Meat and Muscle Biology™

Insights-Driven Development of Humanized Foods for Pets

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Abstract: Pet food is becoming increasingly similar to human food as most pet owners consider their pets to be part of the family. The recent rise in pet ownership is attributed to the pandemic as well as an increase in human–pet bonding, and both have driven growth in the pet food industry. Meeting the demand of pet owners for more transparency and higher quality products brings a challenge to the industry to pursue development and marketing opportunities for innovative pet foods. Alternative pet food formats, such as "fresh-cooked" foods, provide novel options to pet owners but may also present technical challenges to food manufacturers. In comparison with traditional extruded kibble or canned foods, "fresh-cooked" pet foods have a shorter shelf life and must be stored in refrigerated or frozen format. However, recent studies and anecdotal evidence point toward high digestibility and palatability of "fresh-cooked" pet foods, but further research is warranted to elucidate differences in conventional and "fresh-cooked" pet foods. Extrusion and retort processing both utilize high temperature and mixing, whereas "fresh-cooked" processes typically use a gentler cooking method that would potentially improve nutrient retention. Although accompanied by higher costs and shorter shelf life than traditional formats, "fresh-cooked" pet foods continue to appeal to consumers. Although the durability of this trend remains to be seen, the "fresh-cooked" format warrants more research to further elucidate differences in palatability, digestibility, and food safety in both dogs and cats. In conclusion, with the movement toward humanized pet foods, industry should focus on science-based education of pet owners to emphasize the importance of balancing ingredients and formulation to best nourish the animal while limiting environmental impact. A summary of consumer insights and recent publications related to "fresh-cooked" pet food is presented in this paper.

Key words: digestibility, food processing, fresh-cooked, humanization, palatability, pet food
Meat and Muscle Biology 6(3): 14397, 1–12 (2022) **doi:10.22175/mmb.14397**
Submitted 16 April 2022 Accepted 7 September 2022

This paper was accepted as a contribution to the 2022 AMSA Reciprocal Meat Conference.

Introduction

Commercialized pet food has been evolving since the late 1800s. From rock-hard, flour-based biscuits to the adaptation of extrusion and canning or the most recently developed "fresh-cooked" processes, the processing methods of foods for pets and humans are becoming similar (Bohrer, 2011). Today, the United States pet food industry is estimated to be worth $42 billion and continues to rapidly grow year after year (APPA, 2022). This growth is, in part, driven by an increasing pet population accelerated by the pandemic (APPA, 2022; Euromonitor International, 2022); however, much of the growth and evolution of the pet food industry is arguably in response to a growing bond between humans and their pets (Sable, 2013). As pet owners are increasingly looking for new ways to nourish and delight their pets, the development of new, alternative formats of pet foods offers many advantages to pet owners, including more variety of food choices that typically have a more pleasant appearance and aroma than conventional pet foods. Benefits for the pet from these innovative foods include exceptional palatability and nutrient

digestibility as compared with conventional pet food formats (Do et al., 2020; Tanprasertsuk et al., 2021). That said, barriers to the growth of new, alternative pet food formats such as "fresh-cooked" foods do exist. Most notably, the cost of feeding pets a diet solely consisting of "fresh-cooked" foods may be prohibitive for many pet owners (Figure 1). Furthermore, these novel foods bring unique technical challenges to manufacturers that do not exist for conventional kibble and canned pet foods. From securing ingredient supply to ensuring the safety and shelf life of products, manufacturers of "fresh-cooked" pet foods have been challenged to adapt new formulations, processing methods, and supply chain strategies that have not previously existed in the pet food industry. This paper will explore consumer insights that have contributed to the evolution of the pet food industry as well as the unique opportunities that pet food brands face as they seek to satisfy consumer demand for high-quality, humanized pet foods that do not compromise the nutritional adequacy, safety, and sustainability of commercial pet food diets.

History of Commercialized Pet Food

To understand how the pet food industry has evolved to where it is today, we should consider the early development of commercialized pet food. It is believed that dogs were domesticated nearly 16,000 y ago (PFI, 2022). In the Middle Ages, it was common for the wealthy to have cooks dedicated to making meals (typically stews made of grains, vegetables, and some meat and organs) for their hunting dogs (Walsh, 2009; PFI, 2022). In those times, feeding dogs an omnivore diet stemmed from the idea that domesticated dogs should be more civilized than wild, untamed dogs and thereby should eat "like humans" rather than simply eating raw meat. This notion remains today and has arguably been the primary driver behind the growth of the pet food industry.

