Exploring the acceptability and perception by dog owners towards the appearance of dry dog food

by

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Abstract

Sensory analysis techniques play a key role in the pet food industry to ensure the final product meets both the pets' and pet owners' demands and expectations. To date, the study of the pet owners' perception towards pet foods is still an emerging field of study and a few number of publications have been released on the topic. In particular, little research has been conducted on exploring the pet owners' perception regarding the appearance of pet foods. The objective of this work is to study the effect of the visual characteristics of dry dog food on the acceptability and perception by consumer segments of dog owners in the US and in Poland and to explore whether differences exist within countries and across the two countries. For this purpose, dog owners in both locations evaluated the appearance of thirty dry dog food samples with varying visual properties. The participants rated their degree of acceptability towards the appearance of the samples with four different attributes using 9-point hedonic scales. Also, the consumers were asked to associate each one of the samples with a list of positive and negative beliefs on a check-all-that-apply question. Cluster Analysis, ANOVA, and Correspondence Analysis were used to analyze the consumer feedback. The results demonstrate that the acceptability of the appearance of dry dog food is affected by the number of different kibbles present, color(s), shape(s), and size(s) in the product. Similarities were found both within countries and across countries and consumer segments. Consumers overall showed a preference for single-kibble samples of medium brown colors, medium kibble sizes, low-dimensional contrast kibbles and traditional kibble shapes. Furthermore, extra-small or extra-large sized kibble sizes and kibble shapes with a high-dimensional contrast were rejected by the consumers overall. In addition, differences across consumer segments within countries and across countries were identified from the results.

The findings indicate that this topic have possibly been overlooked and opportunities for further research on this field are identified. Dry dog food manufacturers should take special consideration with the appearance of their products to enhance the acceptability by dog owners. The outcome of this work can help to drive dry dog food companies meet consumers' needs and demands in a constantly changing pet food market, with benefits anticipated to the pet food industry and the wellbeing of dog owners.

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Chapter 1 - Literature Review

Pet Food Industry

The global pet food market is on the raise and has experienced growth in the last few years. In 2017, the global pet food market was estimated to hit the US$75 billion mark (1). USA is the world's largest pet food market with an expected US$27 billion pet food retail sales in 2018 (2) and is expected to reach US$30 billion by 2022 (3). Regarding the pet food type, dry pet food makes 68% of the US pet food market sales, followed by wet pet food with 20% and treats with 11% of the share. When dog food and cat food sales are combined, dog food takes 78% of the split in the US market (4) and the combined dog and cat food sales in USA are estimated at around US$30 billion in 2017 (1). USA is the largest manufacturer of dry pet food in the world with 8.451 million metric tons produced in 2015. Also, the pet food industry represents an important sector in the feed processing sector in USA. A study conducted by George Mason University shows that the pet industry, pet food industry included, contributed to an estimated US$221 billion to the US economy and supported more than 1.3 million jobs in USA in 2015 (5).

For the Europe market, pet food retail sales reached an estimated US$20 billion in 2015 (4). The dry pet food market in Europe is expected to hit the US$11 billion mark by 2021 (6). For Eastern Europe, the total pet care sales were estimated to reach US$5.43 billion in 2017. Poland is the second largest pet food market in Eastern Europe representing 14.82% of the regional market share (7). Interestingly, Poland's dog ownership is among the highest worldwide. It is estimated that 45% of Polish population live with dogs (8). In numbers, an estimated total of 7.8 million dogs live in Polish households (9). In 2015, the pet food market in Poland represented an estimated total of US$639 million (9). In terms of the dry pet foods production, Poland was ranked as the eighth highest producing country worldwide in 2015 with 584.000 metric tons produced (4).

Dog food constitutes most of the global pet food sales, representing 78% of the pet food sales in the US market, 75% in Great Britain and 87% in the Czech Republic in 2015 (4). Moreover, the dry pet foods category dominate the global market representing 68% of the sales in the US market, 90% in both France and the Czech Republic, and reaching a 93% of the market share in Greece (4).

Sensory Analysis

Stone & Sidel (10) defined sensory analysis as a scientific method used to evoke, measure, analyze, and interpret the responses to a product as perceived through the senses of sight, smell, touch, taste, and hearing. Sensory Analysis methods using human assessors are divided in three main categories: discrimination analysis, descriptive analysis and affective analysis (11). Discrimination tests are normally conducted to determine if differences exist between samples and can be performed by either trained or semi-trained assessors. Descriptive analysis is used to describe the sensory characteristics of products and it is usually performed by trained assessors. Affective tests are conducted to determine how well products are liked or which products are preferred and the tests are intended to use consumers as the assessors.

Sensory Analysis of Pet Foods

For the successful development of pet food products, both the nutritional and the sensory aspects of the products must be considered to ensure their success in the market, similarly to human food products. The use of sensory evaluation techniques is key to study both the pet and the pet owners' behaviors. Also, sensory evaluation provide researchers and manufacturers valuable feedback regarding how pet food products are perceived by their targets. The number of research publications regarding the sensory characteristics of pet food products have been growing in the last few decades. Koppel (12) described different alternatives available to perform sensory evaluation of pet food products by using either humans, animals or instruments. Humans can be utilized for the evaluation of pet foods as trained panelists to describe the products' characteristics. Also, humans can be used as regular consumers/pet owners to provide feedback on their affective perception of the products.

Descriptive Sensory Analysis

To date, most of the published work on sensory analysis of pet foods using humans comprises the use of descriptive sensory analysis methods to study the characteristics of pet foods. Koppel et al. (13) explored the effect of fiber inclusion on the palatability and sensory characteristics of dry dog food. Di Donfrancesco et al. (14) accomplished the development of a lexicon to describe the appearance, aroma, flavor and texture characteristics of dry dog food products by using a trained human sensory panel. Previous work has also been conducted for other types of pet foods. Pickering (15,16) performed studies aiming to describe the flavor and texture characteristics of dry and wet cat foods by using a human sensory panel.

Affective Tests – Consumer Studies

Previous research has also been conducted on which humans are used as consumers/pet owners to provide feedback on their perception of the products. Moreover, several studies have investigated attitudes pet owners have towards pet foods. Boya et al. (17) studied how the choice of dog food varies across dog owners' segments and examined the similarity between the dog owner's criteria at the time of purchasing food for themselves vs. when purchasing dog food. Tesfom and Birch (18) explored similarities in the way dog owners buy food for their dogs vs. food for themselves. Michel et al. (19) examined feeding practices and attitudes dog and cat owners present towards pet foods and diets they use for feeding their companion animals. Also, Tengpongsathon and Phaosathienpan (20) studied the importance of brand, price, type of food and nutrition on the pet food preferences by consumers in Thailand.

Pet owners are in charge of making the purchase decisions when selecting the pet food products they will feed to their companion animals. Due to the humanization trend that has been growing in the pet food industry over the last few years, it is common for pet food manufacturers to strive to develop products that meet the pet owners' requirements as much as they do with the requirements from the companion animal. From a sensory point of view, the success of the product depends on two factors: (1) the companion animal accepting and consuming the product; and (2) the pet owner's approval and satisfaction since it is the owner who makes the purchase decision.

Pet owners usually interact with pet foods through the senses of sight and smell. Previous research by Di Donfrancesco et al. (21) has studied the overall acceptability, aroma acceptability and appearance acceptability of dry dog food by consumers. The results indicate that the acceptability of dry dog food by the consumers was more driven by the appearance than by the aroma of the products. The results by Di Donfrancesco et al. (21) open an opportunity for further research on what some of the factors driving the appearance liking of dry fog foods by consumers are. Also, further research is necessary to explore what kind of visual properties in dry dog food consumers prefer and whether differences in the preferences exist across consumer segments and across countries.

Research Objectives

Previous research has shown that the appearance of dry dog food influences more the acceptance by dog owners than the aroma of the product. Further research is necessary to address which visual properties, if any, are preferred by consumers and what beliefs are associated with different visual attributes of dry dog food as perceived by dog owners. Therefore, the objectives of this work are:

1) To assess the effect of the visual characteristics of dry dog food on the perception and acceptance by consumers in Poland and USA
2) To understand which visual characteristics are preferred by consumers and which are disliked
3) To gain a deeper understanding at which visual characteristics drive the liking of the products by evaluating several appearance attributes
4) To explore the impact of the visual characteristics on the perception and beliefs associated with dry dog foods
5) To explore potential similarities/differences across different consumer segments and across countries

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Chapter 2 - Acceptability of dry dog food's visual characteristics by consumer segments based on overall liking: a case study in Poland

Abstract

Sensory analysis of pet foods has been emerging as an important field of study for the pet food industry over the last few decades. Few studies have been conducted on understanding the pet owners' perception of pet foods. The objective of this study is to gain a deeper understanding on the perception of the visual characteristics of dry dog foods by dog owners in different consumer segments. 120 consumers evaluated the appearance of thirty dry dog food samples with varying visual characteristics. The consumers rated the acceptance of the samples and associated each one of them with a list of positive and negative beliefs. Cluster Analysis, ANOVA and Correspondence Analysis were used to analyze the consumer responses. The acceptability of the appearance of dry dog foods is affected by the number of different kibbles present, color(s), shape(s), and size(s) of the kibbles in the product. Three consumer clusters were identified. Consumers rated highest single-kibble samples of medium sizes, traditional shapes, and brown colors. Participants disliked extra-small and extra-large kibble sizes, shapes with high-dimensional contrast, and kibbles of light brown color.

Introduction

The pet food industry represents an important sector of the food processing industry. In 2015, global pet food retail sales reached 70 billion USD with 20 billion USD corresponding to Europe's combined market [1]. By 2021, the dry pet food market in Europe is anticipated to reach over 11 billion USD [2]. In 2017, the total pet care sales for Eastern Europe are estimated to reach 5.43 billion USD. Poland represents the second largest pet food market in Eastern

Europe accounting for 14.82% of the regional market share [3]. Poland's dog ownership is among the highest in the world. Approximately, 45% of Polish population live with dogs [4] for an estimated total of 7.8 million dogs living in Polish households [5]. The pet food market in Poland increased 9% in 2014 and represented an estimated total of 639 million USD in 2015 [5]. In the dry pet foods category, Poland was ranked the eighth highest producing country in the world in 2015 with 584.000 metric tons [1].

In 2015, dog food constituted most of the global pet food sales, representing 78% of the pet food sales in the US market, 75% in Great Britain and 87% in the Czech Republic. In terms of food type, the dry pet foods category dominated the global market taking 68% of the sales in the US market, 90% in both France and the Czech Republic, and 93% in Greece [1].

In the pet food industry, the development of successful products depends on a wide variety of factors. As with human foods, the development of new products in this sector must consider both the nutritional and the sensory aspects of the product. From the sensory perspective, the use of sensory analysis methods is key to gain understanding of pet and owner behavior and to provide manufacturers and researchers the means to study pet food selection. Nevertheless, research publications regarding the sensory characteristics of pet food products are relatively new, as much of the work conducted previously seems to be proprietary. As described by Koppel [6], the use of sensory evaluation methods to study pet foods can be accomplished using humans, animals and instruments. Most of the published work on sensory analysis of pet foods using humans has focused on using descriptive sensory analysis methods to study the characteristics of the products. Di Donfrancesco et al. [7] developed a lexicon to describe the appearance, aroma, flavor and texture characteristics of dry dog food products using a trained human sensory panel. Koppel et al. [8] studied the effect of fiber inclusion on the sensory characteristics and palatability of dry dog food products. In addition to dry dog food, Pickering conducted studies to describe the flavor and texture characteristics of dry and wet cat foods using a human sensory panel [9,10]. Some studies have been published on studying the pet owners' response to pet food products. Tengpongsathon and Phaosathienpan [11] studied the importance of brand, price, type of food and nutrition on the consumers' preferences for pet foods in Thailand. Several works have been published on studying the attitudes of pet owners towards pet food. Boya et al. [12] studied how the choice of dog food varies across different dog owners' segments and the similarity between the dog owner's criteria at the time of purchasing food for themselves vs. the criteria used when purchasing dog food. Michel et al. [13] investigated feeding practices and attitudes dog and cat owners have towards pet foods and diets they use for feeding their companion animals. Tesfom and Birch [14] studied similarities in the way dog owners buy food for their dogs vs. food for themselves.

