there is a gap in the literature pertaining to the flow of animal protein through the supply chain, their volumes at each stage, and details on the interactions between players. As the pet food industry and demand for ingredients are growing, this leads to an increased need for this literature gap to be filled. For decision makers in the pet food industry to make informed decisions on the ingredients used and their procurement, information on the overall flow of pet food ingredients through the supply chain is a necessity.

3. Methods

3.1 Supply Chain Mapping

Mapping out the supply chain of animal protein in pet food is essential to understanding how animal protein flows from human food to use in pet food. A supply chain analysis is conducted to delineate the stages, actors, and transactions involved in the flow of animal protein from the human food supply chain to use in pet food manufacturing. A detailed map of the supply chain is constructed using the following steps: (i) map out the human food supply chain for animal protein, (ii) compile a list of products generated and diverted to the use as pet food at each stage of the human food supply chain, (iii) identify and group different activities involved in turning animal-based protein into pet food ingredients, (iv) compile a list of animal protein-based ingredients produced by each group of ingredient processors, (v) synthesize the information from previous steps to illustrate the flow of pet food ingredients, (vi) revise and refine based on input from subject matter experts.

3.2 Trends in Animal Protein Availability and Pet Food Production

Goal: Determine if animal protein production is growing at a fast enough rate to meet the growing need for animal protein in pet food.

Data Needed: Growth rate of animal protein needed for pet food and growth rate of source of animal protein in pet food. These exact measurements are not available, so proxies were used. Change in volume of pet food produced in the US can be used in place of the growth rate of animal protein needed for pet food. Live weight slaughter data from USDA can be used to estimate the growth rate of animal protein available to pet used in pet food.

3.2.1 US Produced Pet Food Growth Rate

Goal: There is clear evidence that the value of pet food sales is increasing in the US. Looking at how pet food volume has changed is important because the volume of ingredients is what is directly related to the amount of ingredients needed to produce pet food.

Data Needed: Ideally, there would be data available on the annual volume of pet food produced in the US. However, this data is not readily available so it must be estimated.

Data Used: There is information available on US dollar sales of pet food, US pet food import values, units of pet food sold in the US, and price per unit of pet food. This information can be used to estimate how many units of pet food are produced annually in the US. There is not a specification on how much a unit of pet food is, but for the purposes of this paper it can be used to illustrate the change in pet food volume.

Calculations:

1) Estimate the value of pet food sold in the US that was produced in the US.

$$US\ produced\ pet\ food\ value = US\ pet\ food\ sales - US\ pet\ food\ imports\ value$$

2) Estimate missing values on price per unit of pet food for 1997-2012 using the average annual inflation rate of pet food of 2%.

$$price\ per\ unit\ Year_{i-1} = price\ per\ unit\ Year_i * 0.98$$

3) Estimate the units of US produced pet food sold each year.

$$Year_i\ US\ produced\ pet\ food\ units\ sold\ = \frac{Year_i\ US\ produced\ pet\ food\ sales}{Year_i\ price\ per\ unit\ of\ pet\ food}$$

4) Estimate the growth rate of US produced pet food indexed to 2001.

$$\frac{Year_i\ US\ produced\ pet\ food\ units\ sold}{2001\ US\ produced\ pet\ food\ units\ sold} * 100$$

3.2.2 US Livestock Slaughter Growth Rate

Goal: Illustrate the growth rate of livestock slaughtered for human consumption in the US. This is important because pet food derives their animal protein ingredients from the livestock for human food supply chain. Therefore, the growth rate of livestock slaughtered for human consumption shows the growth of animal protein available for use in pet food.

Data Needed: The data needed for this analysis includes annual live weight of cattle, hogs, chickens, and turkeys slaughtered in the US.

Data Used: Data is available on the annual live weight slaughter of all four species from the USDA for 2001 to 2020.

Calculations:

1) Estimate the annual growth rate of animal protein slaughter indexed to 2001.