The first commercial pet foods appeared during the 19th century with the rise of the middle class; thereby, families began having more disposable income, which allowed dogs and cats to be kept as companion animals instead of only as working animals (PFI, 2022; Semple, 2022). In the late 1850s, James Spratt, an American inventor visiting England, noticed that sailors were feeding hard biscuits made of flour, water, and salt to their dogs (FEDIAF, 2019). Spratt took this concept back to the United States and by 1895 had developed a biscuit for dogs that the *New York Times* acclaimed to be "the principal food" of show dogs (TCKC, 2018; PFI, 2022). The dog biscuit has evolved since then, most notably in 1907, when Carleton Ellis created a new milk-based dog biscuit shaped like a bone (TCKC, 2018). In 1908, bone-shaped biscuits were being sold by the F.H. Bennett Biscuit Company, and Milk-Bone is still arguably the most popular dog biscuit brand in America today (Slater, 2014; TCKC, 2018). The F.H. Bennett Biscuit Company (currently Nabisco) was acquired by the National Biscuit Company in 1931, becoming the first major human food company to enter the pet food market. Consequently, that opened the door for pet foods to be sold in grocery stores rather than only in feed stores, an appalling concept to grocery stores at first (Phillips, 2007). Interestingly, the "channel wars" persist today as some brands reverted to selling only in pet specialty store channels, but many have expanded back to the general retail outlets, and the online versus offline channels continue to reflect different purchasing patterns (Lim, 2017; Kwak and Cha, 2021).

In 1922, the Chappel brothers of Rockford, Illinois, introduced the first canned dog food, Ken-L Ration, which was primarily made of horse meat. Interestingly, this canned food became so successful by the mid-1930s that the company was breeding horses for their meat (Phillips, 2007). Canned dog food had gained a 90% share of the market by 1941, and Quaker Oats purchased Ken-L Ration in 1942 (Phillips, 2007). The US government began rationing tin and meat during World War II, leading to popularity growth of pet food alternatives such as dry foods (Phillips, 2007). Around the same time, Clarence Gaines, founder of the Gaines Food Company, was selling a new dry dog formula called "Dog Meal" in 100 lb bags (Phillips, 2007). Similar to Ken-L Ration, Gaines leveraged dog show advertising to promote his brand; subsequently, the Gaines Food Company developed national attention and was acquired by General Foods in 1943 (Phillips, 2007). In 1961, General Foods introduced Gaines-Burgers, a soft-moist, hamburger-shaped patty for dogs that was shelf-stable and individually wrapped (Phillips, 2007). In the 1950s, the Ralston Purina Company, manufacturer of whole-grain cereals as well as several "Chow" brands of animal food, including Purina Dog Chow and Purina Cat Chow, began using an extruder to make their Chex cereal (Phillips, 2007; Semple, 2022). In this process, the ingredients were mixed and cooked under high pressure, then puffed up with air, which allowed the crispiness of the product to be maintained in milk (Phillips, 2007). The pet food division of Ralston Purina borrowed an

extruder from the cereal division to address complaints about the appearance, texture, and digestibility of the dry dog food. Experimentation with extrusion technology eventually led to an improved version of Purina Dog Chow in 1957, which quickly became the leading brand of dog food in the United States because of improved palatability and expanded texture, which made the bags of food larger than competitors' products for the same weight of food (Phillips, 2007). Since that time, extrusion has remained the dominant form of processing for the pet food industry, although this is beginning to change.

Throughout the early history of the pet food industry, cats received relatively little attention. Oftentimes, labels suggested that foods were suitable for both dogs and cats, although little was known about specific nutritional requirements of cats. Early cat foods were primarily sold in 1 lb cans and produced near the coast where fish were abundantly available (Phillips, 2007). The invention of smaller cans opened up the cat food market, and Nestlé launched Fancy Feast Gourmet in 3 oz cans in 1982, with many ingredient combinations beyond fish meant to attract the finical cat (Phillips, 2007). Since then, pet food companies learned that cats will also eat semi-moist and dry foods. Another notable shift in the pet food industry came in the mid-1970s when companies like Hill's, Iams, and Nutro began selling their "super premium" brands (≥ 20% higher prices than average pet food products) through veterinarians, breeders, pet stores, and kennels with the idea that the pet owner could receive education about brand benefits and features (Phillips, 2007; Pirisch et al., 2017). Generic (unbranded), popular (variable formulation to allow lower cost), premium (consistent formulation with high-quality ingredients), super premium, and private-label (grocery or commercial retail) are a few of the more common categories for pet food (Karr-Lilienthal, 2019). Most recently, societal shifts have resulted in the terminology of pet owners as "pet parents" with their animals considered as children and referred to as "fur babies," and the foods they select for their pets reflect this sentiment (Greenebaum, 2004; Power, 2008; German, 2015; van Herwijnen et al., 2018; Owens and Grauerholz, 2019; Donadelli et al., 2020).