As pet owners, humans make decisions at the time of purchasing pet food products. Despite the food is intended to be consumed by the pet, it is common for dog food manufacturers to strive for developing foods that satisfy the owners' requirements as much as they do with the pet requirements. From a sensory point of view, the product's success depends on the companion animal accepting the product as palatable. In addition, the pet owner's perception of the product is of great importance since the owner makes the purchase decision. From a sensory perspective, the interaction dog owners have with dog food is usually through the senses of sight and smell. Di Donfrancesco et al. [15] studied the overall acceptability, aroma acceptability and appearance acceptability of dry dog food products by consumers in the United States. The results showed that the appearance is more important than the aroma in driving the consumers' liking of dry dog food products. A wide variety of colors, geometric shapes, sizes and kibble mixtures can be found in the dry dog food market. Companies strive to catch the customers' attention by developing products with innovative visual characteristics to make their products stand out over the competition. Given the results by Di Donfrancesco et al. [15], further study is necessary to gain a deeper understanding on what kind of visual characteristics are preferred by consumers and what are some of the factors driving appearance liking by consumers in dry fog food products. Koppel et al. [16] studied this subject for consumers in Thailand and found that Thai consumers like best kibbles with a bone shape and yellowish color.

To address the study of consumer response to the appearance of dry dog food products, the present work aimed: (1) to understand the impact of visual characteristics of dry dog food on human consumers' acceptance and beliefs; (2) to identify potential differences in the preferred visual attributes by consumer segments in Poland based on their acceptance of the appearance of dry dog foods; (3) to gain a deeper understanding at the impact of different visual characteristics on the overall acceptability by the consumers; and (4) to study the association between the visual characteristics and the beliefs consumers link to dry dog foods.

Materials and Methods

Samples

Thirty dry dog food samples of kibbles from commercially available dry dog foods were used. The samples were prepared by selecting specific kibbles from a wide list of commercial products to use them as a single-kibble sample or by mixing different kibbles to create multiple-kibble samples. The samples were chosen to represent a wide variety of visual characteristics in terms of colors, sizes, shapes and number of kibbles present in the samples. Table 2.1 shows a summary of the samples' characteristics as classified by sample type (single-kibble or multiple-kibble), number of kibbles present, color(s) description, relative size(s) score (1-7), and shape(s) of the kibble(s). To classify the size of the kibbles, a relative size scoring method was used. This method is shown in Table 2.2 and assigns a relative size score ranging from 1-7 based on the largest dimension of the kibble(s) (1 = “extra-small” to 7 = “extra-large”). Kibbles with similar colors were grouped together into general color categories to facilitate the analysis of the data. The shape of the samples is described as an approximation to common 3D shapes. All the commercial products were purchased in local pet stores/grocery stores in the Manhattan, Kansas, area prior to the test and after selection and preparation were stored under frozen conditions until the day of testing. All the products were evaluated within the “best by” date and no recalled products were used.

Table 2.1 Description of the thirty samples used and their visual characteristics.

Sample	Sample type	Number of kibbles present	Color(s)	Relative size(s) score (1-7)	Shape(s)
S1	Single-kibble	1	Bright gold	5	Bones
S2	Single-kibble	1	Bright gold	6	Clovers
S3	Single-kibble	1	Golden brown	6	Cylindrical 'X'
S4	Single-kibble	1	Golden brown	4	Rounded cuboids
S5	Single-kibble	1	Amber brown	7	Sticks
S6	Single-kibble	1	Light brown	5	Discs
S7	Single-kibble	1	Shades of brown (from bright gold to medium brown)	7	Cylinders
S8	Single-kibble	1	Golden brown	2	Cuboids
S9	Single-kibble	1	Medium brown	4	Flat triangular prisms with center hole
S10	Single-kibble	1	Amber brown	4	Puffs (irregular)
S11	Single-kibble	1	Medium brown	3	Flat 'X'
S12	Single-kibble	1	Medium brown	3	Flat cuboids with center hole
S13	Single-kibble	1	Medium brown	3	Flat cylinders
S14	Single-kibble	1	Medium brown	5	Rounded triangular prisms
S15	Single-kibble	1	Medium brown	4	Flat triangular prisms
S16	Single-kibble	1	Medium brown	6	Rack of ribs
S17	Single-kibble	1	Dark brown	5	Semi-flat cuboids
S18	Single-kibble	1	Extra-dark brown	1	Spheres
S19	Single-kibble	1	Medium green	3	Puffs
S20	Single-kibble	1	Dark green	6	Flat elongated cuboids with rounded corners
S21	Single-kibble	1	Red	3	Rounded cuboids
S22	Single-kibble	1	Red meat and white fat, marbled	6	Steaks
M1	Multiple-kibble	2	Light brown, Medium brown	4, 5	Discs, flat triangular prisms with center hole
M2	Multiple-kibble	2	Golden brown, Red	3, 4	Rounded cuboids
M3	Multiple-kibble	3	Light brown, Medium green, Medium brown	3, 4, 5	Discs, flat triangular prisms with center hole, puffs
M4	Multiple-kibble	3	Golden brown, Dark brown, Red	2, 3, 4	Rounded cuboids, flat cylinders
M5	Multiple-kibble	4	Light brown, Medium green, Medium brown	3, 4, 5	Discs, flat triangular prisms with center hole, puffs, flat triangular prisms
M6	Multiple-kibble	4	Golden brown, Dark brown, Medium green, Red	2, 3, 4	Rounded cuboids, flat cylinders, puffs
M7	Multiple-kibble	5	Golden brown, Bright gold, Light brown, Medium brown	4, 5, 6	Clovers, discs, cylindrical 'X', flat triangular prisms, flat triangular prisms with center hole
M8	Multiple-kibble	5	Bright gold, Golden brown, Dark brown, Medium green, Red	2, 3, 4, 5	Rounded cuboids, flat cylinders, puffs, rounded triangular prisms

Table 2.2 Description of the relative size scoring method used to evaluate the size of the kibbles.

Relative size (based on largest dimension)	Size score (1-7)
Extra-small	1
Small	2
Small-to-medium	3
Medium	4
Medium-to-large	5
Large	6
Extra-large	7

All relative sizes were assigned based on the largest dimension for each of the kibbles, regardless of the shape.

Participants

The participants were screened to be: (1) 18 years of age or above; (2) dog owners; (3) to use dry dog food to feed their dog(s); (4) to be responsible for purchasing the dog food or to participate in making the purchase decision on which food is fed to the dog(s); and (5) not to have been diagnosed with color vision deficiencies previously. A total of 120 participants were recruited and participated voluntarily in the study. The demographics of the participants are shown in Table 2.3.

Table 2.3 Summary of the demographics of the participants in the consumer study (percentage of consumers).

Gender			Male			Female	
			40.8%			59.2%	
Age (years)			18-34			35 or above	
			41.7%			58.3%	
Number of dogs owned			1	2	3	4	5 or more
			64.2%	22.5%	6.7%	3.3%	3.3%
Size of dog(s) (can choose more than one answer if more than one dog)			Very small (0.5 - 5 kg)	Small (5.1 - 11.0 kg)	Medium (11.1 - 20.0 kg)	Large (20.1 - 40.0 kg)	Very large (more than 40 kg)
			5.8%	33.3%	36.7%	39.2%	9.2%
Money spent on each dog per month (USD)		Less than $15		$15 - $50		More than $50	
		13.3%		68.3%		18.3%	
Knowledgeable about pet food and pet's health			Yes			No	
			54.2%			45.8%	
Important factor(s) considered when choosing dog food (can choose up to three answers)	Improve dog’s health in general	Brand	Price	Appearance of the product	Dog(s) like(s) that food	Ingredients/Raw materials	Dog(s) need(s) that food because of a health condition
	30.8%	30.0%	50.8%	10.0%	70.8%	75.0%	6.7%
Purchasing location (check-all-that-apply)		Online	Clinic/Veterinary hospitals	Small market in living area	Supermarkets /Convenience stores	Pet shops/Pet stores	Market fairs
		54.2%	15.0%	10.0%	30.0%	44.2%	5.0%

Gender, age, number of dogs, size of dog, money spent on each dog per month, knowledgeable about pet food and pet's health, factor(s) considered when choosing dog food, purchasing location.

Consumer study

Consumer testing was performed in compliance with the Kansas State University (KSU) Institutional Review Board #7710. A Central Location Test (CLT) was conducted at Warsaw University of Life Sciences (Warsaw, Poland). Participants were recruited from the metropolitan area of Warsaw via e-mail, phone, social media, flyers, and word-of-mouth. Test sessions were conducted using a classroom setting and lasted 45 min. The number of participants on each session ranged from 1-14.

The samples were presented monadically to the consumers using a randomized latin square design [17]. Samples were presented in white 8-oz cups Styrofoam® containers covered with lids and labeled with three-digit codes.

Questionnaires

Each consumer was presented with one demographic questionnaire and 30 sets of dog food questionnaires. The participants completed the demographic questionnaire prior to sample evaluation. Afterwards, consumers were asked to visually inspect each of the samples presented and to answer one set of the dog food questionnaires for each of the products. The participants were asked to rate the Overall Liking, Size Liking, Shape Liking and Color Liking for each of the samples using a 9-point hedonic scale (ranging from 1 = "dislike extremely" to 9 = "like extremely", 5 = "neither like nor dislike"). After the hedonic questions, participants were presented with a list of thirteen positive and negative functional terms in a check-all-that-apply question and asked to select all those they associated with each of the samples. The following 5 positive and 8 negative terms were used:

- Positive terms: "Has natural ingredients/raw materials", "Good for dog's health", "My dog will like it", "Has variety of ingredients/raw materials", and "Has all the nutrients that my dog(s) needs".
- Negative terms: "Looks like fake food", "Color is too pale", "Consumption may cause choking hazard", "My dog will not eat it", "I don't like the shape of this sample", "Has artificial color(s)", "Has too much variety of shapes", and "Has too much variety of colors".

The terms were selected based on previous work conducted and expertise on the topic.

Data Analysis

Cluster Analysis

To group consumers with similar liking patterns given the set of samples, cluster analysis was performed using Agglomerative Hierarchical Clustering (AHC) method and Ward's agglomeration method on the Overall Liking scores for all thirty samples. Demographics were calculated for each resulting cluster.

Analysis of Variance

Two-way Analysis of Variance (ANOVA) was performed to model each of the four acceptance attributes Overall Liking, Size Liking, Shape Liking and Color Liking (dependent variable) as a function of Sample and Consumer (explanatory variables) using a 95% level of significance. Tukey's Honest Significant Difference (HSD) pairwise comparison tests were performed for the ANOVA models using Sample as factor for pairwise comparisons to determine significant differences among samples for each acceptance attribute. The Analysis of Variance models for each of the four hedonic attributes were performed: (1) across all 120 consumers; and (2) for each of the consumer clusters.

Correspondence Analysis

To analyze the results from the check-all-that-apply (CATA) question, a contingency table was constructed by summing all the times a term was checked by the consumers for each of the thirty samples and for each of the Overall Liking clusters. Chi-square distance was used to test the independence between samples and terms using a level of significance $\alpha = 0.05$. Correspondence Analysis was used to study the association between samples and attributes and to display the results in two-dimensional maps.

All statistical analyses were performed using XLSTAT Version 2015.3.01 (Addinsoft, New York, NY, USA).

Results

Analysis of Variance for all 120 participants

To analyze the results from the four liking questions, two-way Analysis of Variance (ANOVA) was performed using Sample and Consumer as main factors to determine significant differences in the liking scores among the samples. A summary of the results is shown in Table 2.4. There is evidence of a significant effect by the two explanatory variables (sample and consumer) on the Overall Liking, Size Liking, Shape Liking, and Color Liking mean scores for all the participants and for each of the consumer clusters (p-value < 0.0001). Table 2.5 shows the results from the Type III Sum of Squares (SS) for the two-way ANOVA models for all the participants and for each of the consumer clusters using Sample as the factor under evaluation. The results from the Type III SS indicate a significant effect of the sample on the average score for Overall Liking, Size Liking, Shape Liking, and Color Liking (all p-values < 0.05) in all cases.

Table 2.4 Summary of the two-way ANOVA tests for all the participants and for each of the three consumer clusters. Overall Liking, Size Liking, Shape Liking and Color Liking as dependent variables. Sample and Consumer as explanatory variables. A level of significance α = 0.05 was used.

Parameter	Consumers	Dependent variable			
		Overall Liking	Size Liking	Shape Liking	Color Liking
R^2	All participants	0.314	0.351	0.367	0.324
	Cluster 1	0.214	0.235	0.306	0.300
	Cluster 2	0.270	0.315	0.272	0.240
	Cluster 3	0.313	0.359	0.400	0.415
F	All participants	10.652	12.606	13.512	11.179
	Cluster 1	2.578	2.907	4.156	4.048
	Cluster 2	6.157	7.650	6.212	5.264
	Cluster 3	9.079	11.186	13.285	14.184
p-value	All participants	< 0.0001	< 0.0001	< 0.0001	< 0.0001
	Cluster 1	< 0.0001	< 0.0001	< 0.0001	< 0.0001
	Cluster 2	< 0.0001	< 0.0001	< 0.0001	< 0.0001
	Cluster 3	< 0.0001	< 0.0001	< 0.0001	< 0.0001

Table 2.5 Type III Sum of Squares for the two-way ANOVA tests for all the participants and for each of the three consumer clusters. Analysis of the impact of Sample on the model. Overall Liking, Size Liking, Shape Liking and Color Liking as dependent variables. Sample and Consumer as explanatory variables. A level of significance α = 0.05 was used.