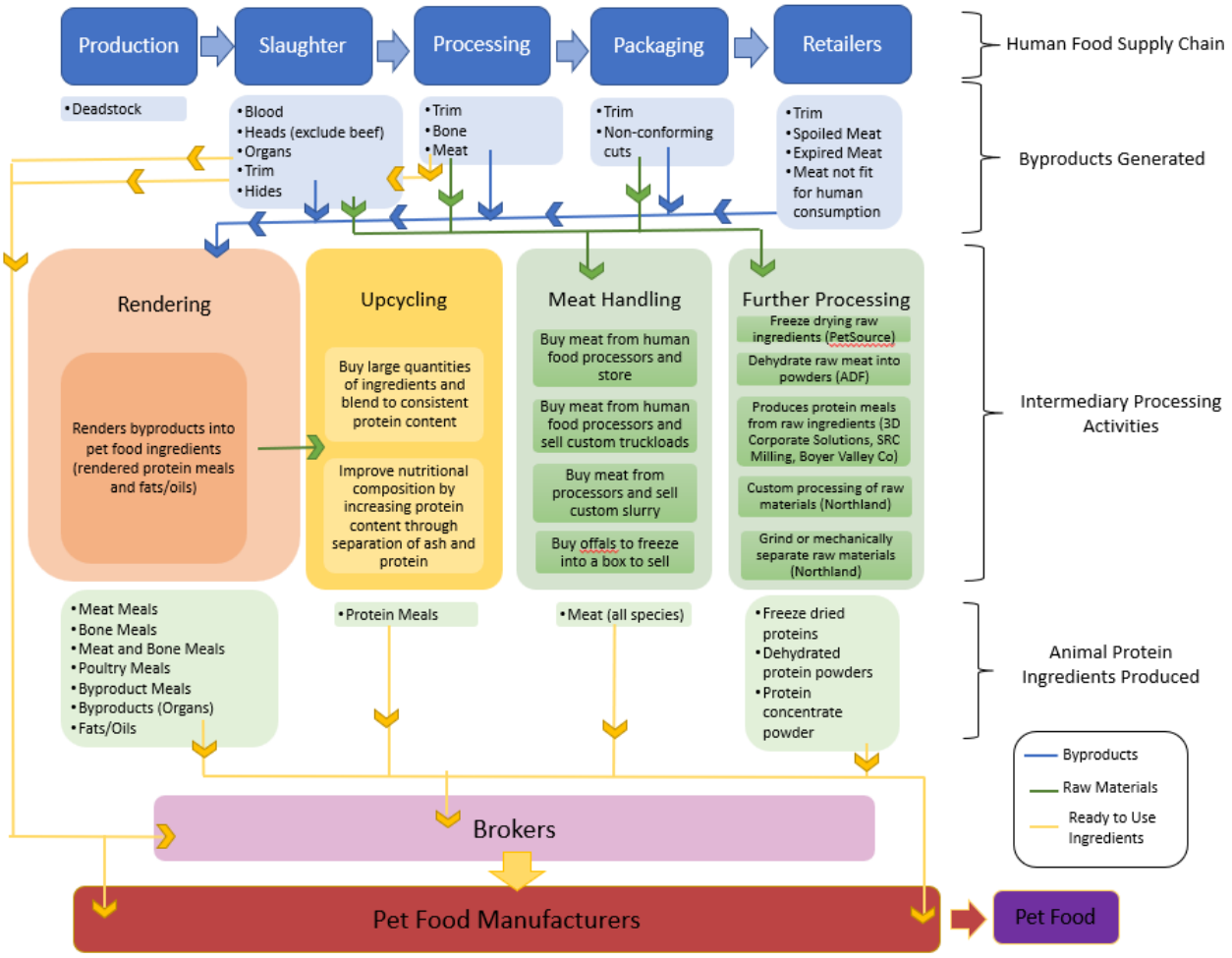
$$\frac{Year_i\ live\ weight}{2001\ live\ weight} * 100$$

4. Analysis and Findings

4.1 Objective 1: Supply Chain Activities and Transaction Characteristics

The supply chain for animal protein used in pet food is derived from the human food supply chain. Byproducts are generated at each step of the human food supply chain and then flow to intermediate pet food ingredient processing. The finished pet food ingredients generated by these processors can then be sold to pet food manufacturers either directly or through brokers. The different paths ingredients can take are displayed in **Figure 1**.

Figure 1: Supply Chain Map



4.1.1 Animal Production

The process of producing animal protein for human consumption begins with animal production. The animal production sector can be broken into groups by species. This paper will focus on cattle, hogs, chickens, and turkeys because those are the most common species used in pet food products (AAFCO, n.d.; DIS using Nielsen, 2020).