Industry Landscape and Consumer Insights

In 2020, the US pet care market surpassed $100 billion for the first time ever, and nearly half of this spending ($42 billion) was in pet food, which represented a 9.7% increase compared with 2019 (APPA, 2022). This expansion is partly due to the rapid growth of the US pet population, which continued to rise each year (Euromonitor International, 2022). According to the 2021 to 2022 American Pet Products Association (APPA) National Pet Owners Survey, 70% of US households (90.5 million homes) own a pet (APPA, 2022). Pet population growth was accelerated by the pandemic (Euromonitor International, 2022). In 2020, there was a 4.7% increase in cats and dogs as compared with 2019, which was double that of any other year in the past 15 y (Euromonitor International, 2022). Pet ownership is higher among younger generations, with 76% of millennials (defined as being born between 1981 and 1996) reportedly owning a pet (Dimock, 2019; APPA, 2022). In 2020, 54% of households included at least 1 dog, whereas 35% of households included at least 1 cat (APPA, 2022). In response, global pet food production has increased to meet the rising demand from pet population growth. According to Alltech's 2022 Global Feed Survey and Agri-Food Outlook report, pet food production in North America was 10.6 million metric tons in 2021, representing a 12.7% increase from 2020, the highest increase among all feed sectors (Alltech, 2022). This speaks to the resiliency of the pet food industry against challenges from COVID-19, including reduced labor and supply chain disruptions. Corresponding to the increasing pet population, pet food humanization and product premiumization continue to drive pet owners to pay more for the foods they feed their pets (Bohrer, 2011). Although human health issues are not necessarily reflected similarly in companion animals, pet owners are increasingly expecting functional claims in pet food to resemble those in human food with emphasis shown toward health or disease improvements, such as immune and digestive health, leading to pet food products resembling human trends and increased "humanization" (Clemens, 2014; Schleicher et al., 2019). According to a recent Packaged Facts (2022) survey, more than 90% of pet owners of all ages consider their pets to be part of the family. Additionally, a growing body of evidence suggests that pets play a key role in mental health and well-being, especially during difficult times (Brooks et al., 2018; Powell et al., 2019; Grajfoner et al., 2021). A recent study concluded that owning a dog during the COVID-19 pandemic may have provided people with a stronger sense of social support because they showed decreased depression scores as compared with people who did not own a dog but would be interested in owning one in the future (Martin et al., 2021).

Petfoodindustry.com recently reported the top business and nutrition trends currently driving growth

and innovation in the pet food market (Beaton, 2022; Phillips-Donaldson, 2022). The first trend identified was sustainability, which extends well beyond recyclable packaging. The Pet Sustainability Coalition outlined a 4-factor framework including environmental impact, social impact, nutrition, and animal welfare, and modern consumers are looking for brands to tell a full sustainability story encompassing all 4 of these factors (Tyler, 2021b). According to a recent survey conducted by Cargill (2022), more than half (55%) of global consumers are more likely to purchase a packaged food item labeled with a sustainability claim, which is up 4 points from a similar survey in 2019.

Transparency was identified as the second industry trend. Pet owners are seeking more information about the product they are purchasing. They seek insight into the origin, safety, and nutrition of ingredients used in foods consumed by pets as well as foods that the pet owners are consuming themselves. From a nutritional perspective, the pandemic has placed more focus on the importance of a healthy diet to support a healthy lifestyle. Just as they try to make healthier food choices for themselves, pet owners are increasingly selecting pet foods with overall "health and wellness" in mind. Pet owners, especially those of the younger generation, are increasingly willing to try new and alternative ingredients, particularly if they support other values such as sustainability or health and wellness. Moreover, this is demonstrated by the growth of both plant-based and insect-based pet foods (Tyler, 2021a). In 2021, insect-based pet foods made up approximately 7% of the global pet food market and were expected to grow 9.3% between 2021 and 2031 to reach $17.29 billion (FMI, 2021). A recent study from the University of Guelph in Canada concluded that pet owners tend to rely on their own dietary preferences when selecting foods for their pets. Furthermore, consumers likely look for similar gluten-free, organic, or grain-free diet characteristics in the dry dog food they purchase (Banton et al., 2021).