Factor: SAMPLE								
Dependent variable	All participants		Cluster 1		Cluster 2		Cluster 3	
	F	p-value	F	p-value	F	p-value	F	p-value
Overall Liking	18.758	< 0.0001	1.9	0.004	11.39	< 0.0001	21.24	< 0.0001
Size Liking	28.371	< 0.0001	2.67	< 0.0001	12.99	< 0.0001	17.06	< 0.0001
Shape Liking	26.151	< 0.0001	2.03	0.002	9.143	< 0.0001	23.87	< 0.0001
Color Liking	20.559	< 0.0001	1.66	0.019	7.473	< 0.0001	32.57	< 0.0001

Pairwise comparisons were performed using the Tukey's HSD test to determine significant differences among samples for each acceptance attribute. The results of the post-hoc tests are shown in Table 2.6. Based on the mean scores, the following insights are obtained from the analysis for all 120 participants.

Table 2.6 Summary of the Tukey's Honest Significant Difference post-hoc comparison tests for the ANOVA models for all the participants and for each of the three consumer clusters. Overall Liking, Size Liking, Shape Liking and Color Liking as dependent variables. Analysis of Sample as factor for multiple comparisons. A level of significance α = 0.05 was used. For each of the dependent variables, samples not sharing the same letter differ significantly (on each column).

Sample	Dependent variable			
	Overall Liking	Size Liking	Shape Liking	Color Liking
S14	6.3 a	6.4 a	6.5 a	6.2 ab
S15	6.3 a	6.0 abc	6.3 ab	6.6 a
S16	5.9 ab	6.0 abc	5.8 abc	5.9 abcd
S3	5.6 abcd	6.2 ab	5.8 abc	5.1 cdef
S4	5.6 abc	5.8 abcd	6.2 ab	5.0 cdefg
S17	5.2 bcdefgh	5.8 abcd	5.9 abc	5.0 defgh
S1	5.4 abcdef	5.7 abcdef	5.6 bc	4.8 efghi
S13	5.4 abcde	4.3 ij	5.8 abc	5.6 bcde
M2	4.7 cdefghij	5.6 abcdef	5.9 abc	4.3 fghijkl
S2	5.3 bcdefg	5.7 abcde	5.1 cd	4.7 efghijk
S11	5.2 bcdefg	4.3 ij	5.2 cd	6.0 abc
S22	4.8 cdefghi	5.7 abcdef	5.4 bc	4.1 fghijkl
S7	4.7 cdefghij	4.3 hij	5.2 cd	5.1 cdef
M8	4.6 efghijk	5.6 bcdef	5.6 bc	3.9 ijkl
S10	4.4 ghijkl	5.6 abcdef	5.4 bc	4.2 fghijkl
M6	4.5 fghijkl	5.2 cdefg	5.6 abc	3.8 jkl
M4	4.5 fghijkl	5.0 defghi	5.5 bc	4.1 ghijkl
S8	4.7 defghijk	3.3 kl	5.2 cd	5.0 cdefg
M7	4.4 ghijkl	5.1 cdefgh	4.3 de	4.3 fghijkl
S19	4.0 ijkl	5.1 defghi	5.7 abc	3.5 l
S21	3.8 jkl	5.1 cdefgh	5.6 bc	3.4 l
M5	4.3 hijkl	4.8 fghij	4.1 e	4.0 hijkl
S9	4.3 hijkl	4.5 ghij	4.1 ef	4.2 fghijkl
S12	4.1 ijkl	4.0 jk	4.1 ef	4.3 fghijkl
M1	4.2 ijkl	4.5 ghij	3.8 ef	4.2 fghijkl
S18	3.8 jkl	3.1 l	4.3 de	4.8 efghij
S20	3.9 ijkl	4.9 efghij	4.4 de	3.5 l
M3	3.8 jkl	4.6 ghij	3.9 ef	3.7 kl
S5	3.7 l	3.3 kl	3.2 f	4.3 fghijkl
S6	3.8 kl	4.6 ghij	3.8 ef	3.6 l
p-value	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Significant	Yes	Yes	Yes	Yes
MIN	3.7	3.1	3.2	3.4
MAX	6.3	6.4	6.5	6.6
Range	2.6	3.3	3.3	3.2
Number of consumers	120			
Percentage of consumers	100%			

(a) All participants

Sample	Dependent variable			
	Overall Liking	Size Liking	Shape Liking	Color Liking
S1	7.6 a	7.2 a	8.0 a	7.4 a
S14	7.3 ab	7.1 ab	7.1 ab	7.2 ab
S15	7.1 ab	7.1 ab	7.2 ab	7.1 ab
S16	7.3 ab	7.2 a	7.2 ab	6.6 ab
S2	7.3 ab	6.8 abc	7.6 ab	6.3 ab
S11	7.5 ab	6.3 abc	7.3 ab	7.1 ab
S3	6.8 ab	6.8 abc	7.5 ab	7.0 ab
M7	6.9 ab	7.0 ab	7.2 ab	6.3 ab
S4	7.0 ab	6.9 ab	6.9 ab	6.5 ab
M5	7.1 ab	6.8 abc	6.7 ab	7.0 ab
S17	6.9 ab	6.6 abc	7.1 ab	6.6 ab
S22	6.6 ab	7.1 ab	7.4 ab	5.8 ab
M8	7.0 ab	6.7 abc	7.1 ab	6.2 ab
S12	6.9 ab	6.5 abc	7.4 ab	6.0 ab
S10	6.6 ab	6.9 abc	6.8 ab	6.3 ab
M4	6.8 ab	6.8 abc	6.7 ab	6.3 ab
S19	6.1 ab	6.7 abc	7.0 ab	6.2 ab
S8	6.5 ab	4.9 abc	6.8 ab	7.1 ab
S13	6.8 ab	5.9 abc	6.2 ab	6.7 ab
S9	6.7 ab	6.1 abc	6.5 ab	6.5 ab
M3	6.6 ab	6.5 abc	6.7 ab	6.1 ab
M2	6.0 ab	6.6 abc	6.9 ab	6.0 ab
M1	6.7 ab	6.3 abc	6.2 ab	6.2 ab
M6	5.9 ab	6.8 abc	6.7 ab	5.3 ab
S7	6.1 ab	4.4 c	5.7 ab	6.5 ab
S20	6.1 ab	6.5 abc	6.1 ab	5.5 ab
S6	5.6 ab	6.0 abc	6.0 ab	5.1 ab
S5	5.6 ab	5.1 abc	5.3 b	5.7 ab
S21	5.0 b	5.4 abc	6.1 ab	4.6 b
S18	5.5 ab	4.7 bc	5.7 ab	5.5 ab
p-value	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Significant	Yes	Yes	Yes	Yes
MIN	5.0	4.4	5.3	4.6
MAX	7.6	7.2	8.0	7.4
Range	2.6	2.8	2.7	2.8
Number of consumers	15			
Percentage of consumers	12.5%			

(b) Cluster 1

Sample	Dependent variable			
	Overall Liking	Size Liking	Shape Liking	Color Liking
S16	6.4 a	6.3 a	6.5 a	6.0 ab
S22	6.4 a	6.3 a	6.2 ab	5.9 ab
S14	5.8 abcd	6.4 a	6.2 ab	5.8 abc
M2	6.1 ab	6.0 ab	6.2 ab	5.8 abc
S15	6.0 ab	5.8 abc	6.1 abc	6.1 a
S3	5.8 abc	6.4 a	6.2 ab	5.2 abcde
M8	6.0 ab	5.8 ab	6.2 abc	5.6 abcd
M6	6.3 a	5.3 abcd	6.0 abc	5.6 abcd
M4	5.9 abc	5.3 abcd	5.9 abcd	5.8 abc
S2	5.8 abc	5.8 ab	5.5 abcdef	5.2 abcde
S10	5.3 abcdefg	5.9 ab	5.6 abcd	5.6 abcd
S7	5.7 abcde	5.2 abcde	5.8 abcd	5.7 abc
S4	5.5 abcdef	5.6 abc	5.9 abcd	5.0 abcdef
S1	5.3 abcdefg	5.6 abc	5.7 abcd	5.0 abcdef
M7	5.4 abcdefg	5.7 abc	5.3 abcdefg	5.0 abcdef
S21	5.0 abcdefgh	5.6 abc	5.8 abcd	4.7 abcdef
S11	4.7 bcdefgh	3.6 fghi	4.7 bcdefgh	5.8 abc
M5	5.1 abcdefgh	5.2 abcde	4.8 bcdefgh	4.6 abcdef
S19	4.7 bcdefgh	5.2 abcde	5.6 abcde	4.0 def
S17	4.5 cdefgh	5.5 abc	5.4 abcdef	3.9 ef
S13	4.8 bcdefgh	3.7 efghi	5.4 abcdef	4.7 abcdef
S20	4.3 efgh	5.0 abcdef	4.8 bcdefgh	3.8 ef
M3	4.3 defgh	4.9 abcdefg	4.4 defgh	4.1 cdef
S8	4.2 efgh	2.8 hi	4.6 cdefgh	4.4 bcdef
S5	4.1 fghi	3.4 ghi	3.7 gh	4.9 abcdef
S9	4.0 ghi	4.2 cdefgh	4.0 efgh	3.7 ef
M1	3.9 ghi	4.6 bcdefg	3.9 fgh	3.7 ef
S6	3.8 hi	4.5 bcdefg	4.0 efgh	3.4 f
S12	3.7 hi	3.8 defghi	3.7 h	3.5 ef
S18	2.7 i	2.7 i	3.6 h	3.5 ef
p-value	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Significant	Yes	Yes	Yes	Yes
MIN	2.7	2.7	3.6	3.4
MAX	6.4	6.4	6.5	6.1
Range	3.7	3.7	2.9	2.7
Number of consumers	40			
Percentage of consumers	33.3%			

(c) Cluster 2

Sample	Dependent variable			
	Overall Liking	Size Liking	Shape Liking	Color Liking
S14	6.3 a	6.3 a	6.6 a	6.3 ab
S15	6.3 a	5.9 ab	6.2 abc	6.8 a
S4	5.4 ab	5.7 abc	6.3 ab	4.7 cdefgh
S17	5.2 abc	5.8 abc	6.0 abc	5.3 bcdef
S3	5.2 abc	5.9 ab	5.2 bcde	4.5 defghi
S16	5.2 abc	5.6 abcd	5.0 cde	5.6 abcd
S13	5.5 ab	4.3 fghijk	5.9 abc	5.9 abc
S1	4.9 bcde	5.4 abcdef	5.0 cdef	4.2 fghi
S11	5.1 bcd	4.2 ghijk	5.0 cdef	5.8 abc
S2	4.5 bcdefg	5.4 abcde	4.3 efghi	4.0 ghij
S8	4.6 bcdef	3.3 klm	5.2 bcde	5.0 cdefg
M2	3.6 fghi	5.1 bcdefgh	5.5 abcde	2.9 jkl
S18	4.1 cdefgh	3.1 lm	4.5 defg	5.4 bcde
S10	3.3 ghi	5.2 abcdefg	5.0 cdef	2.9 jkl
S7	3.8 efghi	3.7 ijklm	4.7 defg	4.3 efghi
S19	3.1 hi	4.7 cdefghij	5.6 abcd	2.7 kl
S9	3.9 defghi	4.2 fghijk	3.6 ghijk	4.0 ghij
S22	3.4 fghi	5.0 bcdefgh	4.4 defgh	2.7 kl
S12	3.7 efghi	3.6 jklm	3.6 ghijk	4.4 efghi
M8	3.2 hi	5.1 bcdefgh	5.0 cdef	2.4 l
M6	3.1 hi	4.8 bcdefghi	5.2 bcde	2.4 l
M1	3.8 efghi	4.1 ghijkl	3.2 hijk	4.0 ghij
M4	3.0 hi	4.5 defghij	5.1 cde	2.5 kl
S21	2.8 i	4.8 bcdefghi	5.3 bcde	2.3 l
S6	3.3 ghi	4.4 efghijk	3.1 jk	3.4 ijkl
S20	3.1 hi	4.4 defghij	3.8 fghij	2.9 jkl
M7	3.2 hi	4.4 efghijk	3.1 jk	3.3 ijkl
M5	3.2 hi	4.2 ghijk	3.2 ijk	3.0 jkl
S5	2.9 hi	2.9 m	2.4 k	3.6 hijk
M3	2.9 hi	4.0 hijkl	3.0 jk	2.9 jkl
p-value	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Significant	Yes	Yes	Yes	Yes
MIN	2.8	2.9	2.4	2.3
MAX	6.3	6.3	6.6	6.8
Range	3.5	3.4	4.2	4.5
Number of consumers	65			
Percentage of consumers	54.2%			

(d) Cluster 3

Overall Liking

A high degree of discrimination was found among the sample set by the consumers. The mean scores presented a range of 2.6 in the hedonic scale (minimum mean score = 3.7; maximum mean score = 6.3). Samples rated highest for Overall Liking include: (1) single-kibble samples with colors in the shades of brown color category (golden brown, medium brown), medium kibble sizes, low-dimensional contrast kibbles and traditional kibble shapes such as triangular prisms (S14, mean score = 6.3; S15, mean score = 6.3), cuboids (S4, mean score = 5.6) and flat cylinders (S13, mean score = 5.4); (2) single-kibble samples with colors in the shades of brown color category (bright gold, golden brown, medium brown), large kibble sizes, low-dimensional contrast kibbles and innovative kibble shapes such as the bones (S1, mean score = 5.4), the cylindrical 'X' (S3, mean score = 5.6) and the rack of ribs (S16, mean score = 5.9). According to the Tukey's HSD test, all these scores were found not to be significantly different to each other at the 95% confidence level.