The animal production sector doesn't have major players because it is a low concentrated industry since there are many players involved with no large market leaders. Beef cattle production takes place in multiple steps including cow/calf operations, stocker/backgrounders, and feedlots. Out of the total 882,692 cattle and calf operations in the United States, 802,317 are

considered cow/calf, stocker/backgrounder farms or ranches, 28,180 are feedlots, and 54,599 are dairy herds (National Cattlemen's Beef Association (NCBA), n.d.). According to the 2012 Census of Agriculture, there were 21,687 farms with primary production in hog and pig production. A majority of farms were family/individuals (83%), followed by corporation (8%), partnership (7%), and other (2%) (USDA NASS, 2014). According to the 2017 Census of Agriculture, there were 164,099 poultry farms in the US. (USDA NASS, 2020b). There were an estimated 2,500 farms producing turkeys in the US in 2020 (National Turkey Federation, n.d.).

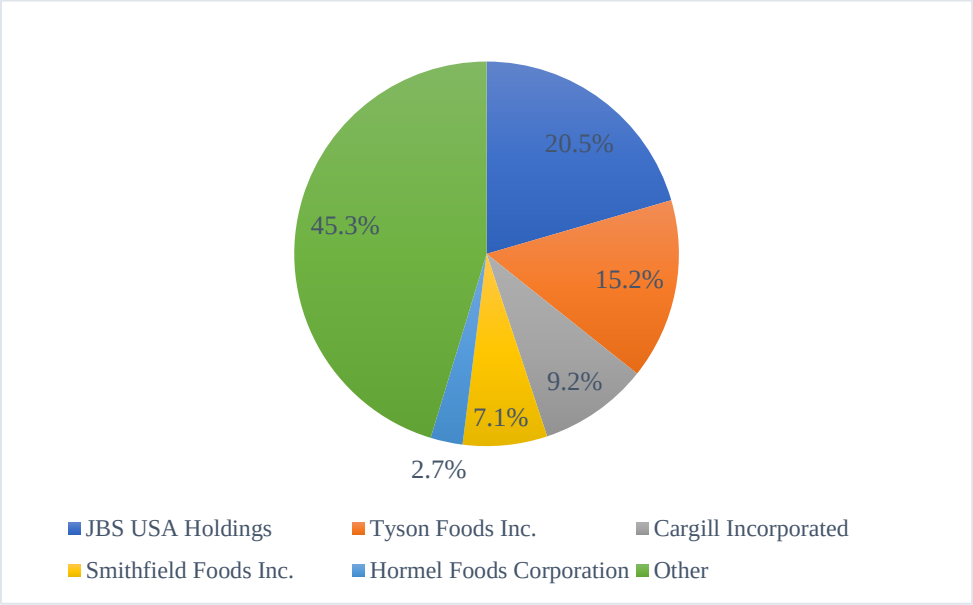
4.1.2 Slaughter/Processing

The next stages in the production of animal protein are slaughter and processing. According to IBISWorld, the meat and poultry processing industry involves slaughtering, processing, and rendering (Schulman, 2021). For the purposes of this paper these functions are divided in the supply chain because different products and byproduct ingredients used in pet food come from each activity. For this paper, meat and poultry slaughter is killing the animal and processing is breaking down the primals and subprimals into cuts for retail sale.

In 2021, there were 858 slaughter plants under federal inspection. There were also 1,917 slaughter plants not under federal inspection bringing the total slaughter plants to 2,775 (USDA NASS, 2021c). There were 683 federally inspected plants slaughtering cattle in 2020. Out of these plants, 13 accounted for 54% of the total cattle slaughtered (USDA NASS, 2021c). There were 621 federally inspected plant slaughtering hogs in 2020. Out of these plants, 14 accounted for 58% of the total hogs slaughtered (USDA NASS, 2021c). In 2019, there were an estimated 370 federally inspected plants slaughtering poultry in the US (USDA NASS, 2021d). Although there are a large number of slaughter plants, a small number are responsible for a significant percentage of slaughter.