The final trend reported to be driving innovation in pet food is functional ingredients (Beaton, 2022). Rather than turning to medicines, there is an increased interest in food-based solutions to support pet health as related to common ailments such as hip/joint, skin/coat, and digestive health (Clemens, 2014; Schleicher et al., 2019). Considering all these trends, pet owners are paying closer attention to what they are feeding their pets and are making pet food decisions that reflect these sentiments, likely wondering, "Is feeding kibble enough?"

The change in pet food purchase decisions is clearly reflected in the market data by segment. Sales are up across the board, with dry kibble still representing nearly 50% of the category; however, sales of wet pet food and emerging pet food formats, such as refrigerated and frozen, are growing rapidly. According to Nielsen data between December 2020 and December 2021, dry dog and cat food sales grew 5.7% and 6.4%, respectively, whereas wet dog and cat food grew 13.7% and 12.3%, respectively, taking overall market share away from dry pet food (Nielsen Company, 2022). Although emerging pet food formats (e.g., frozen, refrigerated, "fresh" foods) represent less than 3% of the market, they exhibited strong growth rates ranging from 13.4% to 26.6% during the same time frame. Specifically, in the 12 mo ending December 2021, refrigerated pet foods grew nearly 26%, which is on top of double-digit growth rates for the last 4 y. Taken together, this information suggests that alternative super premium pet foods have been increasing in popularity for several years (Pirsich et al., 2017). That said, the pandemic has possibly fueled the growth of these pet food categories as people have been spending more time with their pets and paying closer attention to what they are feeding them. The renewed interest in wet pet food and the emergence of alternative formats also suggest that pet owners may be shifting toward the practice of feeding more than one type of food. This is especially evident in the younger generations that are looking to add variety and diversity to their pets' food bowls.

In a recent Packaged Facts survey, 29% of the millennials/Gen Z demographic reportedly used alternative pet food formats compared with 13% of baby boomers (Packaged Facts, 2022). This usage difference may be partially attributed to an awareness or perception that these alternative formats are less processed and that minimally processed foods may be healthier for pets. Brands and retailers are responding as a result of this shift in consumer purchasing behaviors. Frozen pet food is actually not new to the market; brands like Bil-Jac have been in the space for over 75 y (Bil-Jac, 2022). The refrigerated pet food category at retail is currently dominated by one manufacturer, Freshpet, who currently has nearly a 99% share of the segment and is projecting to grow nearly 35% in 2022 (Euromonitor, 2022; Tyler, 2022a). Mars recently entered the refrigerated category at retail with Cesar Fresh Chef and captured 0.34% of this segment as of December 2021. Additionally, private brand options are beginning to emerge, including the Pure Balance offering from retail giant Walmart.

Similar to e-commerce, direct-to-consumer (DTC) pet food sales are increasingly gaining momentum with

many new DTC pet food companies emerging in recent years (Phillips-Donaldson, 2020; Wall, 2022a). This was bolstered by the COVID-19 pandemic, when supply chain challenges, a demand spike, and closer relationships with their pets drove many pet owners to shift the way they shopped for pet food. Across all categories, including pet food, people are looking for convenient shopping options that allow them to shop from home, which has led to a rise in popularity of subscription services (Alvo, 2021; Roberts, 2022; Wall, 2022a). Some large pet food companies are taking notice, as evidenced by Mars Petcare's recent purchase of Nom Nom, one of the major "fresh-cooked" pet food brands available for home delivery (Tse, 2022).

Pet Food Processing Methods

Often following in the footsteps of human food processing, pet food processing methods have evolved to meet changes in consumer demand. Baking was one of the first methods used to make pet food, and this process involves cooking at high temperatures for a relatively short time or until enough moisture has been removed to make the food shelf-stable (Gibson and Sajid, 2013). Extrusion is a versatile processing method commonly used for snacks and cereals in which ingredients are steam-heated, mixed under pressure, forced through a die, and cut into formed kibbles (Gibson and Sajid, 2013). The kibble expands and moisture is released as the product exits the die. The kibbles are further heated and dried in an oven to reduce moisture content (usually below 10%). Extruded foods are typically high in carbohydrates because the starch is needed for kibble expansion. In canning (also known as retort processing), the ingredients (which are primarily meat but may also contain grains, vegetables, and fruits) go through a series of steps: mixing, heating, can filling (or another retort-stable packaging), and hermetic sealing (Hagen-Plantinga et al., 2017). The sealed packages are cooked at high temperatures under pressure in a retort until they become commercially sterile. The most recent pet food processing method that has evolved from human food processing closely resembles deli-meat processing and represents a "gently cooked" or "fresh-cooked" process (Bohrer, 2011; Algya et al., 2018). Similar to canned products, the primary ingredients are typically meat with visible inclusions of fruits and vegetables. Many of these foods are cooked by steam, without pressure, just long enough to cook the proteins and destroy pathogenic and spoilage bacteria. Baked, extruded, and canned foods all offer convenience for pet owners as they can be stored at room temperature with longer shelf lives that make them well suited for buying in bulk, whereas "fresh-cooked" pet foods must be stored in the refrigerator or freezer and have a relatively short shelf life compared with traditional formats (Bohrer, 2011).