Consumers overall rated lowest for Overall Liking: (1) single-kibble samples with colors in the shades of brown color category (amber brown, light brown), kibble sizes ranging from medium-to-large to extra-large, and a high-dimensional contrast kibble shape such as the sticks (S5, mean score = 3.7) and the discs (S6, mean score = 3.8); (2) a single-kibble sample of extra-dark brown color, a low-dimensional contrast kibble shape (spheres) and an extra-small kibble size (S18, mean score = 3.8); (3) a single-kibble sample of medium brown color with holes present in the center of the kibbles (S12, mean score = 4.1); (4) single-kibble samples of green colors (S19, mean score = 4.0; S20, mean score = 3.9); (5) a single-kibble sample of red color (S21, mean score = 3.8); and (6) multiple-kibble samples containing kibbles with some of the previous characteristics - the high-dimensional contrast discs and kibbles with holes present in the center (M1, mean score = 4.2; M3, mean score = 3.8). According to the post-hoc test, all these scores were found not to be significantly different to each other at the 95% confidence level.

Size Liking

For Size Liking, a high degree of discrimination was found from the consumers. The average scores presented a range of 3.3 in the hedonic scale (minimum mean score = 3.1; maximum mean score = 6.4). Samples rated highest include single-kibble samples of: (1) medium size (S4, mean score = 5.8; S15, mean score = 6.0); (2) medium-to-large size (S14, mean score = 6.4; S17, mean score = 5.8); and (3) large size (S2, mean score = 5.7; S3, mean score = 6.2; S16, mean score = 6.0). All these scores were found not to be significantly different to each other according to the Tukey's HSD test.

The consumers overall rated lowest for Size Liking single-kibble samples of: (1) extra-small size (S18, mean score = 3.1); (2) small size (S8, mean score = 3.3); (3) small-to-medium size (S11, mean score = 4.3; S12, mean score = 4.0; S13, mean score = 4.3); and (4) extra-large size (S5, mean score = 3.3; S7, mean score = 4.3). Significant differences were found among these scores according to the post-hoc test, with the score of sample S18 being not significantly different than the scores of samples S5 and S8 only.

Shape Liking

A moderate degree of discrimination was found among the sample set. The mean scores presented a range of 3.3 in the hedonic scale (minimum mean score = 3.2; maximum mean score = 6.5). Samples rated highest overall for Shape Liking include: (1) single-kibble samples of low-dimensional contrast kibbles and traditional shapes such as triangular prisms (S14, mean score = 6.5; S15, mean score = 6.3), cuboids (S4, mean score = 6.2; S17, mean score = 5.9), flat cylinders (S13, mean score = 5.8) and puffs

(S19, mean score = 5.7); (2) single-kibble samples with an innovative kibble shape such as the cylindrical 'X' (S3, mean score = 5.8) and the rack of ribs (S16, mean score = 5.8); and (3) multiple-kibble samples containing kibbles with low-dimensional contrast and traditional kibble shapes such as cuboids (M2, mean score = 5.9) and a mixture of cuboids, flat cylinders and puffs (M6, mean score = 5.6). All these scores were found not to be significantly different to each other according to the Tukey's HSD test.

Samples rated lowest for Shape Liking overall include: (1) single-kibble samples with a high-dimensional contrast kibble shape such as the sticks (S5, mean score = 3.2) and the discs (S6, mean score = 3.8); (2) single-kibble samples with holes present in the center of the kibbles (S9, mean score = 4.1; S12, mean score = 4.1); and (3) multiple-kibble samples containing kibbles with high-dimensional contrast (discs) and holes present in the center (M1, mean score = 3.8; M3, mean score = 3.9). According to the post-hoc test, all these scores were found not to be significantly different to each other at the 95% confidence level.

Color Liking

For Color Liking, a high degree of discrimination was found among the set of samples. The average scores presented a range of 3.2 in the hedonic scale (minimum mean score = 3.4; maximum mean score = 6.6). Samples rated highest by consumers overall include single-kibble samples of medium brown colors (S11, mean score = 6.0; S13, mean score = 5.6; S14, mean score = 6.2; S15, mean score = 6.6; S16, mean score = 5.9). According to the Tukey's HSD test, only the score of sample S13 was found to be significantly lower to the score of sample S15 at the 95% confidence level.

Samples rated lowest for Color Liking by consumers overall include: (1) a single-kibble sample of red color (S21, mean score = 3.4); (2) single-kibble samples of green colors (S19, mean score = 3.5; S20, mean score = 3.5); (3) a single-kibble sample of light brown color (S6, mean score = 3.6); (4) multiple-kibble samples with a high-color contrast containing kibbles of red, green and shades of brown colors (M6, mean score = 3.8; M8, mean score = 3.9); and (5) a multiple-kibble sample containing kibbles with two of the previous characteristics - light brown and green colors (M3, mean score = 3.7). According to the post-hoc test, all these scores were found not to be significantly different to each other.

Analysis by consumer clusters

AHC analysis

From the AHC method and Ward's agglomeration method, three consumer clusters were obtained with the following distribution of participants as shown in Table 2.6. Cluster 1 had the smallest number of consumers with only 12.5% of the participants (15), cluster 2 represented 33.3% of the consumers (40) and cluster 3 included the highest number of assessors with 54.2% (65).

Demographics

The demographics from all three consumer clusters are shown in Table 2.7 in terms of percentage of the total number of consumers on each cluster. Cluster 1 presented the highest proportion of females among all three clusters (80.0% females, 20.0% males) and the highest percentage of young participants (73.3% of 18-34, 26.7% of 35 and above). Cluster 2 comprised mostly females (57.5% females, 42.5% males) and mostly older participants (55.0% of 35 or above, 45.0% of 18-34). Cluster 3 presented the highest proportion of males (44.6% males, 55.4% females) and the highest percentage of older participants (67.7% of 35 or above, 32.3% of 18-34).

Table 2.7 Summary of demographics from the overall liking clusters (percentage of consumers).

Gender	**Cluster number**	**Male**	**Female**
	Cluster 1	20.0%	80.0%
	Cluster 2	42.5%	57.5%
	Cluster 3	44.6%	55.4%
Age (years)	**Cluster number**	**18-34**	**35 or above**
	Cluster 1	73.3%	26.7%
	Cluster 2	45.0%	55.0%
	Cluster 3	32.3%	67.7%

Analysis of Variance

Based on the mean scores shown in Table 2.6, the following insights are obtained from each of the three consumer clusters.

Cluster 1

Overall Liking:

Although significant differences were found for the Overall Liking, a low degree of discrimination was found among the samples in cluster 1. Sample S1 showed the highest average score (mean score = 7.6), despite not significantly different from following samples S11 (mean score = 7.5) and S14, S16 and S2 (mean score = 7.3). Sample S21 had a significantly lower score (mean score = 5.0) than sample S1, but not significantly different from the other 28 samples. All scores were above the neutral category (neither like nor dislike = 5.0) which shows a high level of acceptability by consumers in cluster 1 for all 30 samples. Samples rated highest in Overall Liking are single-kibble samples with colors in the shades of brown category (from bright gold to medium brown), medium sizes (from small-to-medium to large), and with either traditional shapes (triangular prisms) or more innovative shapes (bones, clovers, rack of ribs, flat 'X').

Consumers in cluster 1 overall rated lowest for Overall Liking single-kibble samples with a distinctive visual characteristic from the pool of samples, such as: (1) red color (S21, mean score = 5.0); (2) extra-dark brown color and extra-small size (S18, mean score = 5.5); and (3) a high-dimensional contrast kibble shape such as the sticks (S5, mean score = 5.6) and the discs (S6, mean score = 5.6).

Size Liking:

In terms of size, a higher degree of discrimination was found when compared to the other three acceptance attributes. Samples S1 and S16 showed the highest score (mean score = 7.2) and were rated significantly higher than samples S18 (mean score = 4.7) and S7 (mean score = 4.4). Samples rated highest for Size Liking include: (1) single-kibble samples with kibble sizes in the medium-to-large range such as medium (S15, mean score = 7.1), medium-to-large (S1, mean score = 7.2; S14, mean score = 7.1), and large (S16, mean score = 7.2; S22, mean score = 7.1); and (2) a multiple-kibble sample containing kibbles with sizes ranging from medium to large (M7, mean score = 7.0).

Consumers in cluster 1 rated lowest for Size Liking single-kibble samples with sizes in the two ends of the size scale such as extra-small size (S18, mean score = 4.7), small size (S8, mean score = 4.9) and extra-large size (S7, mean score = 4.4; S5, mean score = 5.1).

Shape Liking:

A low degree of discrimination was found among the samples. Sample S1 showed the highest score (mean score = 8.0) and was rated significantly higher than sample S5 (mean score = 5.3) only. Samples rated highest for Shape Liking include single-kibble samples with innovative shapes such as bones (S1, mean score = 8.0), clovers (S2, mean score = 7.6), cylindrical 'X' (S3, mean score = 7.5), steaks (S22, mean score = 7.4), and flat cuboids with center hole (S12, mean score = 7.4). Most of the samples rated highest are in the shades of brown color category, except from the red meat and white fat steaks (S22).

Samples rated lowest for Shape Liking by consumers in cluster 1 include: (1) single-kibble samples with a high-dimensional contrast such as the sticks (S5, mean score = 5.3) and the discs (S6, mean score = 6.0); and (2) single-kibble samples with a low-dimensional contrast such as the cylinders (S7, mean score = 5.7) and the spheres (S18, mean score = 5.7).

Color Liking:

For Color Liking, a low degree of discrimination between the samples was found among the samples. Sample S1 showed the highest average score (mean score = 7.4) and was significantly higher than sample S21 (mean score = 4.6) only. Samples rated highest in Color Liking are single-kibble samples with shades of brown colors such as bright gold (S1, mean score = 7.4), medium brown (S14, mean score = 7.2; S15, mean score = 7.1; S11, mean score = 7.1), and golden brown (S8, mean score = 7.1).

Samples rated lowest for Color Liking in cluster 1 include: (1) single-kibble samples of red (S21, mean score = 4.6), light brown (S6, mean score = 5.1), dark green (S20, mean score = 5.5), and extra-dark brown (S18, mean score = 5.5) colors; and (2) a multiple-kibble sample with a high-color contrast containing shades of brown, green and red colors (M6, mean score = 5.3).

Cluster 2

Overall Liking:

A high degree of discrimination was found among the samples by consumers in cluster 2. Samples rated highest for Overall Liking include: (1) single-kibble samples with innovative shapes such as the rack of ribs (S16, mean score = 6.4) and the steaks (S22, mean score = 6.4); (2) single-kibble samples with traditional shapes such as flat triangular prisms (S15, mean score

= 6.0); and (3) multiple-kibble samples with high-color contrast and low-dimensional contrast such as M6 (mean score = 6.3), M2 (mean score = 6.1) and M8 (mean score = 6.0).

Consumers in cluster 2 rated lowest for Overall Liking: (1) single-kibble samples in the shades of brown color category with a distinctive visual characteristic from the pool of samples such as extra-dark color and extra-small size (S18, mean score = 2.7), a hole present in the middle of the kibble (S9, mean score = 3.4; S12, mean score = 3.7), and a high-dimensional contrast kibble shape such as the discs (S6, mean score = 3.8); and (2) a multiple-kibble sample containing two of the previously mentioned characteristics (M1, mean score = 3.9).

Size Liking:

In terms of size, a high degree of discrimination was found. Samples rated highest for Size Liking include single-kibble samples of: (1) medium-to-large kibble size (S14, mean score = 6.4); and (2) large sized kibbles (S3, mean score = 6.4; S16, mean score = 6.3; S22, mean score = 6.3).