There are approximately 5,486 companies involved in meat processing in the US. Despite the large number of companies, four companies make up approximately 52% of the market share by revenue. The four major meat processing companies are JBS USA Holdings Inc., Tyson Foods Inc., Cargill Incorporated, and Smithfield Foods Inc (Schulman, 2021). The market share for each major meat processor is displayed in **Figure 2.**

Figure 2. US Meat Processor Market Share, 2021



Source: Schulman (2021)

4.1.3 Rendering

Renderers are companies that recycle the parts of the animal not consumed by humans, such as blood, fat, and byproducts into products used in other industries such as biofuels and pet foods. The main products produced through rendering are fats and proteins (Jekanowski, 2011). Out of animals produced for human consumption, 49% of raw materials from cattle, 37% from poultry, and 44% from swine were not used in human consumption (Tyler, 2021). There are two kinds of rendering businesses, integrated and independent. Integrated rendering plants are meat processing companies that have their own rendering facilities to process the byproducts

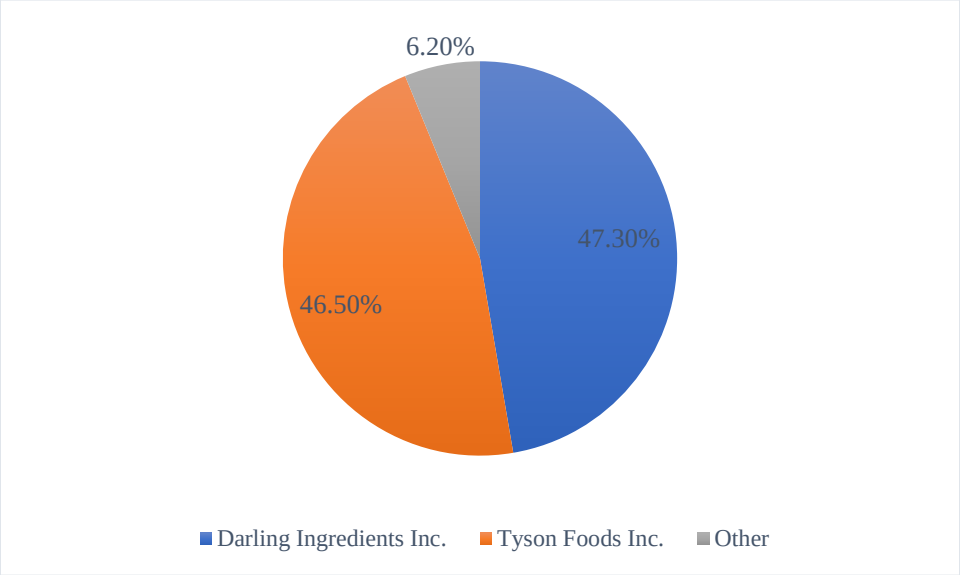
generated. Independent renderers are those that collect and process byproducts from many sources, rather than being owned by a meat processing company (Jekanowski, 2011). There is approximately 16 million tons of rendered products produced annually in the US and Canada (NARA, n.d.).

Ansen Pond, Ph.D., head of food safety, quality and regulatory for Pilgrims/JBS USA provided information on the quantity of rendered ingredients used in pet food. There were 8.9 million tons of rendered protein meals produced annually in the US. Out of this, 1.5 million tons of rendered protein meals, or 16.85%, were used in pet food. Looking at meat, poultry, and organ byproducts, there were 1.83 million tons used in pet food directly from slaughtering (Tyler, 2021). According to Jekanowski (2011) out of the rendered ingredients produced in the US and Canada, 31% of rendered proteins were used in pet food. Pet food is the largest user of poultry by-product meal and non-ruminant mammalian MBM (Jekanowski, 2011).

There are approximately 300 rendering plants in North America, with 156 plants being active members of the NARA in 2021 (Meeker & Hamilton, n.d.; NARA, 2021). Integrated renderers process approximately 48% of the raw materials. These raw materials come from the meat processing companies in which they are affiliated. Independent renderers process the other 52% of raw materials. The raw materials processed by independent renderers include restaurant grease (10%), grocery/butcher scraps (7%), and slaughter byproducts (83%) (Jekanowski, 2011).

According to IBISWorld, the two main rendering companies in the US are Darling International Inc., and Tyson Foods Inc. holding 47.3% and 46.5% market share respectively. Tyson's market share was increased through the acquisition of American Proteins Inc. in 2018. Baker Commodities Inc. is another renderer holding 1.9% of the market share (Diment, b2021). The market share for each major player is displayed in **Figure 3**.