As we seek to differentiate the processing technologies used to make pet food, it is important to understand that food processing can have a desirable or undesirable impact on pet food (Sadler et al., 2021). In almost all cases, pet food processing extends the shelf life of foods by destroying microorganisms or removing moisture to slow spoilage reactions during shelf life. At the same time, heat processing can degrade nutrients, particularly vitamins present in the foods (Tran et al., 2008). Processing often improves both the flavor and texture of foods but may also result in the formation of flavors and colors that are less desirable than the pre-processed versions. Many food ingredients, especially plant-based ingredients, can contain antinutritional factors that are normally destroyed during processing, although excessive heating can cause formation of other antinutritional factors, such as Maillard reaction products, which may have negative health implications (Lund and Ray, 2017). Finally, some nutrients, especially carbohydrates, become more digestible during cooking, whereas other nutrients, including protein and carbohydrates, can become less digestible under more extreme heat processing conditions (FAO, 1998; Anju et al., 2011).

The "Fresh-Cooked" Difference

Appearance and aroma

Considering the total impact of heat treatment on pet foods, "fresh-cooked" pet foods offer some unique advantages that both pets and pet owners find nutritious and acceptable (Tanprasertsuk et al., 2021). In a pet food market in which humanization and premiumization are seemingly no longer trends but rather table stakes for brand growth, appearance and aroma play a huge role in a product's acceptability by pet owners. Fresh and frozen pet foods often have a key advantage compared with standard kibble and canned diets. Oftentimes, fresh and frozen diets are minimally processed as compared with traditional diets and may have vibrant inclusions of vegetables and fruits, potentially leading to the perception that they are healthier. Delime et al. (2020) recently demonstrated that the aroma of pet food strongly influenced pet owners' perceptions of pet

foods. Odors traditionally associated with pet foods including "viscera like," "cereal like," and "fatty – rancid" were associated with negative or neutral emotions, whereas odors more commonly associated with human foods including "roasted chicken like" and "aromatic herbs like" were associated with positive emotions (Delime et al., 2020). Differences in both ingredients and processing conditions can cause refrigerated and frozen foods to lack aromas associated with conventional pet foods such as dry kibble; therefore, these product forms may elicit more positive emotions during feeding experiences, which could ultimately lead to a willingness of pet owners to pay more for such an experience (Delime et al., 2020; Tanprasertsuk et al., 2021).

Digestibility and palatability

For pets, "fresh-cooked" foods are typically highly palatable and digestible. Recent studies have attempted to understand the differences in nutrient digestibility and overall gut health between fresh or "human-grade" pet food diets and conventional pet foods (Algya et al., 2018; Oba et al., 2020; Do et al., 2020, 2021; Tanprasertsuk et al., 2021). Oba et al. (2020) assessed the macronutrient digestibility of 6 fresh, human-grade foods (provided by JustFoodForDogs LLC) using a cecectomized rooster assay. All 6 diets were highly digestible in this study, with protein and amino acid digestibility exceeding 85% in most cases and some exceeding 90% (Oba et al., 2020). Although there are little published data on palatability of "fresh-cooked" diets compared with conventional formats, anecdotal evidence suggests that these foods are highly palatable, and this is supported by the work of Do et al. (2021) out of the University of Illinois.