Samples rated lowest for Size Liking by consumers in cluster 2 include single-kibble samples of: (1) extra-small size (S18, mean score = 2.7); (2) small size (S8, mean score = 2.8); (3) small-to-medium size (S11, mean score = 3.6; S13, mean score = 3.7; S12, mean score = 3.8); and (4) extra-large size (S5, mean score = 3.4).

Shape Liking:

A high degree of discrimination was found among the sample set. Samples rated highest in terms of Shape Liking include: (1) single-kibble samples with innovative shapes such as the rack of ribs (S16, mean score = 6.5), the cylindrical 'X' (S3, mean score = 6.2), and the steaks (S22, mean score = 6.2); (2) single-kibble samples with more traditional-looking shapes such as rounded triangular prisms (S14, mean score = 6.2); and (3) multiple-kibble samples containing low-dimensional contrast kibbles such as a mixture of rounded cuboids (M2, mean score = 6.2), and a mixture of rounded cuboids, puffs, rounded triangular prisms, and flat cylinders (M8, mean score = 6.2).

Samples rated lowest for Shape Liking in cluster 2 include: (1) the extra-small spheres (S18, mean score = 3.6); (2) single-kibble samples with high-dimensional contrast such as the sticks (S5, mean score = 3.7) and the discs (S6, mean score = 4.0); (3) single-kibble samples with holes present such as the flat cuboids with center hole (S12, mean score = 3.7) and the flat triangular prisms with center hole (S9, mean score = 4.0); and (4) a multiple-kibble sample with high-dimensional contrast containing discs and flat triangular prisms with center hole (M1, mean score = 3.9).

Color Liking:

For Color Liking, a high degree of discrimination among the samples was found. Samples rated highest include: (1) single-kibble samples with medium brown colors such as S15 (mean score = 6.1), S16 (mean score = 6.0), S11 (mean score = 5.8) and S14 (mean score = 5.8); (2) the innovative red meat and white fat raw steak-like kibbles (S22, mean score = 5.9); and (3) multiple-kibble samples with high-color contrast such as combination of golden brown and red (M2, mean score = 5.8), and combination of golden brown, dark brown and red (M4, mean score = 5.8).

Samples rated lowest for Color Liking by consumers in cluster 2 include: (1) single-kibble samples in the shades-of-brown color category such as light brown (S6, mean score = 3.4), extra-dark brown (S18, mean score = 3.5), medium brown (S12, mean score = 3.5; S9, mean score = 3.7), and dark brown (S17, mean score = 3.9); (2) the single-kibble dark green sample (S20, mean score = 3.8); and (3) a multiple-kibble sample in the shades of brown color category with low-color contrast (M1, mean score = 3.7).

Cluster 3

Overall Liking:

A high degree of discrimination was found from consumers in cluster 3. Samples rated highest for Overall Liking include single-kibble samples with colors in the shades of brown category (from golden brown to medium brown), medium sizes (from small-to-medium to medium-to-large) and traditional-looking shapes such as triangular prisms (S14, mean score = 6.3; S15, mean score = 6.3), flat cylinders (S13, mean score = 5.5), and rounded cuboids (S4, mean score = 5.4).

Samples rated lowest for Overall Liking in cluster 3 include: (1) single-kibble samples with high-dimensional contrast such as the sticks (S5, mean score = 2.9); (2) single-kibble samples of red color (S21, mean score = 2.8) and green color (S19, mean score = 3.1; S20, mean score = 3.1); and (3) multiple-kibble samples with high-color-contrast containing green (M3, mean score = 2.9; M5, mean score = 3.2), red (M4, mean score = 3.0), and green and red colors (M6, mean score = 3.1; M8, mean score = 3.2).

Size Liking:

For Size Liking, a high degree of discrimination was found from the consumers. Samples rated highest include single-kibble samples of: (1) medium kibbles sizes (S15, mean score = 5.9; S4, mean score = 5.7); (2) medium-to-large size (S14, mean score = 6.3; S17, mean score = 5.8); and (3) large size (S3, mean score = 5.9).

Samples rated lowest for Size Liking in cluster 3 include single-kibble samples of: (1) extra-small size (S18, mean score = 3.1); (2) small size (S8, mean score = 3.3); (3) small-to-medium size (S12, mean score = 3.6); and (4) extra-large size (S5, mean score = 2.9; S7, mean score = 3.7).

Shape Liking:

A high degree of discrimination was found among the samples. Samples rated highest include single-kibble samples with traditional-looking shapes such as triangular prisms (S14, mean score = 6.6; S15, mean score = 6.2), rounded cuboids (S4, mean score = 6.3), cuboids (S17, mean score = 6.0), and flat cylinders (S13, mean score = 5.9).

Samples rated lowest for Shape Liking in cluster 3 include: (1) single-kibble samples with high-dimensional contrast such as the sticks (S5, mean score = 2.4) and the discs (S6, mean score = 3.1); and (2) multiple-kibble samples with different characteristics fall in this category, all of which contain discs and flat triangular prisms with center hole (M3, mean score = 3.0; M7, mean score = 3.1; M1, mean score = 3.2; M5, mean score = 3.2).

Color Liking:

For Color Liking, a high degree of discrimination was found among the sample set. Samples rated highest include single-kibble samples with medium brown color (S15, mean score = 6.9; S14, mean score = 6.3; S13, mean score = 5.9; S11, mean score = 5.8).

Consumers in cluster 3 rated lowest for Color Liking: (1) single-kibble samples of red (S21, mean score = 2.3; S22, mean score = 2.7) and green (S19, mean score = 2.7) color; and (2) multiple-kibble samples with high-color contrast where the red and/or green colors are present (M6, mean score = 2.4; M8, mean score = 2.4; M4, mean score = 2.5).

Correspondence Analysis

As expected, a p-value lower than the significance level $\alpha = 0.05$ (p-value < 0.0001) was found for all three clusters using the Chi-square distance tests, which indicates a difference on the distribution of the functional terms consumers link to the samples on each cluster. Table 2.8 shows the results from the Chi-square distance tests. The results from the contingency table were used to construct the Correspondence Analysis (CA) maps that are shown in Figure 2.1. Based on the distribution of samples and functional terms, the following insights are obtained from each consumer cluster.

Table 2.8 Chi-square distance tests of association between samples and terms from the CATA question for all three clusters. A level of significance α = 0.05 was used.

Cluster No.	1	2	3
Chi-square (Observed value)	621.092	1327.974	3176.161
Chi-square (Critical value)	392.501	392.501	392.501
DF	348	348	348
p-value	< 0.0001	< 0.0001	< 0.0001
alpha	0.05	0.05	0.05

Cluster 1

As seen in Figure 2.1, 63.12% of the total variation is explained by the first two dimensions. Positive terms such as "Has all the nutrients that my dog(s) needs", "Good for dog's health", "My dog will like it" and "Has natural ingredients/raw materials" are found close to each other on the CA map and are associated with: (1) single-kibble samples (S1, S4, S9, S11, S14, S15, S16, and S17) to which colors in the shades of brown category and medium sizes are characteristic; and (2) multiple-kibble samples with low-color contrast (M1 and M5). Samples S19 and M3 share in common the presence of green kibbles and are both related with the term "Has variety of ingredients/raw materials".

Samples S5 (extra-large size) and S18 (extra-small size) are associated with the term "Consumption may cause choking hazard". Samples S21, M2 and M4 share in common that all three of them contain red kibbles and are related with the term "Looks like fake food". Samples S21, S22, M2, M4, M6, and M8 are associated with the term "Has artificial color(s)", and they all have red kibbles present. As expected, the high-color contrast multiple-kibble sample M6 is related with the term "Has too much variety of colors". Samples S2 (bright gold), S3 (golden brown), S6 (light brown), S7 (from bright gold to medium brown), and S8 (golden brown) are associated with the term "Color is too pale". Samples S3 (cylindrical 'X'), S6 (discs), S7 (cylinders), and S8 (cuboids) are related with the term "I don’t like the shape of this sample".

Cluster 2

Figure 2.1 shows that 61.34% of the total variation is explained by the first two dimensions. All 5 positive beliefs are associated by consumers in cluster 2 with: (1) single-kibble samples (S14, S15, S16 and S17) to which medium-to-dark brown colors, medium-to-large sizes and traditional shapes (except from S16) are characteristic; and (2) a high-color-contrast and low-dimensional-contrast multiple-kibble sample (M2).

Samples S6 (light brown) and M1 (light brown, medium brown) are associated with the term "Color is too pale". As expected, samples M5 (discs, flat triangular prisms, flat triangular prisms with center hole, puffs) and M7 (clovers, discs, cylindrical 'X', flat triangular prisms, flat triangular prisms with center hole) are related with the term "Has too much variety of shapes". Samples S7 (cylinders), S8 (cuboids), S9 (flat triangular prisms with center hole), S11 (flat 'X'), S12 (flat cuboids with center hole) and S13 (flat cylinders) are associated with the terms "I don’t like the shape of this sample" and "My dog will not eat it". Samples S18 (extra-small size) and S5 (extra-large size) are related with the term "Consumption may cause choking hazard". As expected, high-color-contrast multiple-kibble samples (M4, M6 and M8) are associated with the term "Has too much variety of colors". Samples containing red kibbles (S21, S22, M2, M4, M6 and M8) and green kibbles (S19, S20, M6 and M8) are related with the term "Has artificial color(s)". Samples containing green (S19 and S20), red (S22) and amber brown (S10) are associated with the term "Looks like fake food".

Cluster 3

As seen in Figure 2.1, 76.47% of the total variation is explained by the first two dimensions. All 5 positive beliefs are found close to each other in the CA map and are associated with single-kibble samples such as S13, S14, S15 and S17 to which medium-to-dark brown colors, medium sizes, traditional shapes (cuboids, triangular prisms, flat cylinders) and low-dimensional contrast kibbles are characteristic. Two more innovative-looking samples such as the medium brown and large size rack of ribs (S16) and the extra-small size and extra-dark brown spheres (S18) are also related with all five positive terms.

The terms "Has artificial color(s)" and "Looks like fake food" are associated with: (1) single-kibble samples of red (S21 and S22), green (S19 and S20) and amber brown (S10) colors; and (2) multiple-kibble samples with high-color-contrast containing red (M2, M4, M6, and M8) and green (M6 and M8) colors. As expected, high-color-contrast multiple-kibble samples (M2, M4, M6 and M8) are related with the term "Has too much variety of colors". Samples S6 (light brown) and M1 (light brown, medium brown) are associated with the term "Color is too pale". Samples S8 (small size), S3 (large size) and S7 (extra-large size) are related with the term "Consumption may cause choking hazard". The term "I don’t like the shape of this sample" is associated with: (1) samples containing kibbles with disc shapes (S6 and M1); and (2) single-kibble samples with innovative shapes such as holes in the center (S9, S12 and M1), bones (S1), cylindrical 'X' (S3) and cylinders (S7). As expected, the three multiple-kibble samples with the highest variety in terms of shapes (M3, M5 and M7) are related with the term "Has too much variety of shapes". The term "My dog will not eat it" is associated with: (1) single-kibble samples with innovative shapes such as clovers (S2) and sticks (S5); and (2) multiple-kibble samples with a high variety of shapes (M3, M5 and M7).