Figure 3. US Renderer Market Share, 2021



Source: Diment (b2021)

4.1.4 Upcycling

Upcycling involves taking the protein meals created during rendering and increasing their value through extra processing. This processing includes buying large quantities of rendered protein and blending it to a consistent protein content or improving the nutritional composition of the protein meal by separating the ash from protein. The ingredients generated from upcycling are higher value protein meals than those generated from renderers (Aldrich, 2021).

4.1.5 Meat-Handling

Meat handlers are companies that buy, store, or minimally process meat. For example, some companies simply buy meat directly from human food processors and store it before selling. Others will buy meat from human food processors to sell custom truckloads. Other companies will do something similar but with a meat slurry. Finally, some companies will buy offals from human food processors to box and sell to pet food manufacturers. The ingredients generated from meat handling include a variety of frozen meat and meat slurry (Aldrich, 2021).

4.1.6 Further Processing

The final category of intermediate processing activities are further processors that take raw materials or pet food ingredients and put them through significant additional processing. Some of the ingredients generated from further processing include freeze dried proteins, dehydrated protein powders, protein concentrate powders, and mechanically separated proteins (Aldrich, 2021).

4.1.7 Brokers

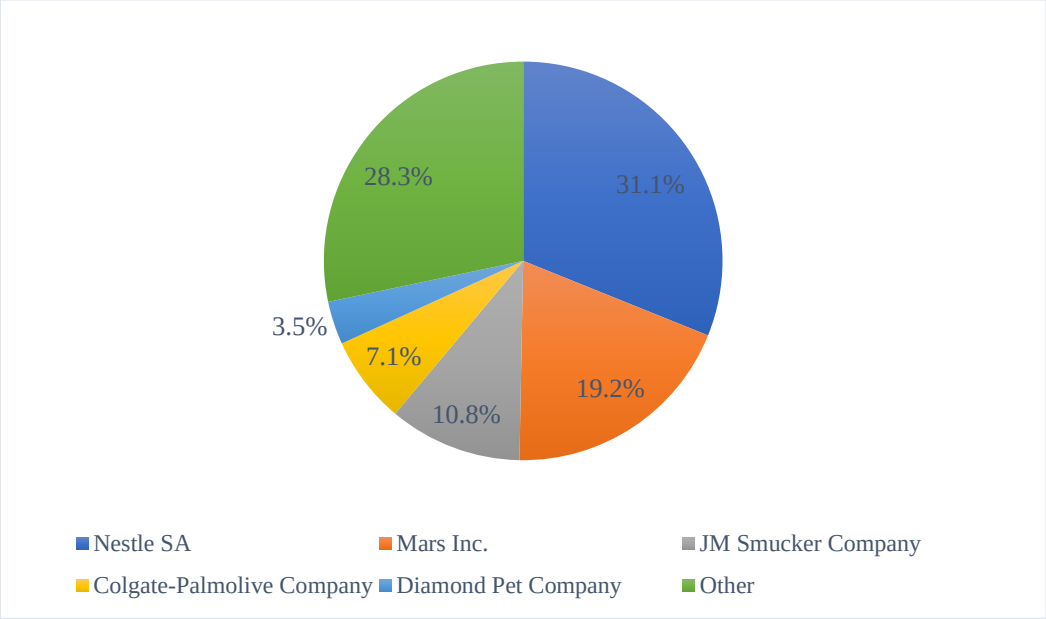
Brokers act as a middleman that facilitate the trade of pet food ingredients between an ingredient supplier and pet food manufacturer without ever taking physical possession of the ingredient (Aldrich, 2021).

4.1.8 Pet Food Manufacturers

Pet food manufacturers are the companies that buy ingredients and produce finished pet food products. There are a variety of types of pet food being produced including dry, wet, semi moist, and treats. The pet food produced by manufacturers is ready for sale through retail channels (Diment, a2021). There are 516 FDA-registered pet food manufacturing facilities in the US (DIS, 2017). According to the Pet Food Institute (PFI), their 21 producer members produce 98% of all pet food and treats in the United States (PFI, 2020). The top five pet food manufacturers in 2020 were Mars Petcare Inc., Nestle Purina Pet Care, J.M. Smucker, Hill's Pet Nutrition, and General Mills (WATT Global Media, b n.d.).