Nutrient retention

Another potential advantage of a gentle cooking process is that more nutrients may be retained during the process. Vitamins are highly sensitive to heat, light, oxygen, and mixing and are subsequently often oxidized or degraded during pet food processing (Tran et al., 2008; Dainton et al., 2021). As such, pet food formulators must add additional supplementation to compensate for the losses that occur during processing and ensure that the finished product meets the nutritional requirements for the animal. Generally, the higher the temperature is during processing, the lower the vitamin retention will be. Thiamine (vitamin B1) is one of the most biologically important vitamins to consider relative to nutrient retention. Because thiamine is particularly sensitive to degradation by heat, heat denaturation of vitamin B1 has been associated with many recalls of commercial pet foods (FDA, 2020; Dainton et al., 2021). In fact, the Association of American Feed Control Officials (AAFCO, 2022) suggested that processing may destroy up to 90% of thiamine in the final pet food product. Thiamine retention reported in the literature is widely variable; however, an average across several studies suggests that up to 70% of thiamine is retained during extrusion (Morin et al., 2021). Barrel temperature appeared to be the most significant factor affecting thiamine retention, but other processing parameters such as moisture and screw speed impacted final thiamine retention (Ilo and Berghofer, 2008). Simmons Foods has many years of historical data (unpublished) on thiamine retention during retort processing and has found that 40% is retained after processing, which is consistent with the literature (Dainton et al., 2021). Much less is known about vitamin retention during "fresh-cooked" processes, but it stands to reason that a gentler process will potentially retain more nutrients. Recently, Simmons Pet Food demonstrated 87% retention of thiamine during a process that mimics "fresh-cooked" procedures (unpublished data). Similar to thiamine, published data on the retention of other vitamins are highly variable (Morin et al., 2021); however, in general, data suggest that vitamin retention is lower for extrusion processing as compared with retorting, and "fresh-cooked" processes may retain more nutrients. Although retort time and temperature conditions are considered severe, the exposure to light, shear, and mixing is minimal as compared with extrusion. Furthermore, "fresh-cooked" processes are typically less severe than extrusion and retort processing. Moving forward, a single study that directly compares nutrient retention among different pet food processing methods may be warranted.

Shelf life

As previously noted, a key difference between the current "fresh-cooked" pet foods and traditional pet foods is that "fresh-cooked" pet food requires unique storage and shelf life considerations. Even though refrigerated and frozen pet foods may have a shelf life of several months, this shelf life is reduced to only a few days once the product is opened or thawed. When considering shelf life, product developers have to consider 3 aspects: nutrients, aroma/appearance, and spoilage microorganisms. During processing, vitamins are particularly sensitive to temperature, light, and oxygen during storage; losses may also occur if the food is not stored properly (Ilo and Berghofer, 2008; Tran et al.,

2008; Dainton et al., 2021; Morin et al., 2021). The aroma and appearance of fresh, high-moisture pet foods can also change rapidly during storage because the fats in the foods are prone to oxidation when exposed to air (Koppel et al., 2014). Finally, even though the foods are cooked, they are still susceptible to microbial spoilage, which is typically the limiting factor in the shelf life of "fresh-cooked" pet foods (Lorenzo et al., 2018).

A number of strategies are used by pet food developers to preserve and extend the shelf life of their foods. One strategy is to leverage packaging. As described previously, canned and other retorted foods are cooked to commercial sterility and hermetically sealed to inhibit exposure to oxygen or light. These foods can be stable for up to 3 y, with relatively minimal losses of nutrients over time. Some other pet foods, including "fresh-cooked," can be in sealed packages with oxygen eliminated, but this benefit is lost once the package is opened. Other pet foods rely on water activity as a preservation method. Kibble and other shelf-stable, dried foods rely on the removal of moisture to slow spoilage or degradation reactions that require water to progress (Lowe and Kershaw, 1995). Preservatives may be added as an additional hurdle to slow oxidative and microbial spoilage as well as prevent nutrient losses over time. Synthetic options are very effective, but these preservatives are typically off-limits in the premium or super premium pet food space due to consumer preference for all-natural preservatives in this category (Karr-Lilienthal, 2019). Natural antioxidants such as tocopherols (vitamin E), green tea, and other plant extracts can control both oxidative spoilage and nutrient losses during storage (Lourenço et al., 2019). Microbial preservation is often more challenging, and formulators rely on organic acids such as vinegar or lactic acid to slow the growth of microorganisms, although care must be taken when adding these ingredients because they can negatively impact the aroma and palatability of the food (Tyler, 2022b). High pressure processing is an emerging technology to slow microbial spoilage in which cooked and packaged products are treated under very high pressures to destroy microorganisms without the use of heat (Woldemariam and Emire, 2019). Finally, another emerging strategy is the use of competitive microbes or putatively "good bacteria" that can outcompete the "bad bacteria" that can cause spoilage during the shelf life of "fresh-cooked" food products (Devlieghere et al., 2004). Typically, manufacturers use a multi-hurdle approach to shelf life extension by combining 2 or more of these strategies.