(a) Cluster 1

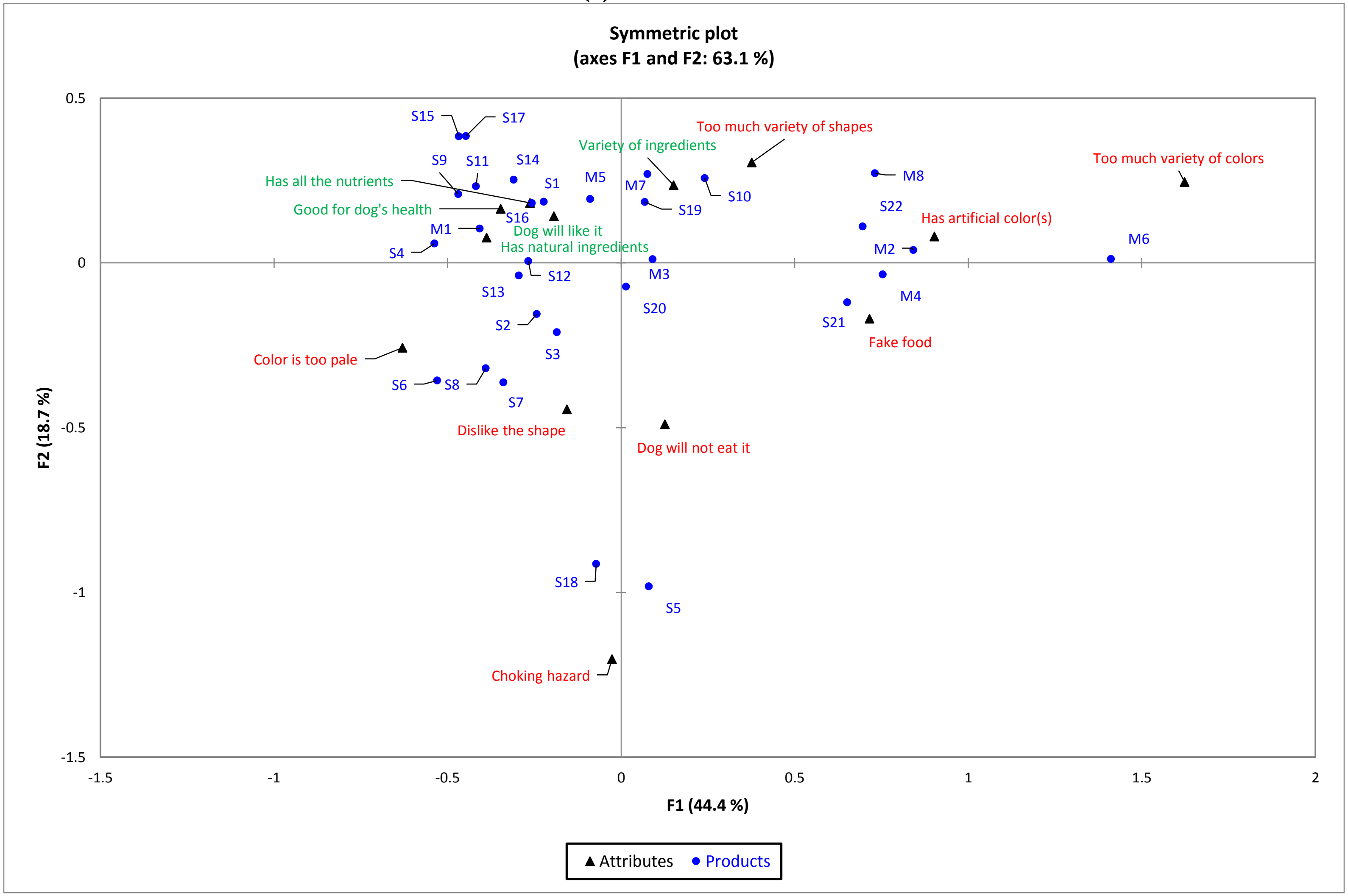
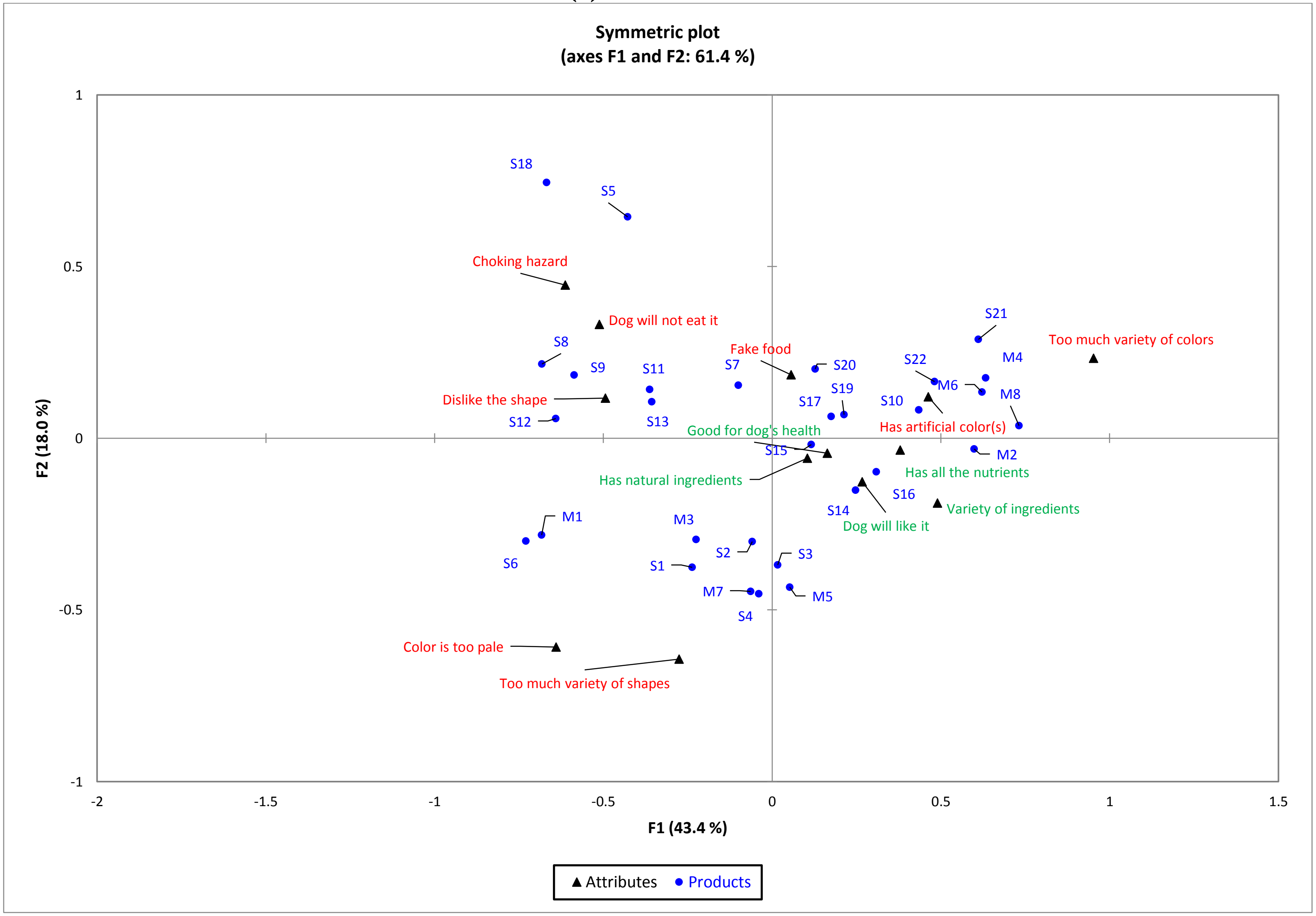
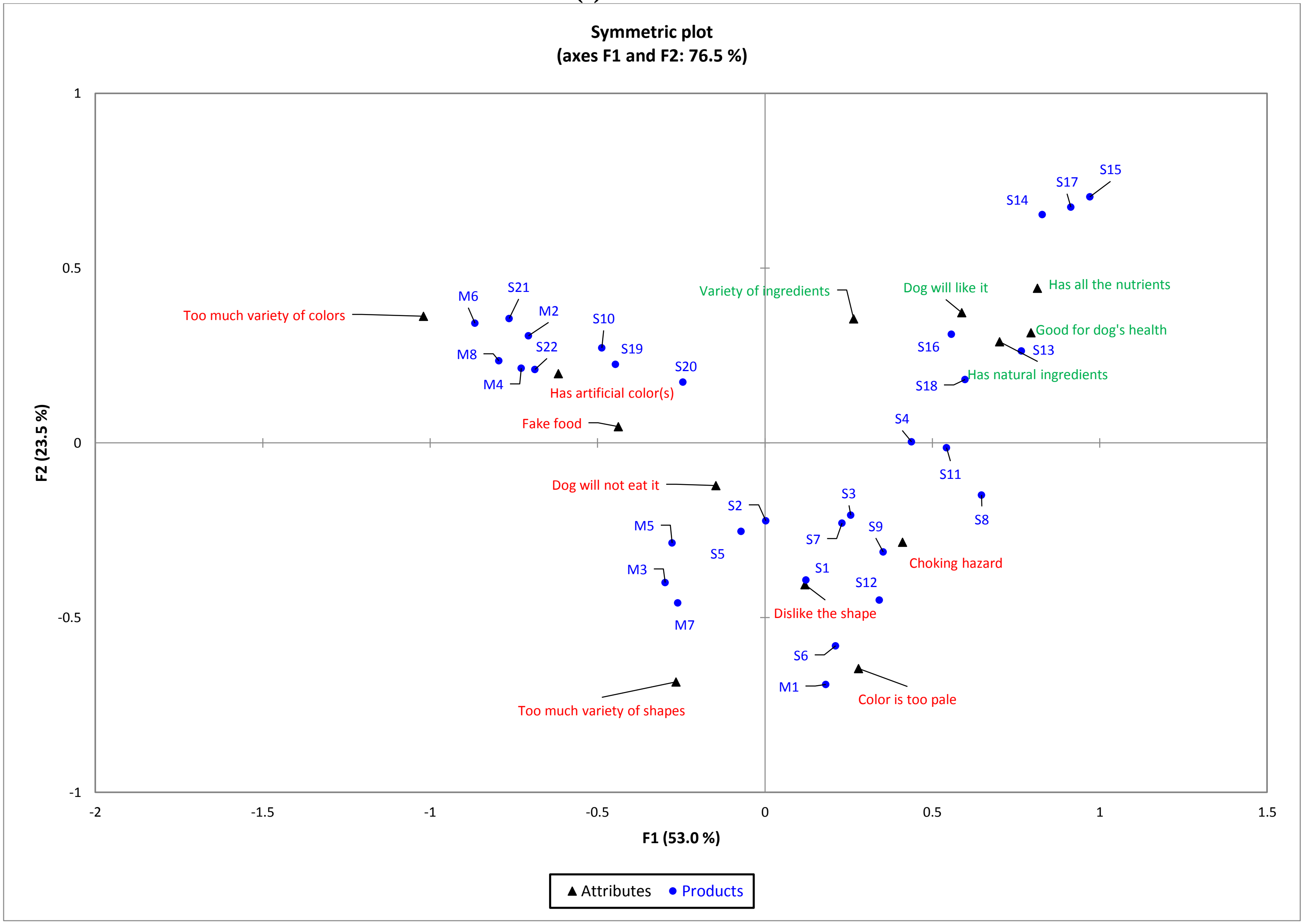


Figure 2.1 Correspondence Analysis maps between all thirty samples and all thirteen functional terms from the check-all-that-apply question for all three Overall Liking consumer clusters. Positive terms shown in green; negative terms shown in red.

(b) Cluster 2


Symmetric plot
(axes F1 and F2: 61.4 %)
F2 (18.0 %)
F1 (43.4 %)
1
0.5
0
-0.5
-1
-2
-1.5
-1
-0.5
0
0.5
1
1.5
S18
S5
Choking hazard
Dog will not eat it
S8
S9
S11
Fake food
S7
S20
S21
Too much variety of colors
S22
M4
M6
S19
M8
S17
S10
Dislike the shape
S12
S13
Good for dog's health
Has artificial color(s)
S15
M2
Has natural ingredients
Has all the nutrients
S16
S14
Variety of ingredients
Dog will like it
M1
M3
S6
S2
S3
S1
M7
M5
S4
Color is too pale
Too much variety of shapes
Attributes
Products

(c) Cluster 3



Symmetric plot
(axes F1 and F2: 76.5 %)
1
0.5
0
-0.5
-1
-2
-1.5
-1
-0.5
0
0.5
1
1.5
F2 (23.5 %)
F1 (53.0 %)
S15
S17
S14
Has all the nutrients
Dog will like it
Variety of ingredients
Good for dog's health
S16
S13
Has natural ingredients
S18
S4
S11
S8
Too much variety of colors
M6
S21
M2
S10
S19
S20
M8
S22
M4
Has artificial color(s)
Fake food
Dog will not eat it
S2
S3
S7
S9
Choking hazard
M5
S5
M3
S1
S12
Dislike the shape
M7
S6
M1
Color is too pale
Too much variety of shapes
Attributes
Products

Discussion

The results of this research show that the acceptability of the appearance of dry dog food by consumers is affected by the number of kibbles, color(s), shape(s), and size(s) present in the product. These results complement the results by Di Donfrancesco et al. [15] who found that the color of the kibbles and the size of them affect the liking of dry dog food by consumers. The participants overall showed preference for single-kibble samples of brown colors, medium kibble sizes, and traditional kibble shapes such as triangular prisms. It should be noted that samples liked best overall presented a low-dimensional contrast kibble shape which is in agreement with the results by Di Donfrancesco et al. [15] who found that samples containing kibbles with a high uniformity of shape were liked better than samples with kibbles with a low uniformity of shape. The consumers overall disliked kibbles of extra-small size and with the darkest brown color in the sample set which is in accordance with the results by Di Donfrancesco et al. [15] and Koppel et al. [16]. In addition, kibbles of extra-large size were disliked by the participants overall which was reported by Koppel et al. [16]. Also, kibbles of light brown color were disliked overall by the participants which was previously found by Di Donfrancesco et al. [15]. In addition, the participants overall did not rate among the highest multiple-kibble samples containing variety of colors, shapes and sizes. In contrast, previous studies found that multiple-kibble samples were well received by the consumers in the US [15] and in Thailand [16] which shows an interesting difference in the liking of the visual characteristics of dry dog food by consumers in different countries. Furthermore, Koppel et al. [16] found that consumers in Thailand liked best a single-kibble sample with a bone shape and received well dry dog food with non-traditional kibble shapes which differs from the findings of the present study. However, some similarities in the preferences of consumers towards the appearance of dry dog food are identified across countries which provide guidelines pet food manufacturers could use as a basis for product development targeting different markets on a global scale. Previous research has shown the similarities/differences in the consumer perception and preferences when testing consumer products across different countries [18-21]. This shows the importance of understanding the needs and preferences of the target consumers on each market to achieve the development of successful products. The results of this research and the differences found across countries in the liking of the appearance of dry dog food evidences the importance of conducting further research on specific markets to accomplish a successful marketing of pet foods.