Looking at US specific data from IBISWorld, Nestle, Mars, J.M. Smucker, and Colgate-Palmolive (Hill's Pet Nutrition), remain in the top of pet food manufacturers with 31.1%, 19.2%, 10.8%, and 7.1% market share by revenue respectively as seen in **Figure 4** (Diment, a2021). This means there is high market concentration with pet food manufacturers in the US.

Figure 4: US Pet Food Manufacturer Market Share, 2021



Source: (Diment, a2021)

4.1.9 Vertical Integration

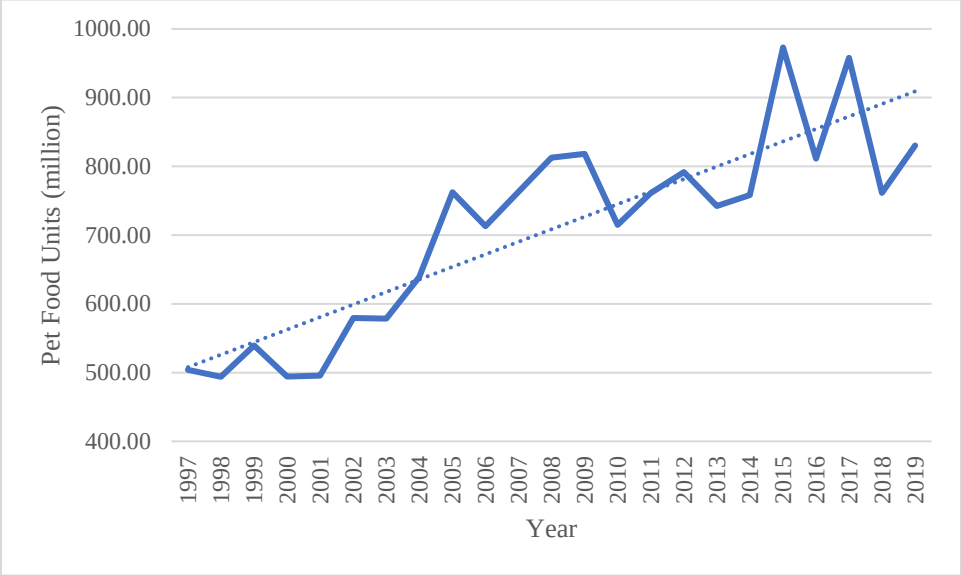
Vertical integration can be seen in many stages of the animal protein-based ingredient supply chain. Although slaughter and processing can be considered two different activities because they result in different products, they are often vertically integrated (Schulman, 2021). There is also vertical integration between some meat processing and renderers. This is seen in large meat processors with integrated rendering facilities (Jekanowski, 2011).

4.2 Objective 2: Trends in Animal Protein Availability for Pet Food

4.2.1 Change in US Produced Pet Food

The increased consumption in pet food is seen by the increase in pet food sold by volume and value (Bedford using US APPA, 2021). The growth in pet food produced in the US can be seen by looking at the increase in the number of units of pet food produced in the US as displayed in **Figure 5** (Gibbons using US BLS, 2021; The Observatory of Economic Complexity (OEC), n.d.; Statista, n.d., US BLS, n.d.).

Figure 5. US Produced Pet Food Units Sold Domestically, 1997-2019



Source: Gibbons using US BLS (2021); The Observatory of Economic Complexity (OEC) (n.d.); Statista, (n.d.); US BLS, (n.d.)