Cost

There are arguably many tailwinds that are fueling the growth of fresh and frozen pet foods at retail and in the DTC market; however, there are some disadvantages that may be impeding full market potential. One of the most notable differentiating factors between fresh pet food and traditional formats is price. The left side of Figure 1 compares cost per ounce of the leading premium brands of kibble, wet, "fresh-cooked" retail, and "fresh-cooked" DTC foods. The right side of Figure 1 presents the cost to feed a 20 lb dog per day considering the calorie content of the selected foods. Kibble has a distinct advantage because it is less expensive per ounce and is calorie dense; thereby, animals require less food to meet their calorie requirements, resulting in lower cost to feed a pet per day.

Jefferies, a financial services firm, shared data on pet food preferences at the Petfood Forum 2021. In this survey, if cost and availability were not a factor, the number of respondents that would purchase fresh pet food doubled from 17% to 34% (Wall, 2021). Price appeared to be a major hurdle for increased market penetration and may explain why pet owners seem to be more likely to combine or intermittently offer these alternative formats along with kibble rather than offering them as the sole diet. Additionally, the survey revealed that 47% of dog and cat owners selected their food based on nutrition and health considerations as compared with only 18% who selected based on price. Furthermore, respondents indicated that veterinarian recommendation was also a key factor in their decision to switch brands. These consumer insights are likely why so many refrigerated and frozen pet food brands highly emphasize the health benefits of feeding "fresh" diets to pets and many advertise that they were formulated by a veterinarian. Brands that are leveraging claims that are the most important to pet owners who consider their pets as part of the family and are increasingly concerned about their pets' health are, arguably, achieving success in overcoming the price barrier to growing market share.

"Human-grade"

A seemingly simple yet confusing claim that has appeared recently in the pet food space is "human-grade," whereby additional regulations regarding manufacturing, packaging, and storing of the food ensure compliance with safety standards of human consumption guidelines (Oba et al., 2020). Although this claim has been used for pet foods for a few years, it has no definition in animal feed regulations. The term "edible," however, is defined by the US Department of

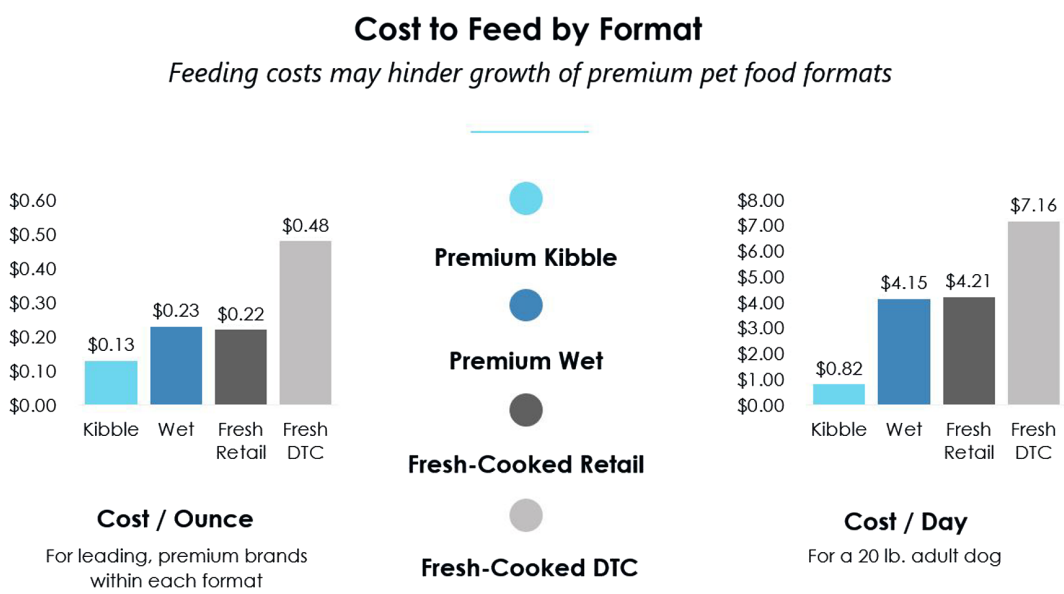

Figure 1. Feeding cost comparisons among premium brands of kibble, wet, "fresh-cooked" at retail, and "fresh-cooked" direct-to-consumer (DTC) pet foods on the market.