As explained by Koppel [6], there are a number of factors that affect the purchase decision of dry dog food which include price, brand, packaging, advertising claims, nutritional value and ingredients, and specific characteristics of the product such as appearance (number of different kibbles, color(s), shape(s), size(s)) and aroma. Also, the dog's response to the product and the amount consumed by the companion animal plays a key role on influencing the purchase decision, along with the health benefits perceived by the owner and the digestive effect and characteristics of the stool. For this reason, repurchase of a dry dog food product depends on its ability to meet the pet owners' and the companion animal's needs along all the previously mentioned factors. Specific visual characteristics of dry dog food that are perceived as satisfactory by the target population can increase the overall consumers' degree of satisfaction with the product and improve the chance of repurchase. However, manufacturers should strive to meet the consumers' requirements for all the factors influencing the purchase decision of dry dog food.

The results of the Correspondence Analysis showed that consumers associate specific visual characteristics with positive beliefs such as "Has natural ingredients", "Good for dog's health", "Has variety of ingredients" and "Has all the nutrients that my dog(s) needs". Likewise, the consumers related specific visual characteristics with negative beliefs. Kumcu and Woolverton [22] found that premium human food purchasers are more likely to purchase premium pet food for their pets. This raises a question of whether dry dog food with visual characteristics that are well received by the consumers and that is associated with positive beliefs is seen as being more premium quality by the consumers. Furthermore, the same question can be made for pet food other than dry dog food as the pet food market continues to diversify following the trend of humanization of pet foods. This could be an interesting topic to address in further research projects. In addition, Kumcu and Woolverton [22] found that young consumers are more likely to purchase premium pet foods despite budget constraints. This tendency may be expected to persist and perhaps even to grow in the future as young consumers age. As the pet food market continues to grow following the humanization trend, consumers are demanding more specialized premium pet foods.

Samples containing red kibbles were perceived as "Looks like fake food" and "Has artificial color(s). Genschow et al. [23] concluded in a previous study with human foods that red color functions as a subtle stop signal that works even outside of a person's focused awareness and may thereby reduce incidental intake of foods and drinks. In another study, Bruno et al. [24] found that red plates reduced the consumption of food and the use of hand cream, while the liking towards the samples presented similar scores from all the plates. In addition, Bruno et al. also proved that their results were neither dependent on the Michelson (luminance) contrast nor on the color contrast either, which led them to suggest that the effect of the red color on consumption might simply be due to avoidance associated with the color of the plate that was influencing the participants. This human behavior that has been reported previously regarding red color may not just be limited to human foods, but it could also extend to the perception of humans towards pet foods. This could be an interesting topic for further research on human perception of the visual characteristics of pet foods.

The present study took place in Warsaw, Poland, and polish citizens from the metropolitan area of Warsaw participated in the sessions. It should be pointed out that the results of this research represent a good estimation for urban consumers in Poland but do not necessarily represent the preferences for consumers in rural areas of Poland. However, the analysis performed using consumer clusters allows to show the results from different consumer groups and enables a better representation of the variation that can be found in the polish market. In addition, Poland represents the second largest pet food market in Eastern Europe [3] and the findings from this study may be of good use by manufacturers who market their products in Eastern Europe as a basis for product development.

Conclusions

The degree of liking of the appearance of dry dog food samples by dog owners is influenced by the number of different kibbles present, color(s), shape(s), and size(s) in the product. The results indicate that dry dog food manufacturers should take special consideration with the visual characteristics of the kibbles to satisfy the pet owners' expectations and to enhance the acceptability of their products. It is recommended for dry dog food manufacturers who market their products in Poland to prioritize the production of single-kibble samples of brown colors (from golden brown to medium brown), medium kibble sizes, and traditionally-looking kibble shapes such as triangular prisms. Likewise, it is recommended for dry dog food companies to avoid the production of kibbles with a high-dimensional-contrast shape such as discs and sticks, extra-small and extra-large sized kibbles, and the use of light brown colors.

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Chapter 3 - Exploring differences in the acceptability of dry dog food's visual characteristics by dog owners in the US

Abstract

Sensory analysis of pet foods plays an important role in the pet food industry to ensure the products meet both the pets' and pet owners' expectations. Few studies have been published on studying the pet owners' perception and beliefs towards pet foods. The objective of this research is to study the effect of the visual characteristics of dry dog foods on the perception and acceptance by consumer segments of dog owners in the US. Dog owners (n = 120) evaluated the appearance of thirty dry dog food samples with varying visual characteristics. The consumers rated their level of acceptability of the samples using 9-point hedonic scales and four acceptance attributes, and then associated each one of them with a list of positive and negative beliefs on a check-all-that-apply question. Cluster Analysis, ANOVA, and Correspondence Analysis were used to analyze the consumer responses. The results show that the acceptability of the appearance of dry dog foods is influenced by the number of different kibbles present, color(s), shape(s), and size(s) present in the product. Consumers overall showed preference for single-kibble samples of medium brown colors, medium kibble sizes, low-dimensional contrast kibbles and traditional kibble shapes. Participants overall disliked samples of extra-small and extra-large kibble sizes, kibble shapes with a high-dimensional-contrast, single-kibble samples of green colors, and multiple-kibble samples containing kibbles with low-color contrast and high-dimensional contrast kibble shapes. Dry dog food manufacturers should take special consideration with the visual properties of their products to enhance the acceptability of the appearance by dog owners.

Introduction

The global pet food market has continued to experience a slow-but-steady growth over the last few years. In 2017, the global pet food market reached about US$75 billion (1). USA is the world's largest pet food market with US$24 billion pet food retail sales in 2015 (2) and it is expected to reach US$27 billion in 2018 (3) and US$30 billion by 2022 (4). Regarding the pet food type, dry pet food makes 68% of the US pet food market sales, while wet pet food comes second with 20% and treats represent the remaining 11%. With regard to dog food and cat food sales combined, dog food represents 78% of the split in the US market (2) and the total dog and cat food sales in the US accounted for nearly US$30 billion in 2017 (1). In terms of dry pet food production, USA is the largest manufacturer in the world with 8.451 million metric tons produced in 2015. The pet food industry represents an important sector in the feed processing sector in the US. According to a study conducted by George Mason University, the pet industry, pet food industry included, contributed to US$221 billion to US economy while supporting over 1.3 million jobs in the US in 2015 (5).

In the development of pet food products, similarly to human food products, both the nutritional and the sensory aspects of the products must be considered to ensure their success in the market. From a sensory point of view, the use of sensory evaluation techniques is crucial to study both the pet and the pet owners' behaviors and to provide manufacturers and researchers feedback on the way the products are perceived by their targets. In the last few decades, a growing number of research publications regarding the sensory characteristics of pet food products have been published in the scientific community. Koppel described that the use of either humans, animals or instruments constitute the different alternatives available to perform sensory evaluation of pet food products (6). Humans can be utilized for the evaluation of pet foods either as trained panelists to describe the products' characteristics, or as consumers/pet owners to provide feedback on their affective perception of the products. The use of descriptive sensory analysis methods to study the characteristics of pet food products comprises most of the published work on sensory analysis of pet foods using humans to date. Di Donfrancesco et al. (7) used a trained human sensory panel to develop a lexicon to describe the appearance, aroma, flavor and texture characteristics of dry dog food products. Koppel et al. (8) studied the effect of fiber inclusion on the sensory characteristics and palatability of dry dog foods. For other types of pet foods, Pickering used a human sensory panel to perform studies aiming to describe the flavor and texture characteristics of dry and wet cat foods (9,10). A fewer number of studies have been published on studying the pet owners' response to pet food products. Tengpongsathon and Phaosathienpan (11) examined the importance of brand, price, type of food and nutrition on the pet food preferences by consumers in Thailand. Several studies have investigated attitudes pet owners have towards pet foods. Boya et al. (12) explored how the choice of dog food varies across dog owners' segments and examined the similarity between the dog owner's criteria at the time of purchasing food for themselves vs. when purchasing dog food. Tesfom and Birch (13) examined similarities in the way dog owners buy food for their dogs vs. food for themselves. Michel et al. (14) studied feeding practices and attitudes dog and cat owners present towards pet foods and diets they use for feeding their companion animals.

Pet owners are responsible for making the purchase decisions when it comes to selecting the pet food product they will feed to their pet. Despite the food is meant to be consumed by the companion animal, it is common in the pet food industry for manufacturers to strive for developing foods that meet the owners' requirements as much as they do with the pet requirements. From a sensory perspective, the product's success depends on: (i) the companion animal accepting and consuming the product; and (ii) the pet owner's approval and satisfaction since the owner makes the purchase decision. The interaction dog owners have with dog food usually happens through the senses of sight and smell. Previous work have been conducted on studying the overall acceptability, aroma acceptability and appearance acceptability of dry dog foods by consumers in the United States by Di Donfrancesco et al. (15). The results showed that the consumers' liking of dry dog foods was more driven by the appearance than by the aroma of the products. The results by Di Donfrancesco et al. (15) open an opportunity for further studying what some the factors driving the liking of the appearance of dry fog foods by consumers are and what kind of visual characteristics are preferred by them. Koppel et al. (16) explored this topic previously and found that consumers in Thailand prefer bone-shaped kibbles with a yellowish color. A question arises of whether consumers in different countries have similar/different preferences towards the appearance of dog food. In the dry dog food market, a diversity of kibble shapes, sizes, colors, and kibble mixtures can be found while pet food companies strive to catch the customers' attention and to stand out over competitors by developing products with innovative visual characteristics.

In order to study the perception and acceptability by dog owners in the US towards dry dog food's visual characteristics, the objectives of this research are: (1) to understand the impact of the appearance properties of dry dog food on human consumers' acceptance and perception; (2) to identify potential differences in the preferred visual characteristics of dry dog food by consumer segments in the US based on the degree of acceptability towards the samples; (3) to explore the effect of varying visual attributes on the overall acceptability by the consumers; and (4) to study the association between the appearance properties of dry dog food and the beliefs consumers associate with them.

Materials and Methods

Samples

A total of thirty dry dog food samples of kibbles from commercially available dry dog foods in the US market were used. The samples were prepared by selecting/extracting specific kibbles from a wide list of either single-kibble or multiple-kibble commercial products. Selected kibbles were used by itself to make single-kibble samples or a combination of different kibbles was used to create multiple-kibble samples. The final set of samples was intended to represent a wide variety of visual characteristics in terms of number of kibbles, shape(s), size(s), and color(s) present in the samples. A summary of the samples' visual characteristics is shown in Table 3.1. Samples were classified by sample type (single-kibble or multiple-kibble), number of kibbles present, color(s) description, relative size(s) score (1-7), and shape(s) of the kibble(s) present. A relative size scoring method was used to classify the size of the kibbles. This method is illustrated in Table 3.2 and assigns a relative size score (ranging from 1-7) to each kibble based on the largest dimension of the kibble (1 = "extra-small" to 7 = "extra-large"). Kibbles with similar colors were grouped together into general color categories to be used at the time of analyzing the data and describing the results. The shape of the samples was described by approximating it to common 3D shapes or common objects and additional description was made as necessary. The commercial products were purchased in local pet stores/grocery stores in the Manhattan, Kansas, area prior to the consumer sessions. After selection and preparation of the samples, they were stored under frozen conditions until the day of testing.

Table 3.1 Description of the thirty samples used and their visual characteristics.