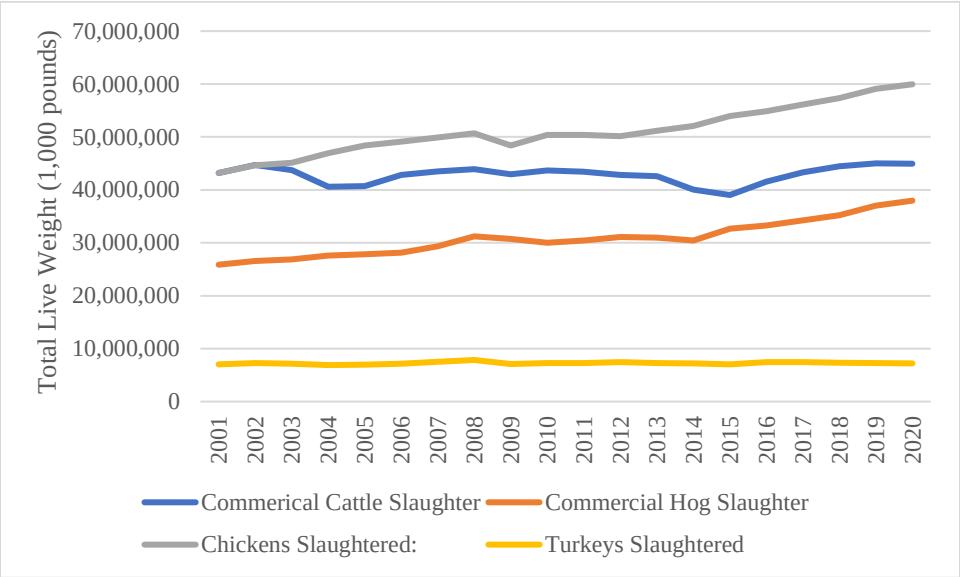
Now that it can be seen how the volume of pet food produced is increasing over time and the importance that animal protein-based ingredients play in pet food, it makes sense to look at how the availability of animal protein for pet food is going to change over time. As mentioned earlier, animal-based protein ingredients make up 38% of pet food by volume (DIS using Nielsen, 2020). This shows that animal protein-based ingredients make up a significant component of pet food that will need to increase in availability in order to keep up with the growing need for ingredients driven by an increase in units of pet food produced.

4.2.2 Change in Supply of Animal Protein

The supply of animal-based protein in pet food is predominantly derived from animal slaughter for human consumption. Data on animal slaughter in the US can be found from the USDA. How annual total live weight slaughtered has changed for commercial cattle, commercial

hogs, chickens, and turkeys is displayed in **Figure 6.** Commercial cattle and hogs were chosen because they make up over 90% of cattle and hogs slaughtered (USDA NASS, 2021c).

Figure 6. Animals Slaughtered by Live Weight in the US, 2001-2020



Source: USDA NASS Livestock Slaughter Summary (2002-2021); USDA NASS Poultry Slaughter Annual Summary (2002-2021)

4.2.3 Comparison of Animal Protein Availability and Pet Food Growth

A comparison of the growth rates of US pet food production and US animal slaughter for human consumption can be used to determine if animal protein is growing fast enough to keep up with the growth in pet food. How the units of pet food produced in the US have been growing at a faster rate than animals slaughtered for human consumption can be seen in **Figure 7**. This is significant because if these growth rates continue there will be a point where there are no longer enough animal protein-based ingredients to meet the needs of pet food production. This demonstrates the importance of understanding the supply chain of animal protein to reduce bottlenecks and increase availability of animal-based protein ingredients.

Figure 7. US Produced Pet Food vs US Animal Slaughter, 2001-2019

Source: Gibbons using US BLS (2021); The Observatory of Economic Complexity (OEC) (n.d.); Statista, (n.d.); US BLS, (n.d.); USDA NASS Livestock Slaughter Summary (2002-2021); USDA NASS Poultry Slaughter Annual Summary (2002-2021)

4.3 Objective 3: Supply Chain Challenges

Supply chain challenges involving ingredients, labor, and transportation are key issues impacting the pet food industry. These issues will likely be exasperated in 2022 by government mandates and tax incentives involving renewable diesel production (Beaton, 2022). Speaking with industry stakeholders at Petfood Forum 2022 provided more details on the supply chain issues in the pet food industry. Some of these issues include a lack of labor to keep up with demand, the opportunity cost of raw materials taking ingredients out of pet food, and longer wait times to get ingredients from imports (Industry Stakeholder, 2022). Some rendering companies are having problems with upstream supply chain issues at the meat processing level. Labor issues

in meat processing are causing delays in the amount of material available for rendering (Industry Stakeholder, 2022).

5. Conclusions

The objectives of this paper are to map out the supply chain of animal protein-based ingredients in pet food, compare the supply of animal protein available to pet food growth, and identify inefficiencies in the supply chain. The supply chain involves many different members and animal protein can take many paths before being used in pet food. Animal protein production is growing at a slower pace than pet food production, which could lead to issues with ingredient availability in the future. Supply chain challenges occur at many stages in the supply chain and include issues with labor, other uses of ingredients, and waiting on other supply chain players.

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