Agriculture as foodstuffs that have been processed, inspected, and passed manufacturing regulations that are designed to ensure safety for consumption by humans. Pet foods that truly meet this standard must include only ingredients that are human edible and must be manufactured, packed, and held in accordance with the Code of Federal Regulations (CFR) Title 21 (AAFCO, 2021; FDA, 2022). Currently, AAFCO is in the process of drafting guidance for "human-grade" claims in pet foods in an attempt to provide clarity to the claim (AAFCO, 2021). The proposed definition outlines that pet foods using the "human-grade" claim are first and foremost animal food products that are subjected to inspection under 21 CFR 507, manufacturing must be in accordance with 21 CFR 110, and the overall process is conducted according to standards ensuring human consumption safety (Carter et al., 2014; Oba et al., 2020; FDA, 2022). Furthermore, the pet food bearing a "human-grade" claim must be manufactured in accordance with the applicable human food regulations for ready-to-eat human food (AAFCO, 2021, 2022). Although it is most commonly associated with refrigerated and frozen pet foods (including but not limited to brands such as The Farmer's Dog, JustFoodforDogs, Nom Nom, and private brand, frozen offering, Tylee's by Chewy.com), the "human-grade" label has also appeared with brands that offer conventional, shelf-stable formats (e.g., The Honest Kitchen, Caru, and Spot & Tango). An inherent advantage of a defined "human-grade" claim is that it allows the pet food industry to meet a consumer need with foods that are nutritionally complete and balanced for pets compared with home-prepared meals, which are often deficient in one or more of the required nutrients (Wilson et al., 2019). Recently at the American Feed Industry Association Pet Food Conference, Kennedy (2022) described a number of drawbacks associated with meeting a "human-grade" claim in pet food. These drawbacks include increased costs, limited ingredient supply, increased regulatory and manufacturing complexity, and potentially decreased palatability for the pet (Kennedy, 2022).

Regardless of whether pet owners truly understand the meaning, it is evident that some individuals are seeking out foods with a "human-grade" claim, possibly because they feel it symbolizes higher quality foods that are safer and more nutritious for their pets. It is the apparent epitome of the "if it is good enough for me, it must be good for them" mentality. With the appropriate regulatory oversight, "human-grade" pet food has an opportunity to continue to grow in the market by meeting consumer demand for pet food that is more similar to their own. Other brands should not ignore this insight and must respond to the increasing consumer demand for transparency and high-quality ingredients; however, it is the responsibility of the pet food industry to educate pet owners to the concept that a "human-grade" pet food does not necessarily mean that it is nutritionally balanced or safe for pets.

Looking to the Future

The size of the cat food market has lagged behind the dog food market because cats consume less than dogs. That said, the US cat population is on pace to

exceed the dog population, presenting a ripe opportunity for companies to innovate (Euromonitor International, 2022). In 2021, US retail sales of cat food reached $12.1 billion, which is up 6.6% compared with sales in 2020 (Packaged Facts, 2021; Wall, 2022b). Moreover, given that cats are obligate carnivores, it stands to reason they would benefit more than dogs with a shift to increased meat or "fresh" food formats that more closely resemble their natural prey. Despite these potential benefits, innovation in refrigerated and frozen cat food seems to be lagging behind options available for dogs. Taken together, these could be significant opportunities for brands to differentiate themselves in this market space to delight both cats and cat parents.

Consumer consideration of the broad definition of sustainability is another critical evaluation for new pet food innovation. With the estimation that cats and dogs consume ~25% of all animal-derived calories produced in the US, the pet food industry has an opportunity to make a significant impact on the sustainability of our food supply chain (Okin, 2017). As the humanization of pet food progresses, there will be increased competition for ingredients, especially proteins, and the challenges associated with feeding a growing human population will be exacerbated by the need to feed a growing pet population. Importantly, pets have unique nutritional requirements compared with humans, so this must also be considered.

In conclusion, pet food is evolving to become more similar to human food as we increasingly consider pets to be part of our family. Opportunities exist for new innovation, responsible marketing, and product development to meet the changing demands of pet owners. Because pet owners will continue to demand transparency and higher quality foods for their pets, brands must find innovative solutions without compromising the environmental impact, safety, or nutritional value of the diets. Moving forward, there should be an industry-wide effort to educate pet owners on the importance of a science-based approach to formulation and selection of ingredients that meet the animal's nutritional requirements without negatively impacting the environment.

Acknowledgments

The author would like to extend appreciation to Dr. Lesleigh Beer of Simmons Pet Food for her assistance in the preparation of this paper.

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