Sample	Sample type	Number of kibbles present	Color(s)	Relative size(s) score (1-7)	Shape(s)
S1	Single-kibble	1	Bright gold	5	Bones
S2	Single-kibble	1	Bright gold	6	Clovers
S3	Single-kibble	1	Golden brown	6	Cylindrical 'X'
S4	Single-kibble	1	Golden brown	4	Rounded cuboids
S5	Single-kibble	1	Amber brown	7	Sticks
S6	Single-kibble	1	Light brown	5	Discs
S7	Single-kibble	1	Shades of brown (from bright gold to medium brown)	7	Cylinders
S8	Single-kibble	1	Golden brown	2	Cuboids
S9	Single-kibble	1	Medium brown	4	Flat triangular prisms with center hole
S10	Single-kibble	1	Amber brown	4	Puffs (irregular)
S11	Single-kibble	1	Medium brown	3	Flat 'X'
S12	Single-kibble	1	Medium brown	3	Flat cuboids with center hole
S13	Single-kibble	1	Medium brown	3	Flat cylinders
S14	Single-kibble	1	Medium brown	5	Rounded triangular prisms
S15	Single-kibble	1	Medium brown	4	Flat triangular prisms
S16	Single-kibble	1	Medium brown	6	Rack of ribs
S17	Single-kibble	1	Dark brown	5	Semi-flat cuboids
S18	Single-kibble	1	Extra-dark brown	1	Spheres
S19	Single-kibble	1	Medium green	3	Puffs
S20	Single-kibble	1	Dark green	6	Flat elongated cuboids with rounded corners
S21	Single-kibble	1	Red	3	Rounded cuboids
S22	Single-kibble	1	Red meat and white fat, marbled	6	Steaks
M1	Multiple-kibble	2	Light brown, Medium brown	4, 5	Discs, flat triangular prisms with center hole
M2	Multiple-kibble	2	Golden brown, Red	3, 4	Rounded cuboids
M3	Multiple-kibble	3	Light brown, Medium green, Medium brown	3, 4, 5	Discs, flat triangular prisms with center hole, puffs
M4	Multiple-kibble	3	Golden brown, Dark brown, Red	2, 3, 4	Rounded cuboids, flat cylinders
M5	Multiple-kibble	4	Light brown, Medium green, Medium brown	3, 4, 5	Discs, flat triangular prisms with center hole, puffs, flat triangular prisms
M6	Multiple-kibble	4	Golden brown, Dark brown, Medium green, Red	2, 3, 4	Rounded cuboids, flat cylinders, puffs
M7	Multiple-kibble	5	Golden brown, Bright gold, Light brown, Medium brown	4, 5, 6	Clovers, discs, cylindrical 'X', flat triangular prisms, flat triangular prisms with center hole
M8	Multiple-kibble	5	Bright gold, Golden brown, Dark brown, Medium green, Red	2, 3, 4, 5	Rounded cuboids, flat cylinders, puffs, rounded triangular prisms

Table 3.2 Description of the relative size scoring method used to classify the size of the kibbles. All relative sizes were assigned based on the largest dimension for each of the kibbles, regardless of the shape.

Relative size (based on largest dimension)	Size score (1-7)
Extra-small	1
Small	2
Small-to-medium	3
Medium	4
Medium-to-large	5
Large	6
Extra-large	7

Participants

Participants in the study were screened to be: (1) 18 years of age or above; (2) dog owners; (3) users of dry dog food to feed their dog(s); (4) responsible for purchasing the dog food or to participate in making the purchase decision on which food is fed to the dog(s); and (5) not to have been diagnosed with color vision deficiencies previously. A total of 122 consumers participated in the study (72.1% females, 27.9% males). The demographics of the participants are shown in Table 3.3.

Table 3.3 Summary of the demographics of the participants in the consumer study (percentage of consumers).

	Percentage of consumers						
Gender	**Male**	**Female**					
	27.9%	72.1%					
Age (years)	**18-34**	**35 or above**					
	28.7%	71.3%					
Number of dogs	**1**	**2**	**3**	**4**	**5 or more**		
	54.9%	30.3%	11.5%	2.5%	0.8%		
Size of dog	**Very small size (0.5 - 5 kg)**	**Small size (5.1 - 11.0 kg)**	**Medium size (11.1 - 20.0 kg)**	**Large size (20.1 - 40.0 kg)**	**Very large size (more than 40 kg)**		
	15.6%	29.5%	24.6%	49.2%	10.7%		
Dog's breed type	**Purebred**	**Mixed breed**					
	63.9%	47.5%					
Money spent on each dog per month (USD)	**Less than $15**	**$15 - $50**	**More than $50**				
	11.5%	73.0%	15.6%				
Knowledgeable about pet food and pet's health	**Yes**	**No**					
	76.2%	23.8%					
Important factor(s) considered when choosing dog food	**Improve dog's health in general**	**Brand**	**Price**	**Appearance of the product**	**Dog(s) like(s) that food**	**Ingredients/Raw materials**	**Dog(s) need(s) that food because of a health condition**
	68.9%	23.0%	46.7%	2.5%	70.5%	43.4%	16.4%
Purchasing location	**Online**	**Clinic/Veterinary hospitals**	**Small market in living area**	**Supermarkets /Convenience stores**	**Pet shops/Pet stores**	**Market fairs**	
	9.0%	13.9%	12.3%	52.5%	45.1%	0.0%	

Consumer study

Consumer testing was performed in compliance with the Kansas State University (KSU) Institutional Review Board #7710. A Central Location Test (CLT) was conducted at the Center for Sensory Analysis and Consumer Behavior (CSACB), Kansas State University. Participants from the Manhattan, KS area were recruited using the participants database from the CSACB and through ads in local newspapers. The test sessions were conducted using a classroom setting and lasted for 45 min. The consumers received a monetary compensation for their participation. The number of participants on each session ranged from 2-12. The samples were presented to the participants in white 8-oz cups Styrofoam® containers covered with lids and labeled with three-digit codes. The samples were evaluated monadically by the consumers and a randomized latin square design (17) was used for the order of presentation. The participants were instructed to not touch or smell the samples and to evaluate them based on the appearance only.

Questionnaires

Each consumer was presented with one demographic questionnaire and 30 sets of a dog food questionnaire, one for each of the samples. The participants completed the demographic questionnaire prior to sample evaluation. Afterwards, the consumers were asked to visually inspect each of the samples presented (monadically) and to answer one set of the dog food questionnaires for each of the products. In the dog food questionnaire, the participants were asked to rate the overall liking, size liking, shape liking and color liking for each of the samples using a 9-point hedonic scale (ranging from 1 = “dislike extremely” to 9 = “like extremely”, 5 = “neither like nor dislike”). After finishing with the hedonic questions, the consumers were presented with a list of thirteen positive and negative beliefs associated with pet foods in a check-all-that-apply (CATA) question and they were asked to select all those they associated to each of the samples. Five of these beliefs were positive ones whereas the remaining eight were negative and the list of terms used is shown below:

- Positive terms: “Has natural ingredients/raw materials”, “Good for dog’s health”, “My dog will like it”, “Has variety of ingredients/raw materials”, and “Has all the nutrients that my dog(s) needs”.
- Negative terms: “Looks like fake food”, “Color is too pale”, “Consumption may cause choking hazard”, “My dog will not eat it”, “I don’t like the shape of this sample”, “Has artificial color(s)”, “Has too much variety of shapes”, and “Has too much variety of colors”.

The terms were chosen based on expertise on the topic and previous work conducted.

Data Analysis

Cluster Analysis

Cluster analysis was performed using Agglomerative Hierarchical Clustering (AHC) method and Ward’s agglomeration method on the overall liking scores of all thirty samples to group consumers with similar liking patterns. Demographics were calculated for each of the resulting clusters and the preferences of consumers regarding the visual characteristics were analyzed for each resulting cluster. The data from two of the consumers was found to be incomplete and was removed during the analysis. Therefore, the data from a total of 120 participants was used for further analysis.

Analysis of Variance

All 120 consumers

Two-way Analysis of Variance (ANOVA) ($p \leq 0.05$) was used to model each of the four liking attributes as a function of sample and consumer. Fisher’s protected Least Significant

Difference (LSD) tests were performed to determine significant differences among samples for each hedonic attribute at the 95% confidence level with sample as factor for the pairwise comparisons. Insights regarding the preferences of the consumers towards the visual properties of the samples were obtained for each acceptance attribute.

Consumer clusters

Two-way Analysis of Variance (ANOVA) was used to model each of the four hedonic attributes - overall liking, size liking, shape liking and color liking (dependent variable) as a function of sample and consumer (explanatory variables). A 95% level of significance was used. To determine significant differences among samples for each acceptance attribute and for each cluster, pairwise comparison tests were performed using the Tukey's Honest Significant Difference (HSD) for the ANOVA models with sample as factor for the pairwise comparisons. The preferences of the participants regarding the visual characteristics were analyzed for each acceptance attribute on each cluster.

Correspondence Analysis

To analyze the results from the CATA question, a contingency table was built by summing all the times a term was checked by the consumers for each of the thirty samples and for each cluster. Chi-square distance was used to test the association between samples and terms using a level of significance $\alpha = 0.05$. Correspondence Analysis was utilized to study the association between samples and terms and to show the results in two-dimensional maps. A Correspondence Analysis map was obtained for each cluster and the association between samples and terms was analyzed.

On this study, the Analysis of Variance for all four acceptance attributes across all 120 consumers was performed using SAS® statistical software version 9.3 (SAS Institute Inc., Cary, NC, USA). The rest of the statistical analyses were performed using XLSTAT version 2018.1 (Addinsoft, New York, NY, USA).

Results

Analysis of Variance for all 120 participants

Pairwise comparisons for the ANOVA models were performed using the Fisher's protected LSD test to determine significant differences among samples for each acceptance attribute. The results of the post-hoc tests are shown in Table 3.4. A significant effect of the sample (p-value < 0.05) on the average score for Overall Liking, Size Liking, Shape Liking, and Color Liking was found at the level of significance $\alpha = 0.05$.

Table 3.4 Summary of the Fisher's protected LSD post-hoc comparison tests for the ANOVA models for all 120 consumers. Overall Liking, Size Liking, Shape Liking and Color Liking as dependent variables. Analysis of Sample as factor for multiple comparisons. A level of significance α = 0.05 was used. For each of the dependent variables, samples not sharing the same letter differ significantly (on each column).

Sample	Dependent variable			
	Overall Liking	Size Liking	Shape Liking	Color Liking
S15	6.4 a	6.2 ab	6.5 ab	6.4 a
S14	6.1 ab	6.3 a	6.5 ab	6.1 a
S4	5.9 bc	6.2 ab	6.7 a	5.4 bc
S13	5.6 cd	4.8 gh	5.9 def	6.1 a
M4	5.6 cd	5.9 abcd	6.3 abcd	5.0 bcd
M8	5.6 cd	6.1 abc	6.4 ab	5.0 bcde
M2	5.5 cd	6.2 ab	6.7 a	4.9 defg
S16	5.5 d	5.5 de	5.4 hi	5.5 b
M6	5.4 d	6.1 abc	6.3 abcd	4.8 defg
S1	5.4 de	5.7 cd	5.5 fgh	4.7 defg
S17	5.3 de	6.2 ab	6.0 cde	4.8 defg
S3	5.0 ef	5.3 ef	4.7 jk	4.4 ghi
S10	4.7 fg	5.8 bcd	5.8 efg	3.8 jkl
S2	4.7 fgh	5.1 efg	4.3 klmn	4.2 hij
S22	4.6 fgh	5.8 cd	5.1 ij	3.9 jk
S8	4.5 gh	3.8 k	5.5 ghi	5.4 b
S11	4.5 gh	4.3 j	4.6 k	5.0 bcde
S21	4.4 gh	5.8 bcd	6.4 abc	3.3 m
S9	4.3 ghi	4.9 fgh	4.4 klm	4.6 efgh
M5	4.3 ghi	4.8 gh	4.4 kl	3.9 jk
S12	4.3 ghi	4.3 j	4.4 klm	4.9 cdef
M7	4.2 hij	4.8 ghi	4.1 lmn	4.5 fghi
M3	3.9 ijk	4.7 hij	4.1 lmn	3.3 m
S19	3.8 jkl	5.9 bcd	6.2 bcde	2.8 n
M1	3.7 klm	4.6 hij	3.6 op	4.1 ij
S6	3.5 lmn	4.4 ij	3.3 p	3.4 lm
S7	3.4 mno	2.8 m	4.0 mno	4.1 hij
S20	3.3 mno	4.6 hij	3.9 no	2.5 n
S5	3.2 no	3.5 kl	2.7 q	3.9 jkl
S18	3.0 o	3.1 lm	4.0 lmno	3.6 klm
p-value	<0.0001	<0.0001	<0.0001	<0.0001
Significant	Yes	Yes	Yes	Yes
MIN.	3.0	2.8	2.7	2.5
MAX.	6.4	6.3	6.7	6.4
Range	3.4	3.5	4.0	3.9
Number of consumers	120			
Percentage of consumers	100%			

The following insights are obtained from the analysis for all 120 participants.

Overall Liking

A high degree of discrimination was found among the sample set by the consumers. The mean scores presented a range of 3.4 in the hedonic scale (minimum mean score = 3.0; maximum mean score = 6.4). Samples rated highest for Overall Liking include single-kibble samples with colors in the shades of brown color category (golden brown, medium brown), medium kibble sizes, low-dimensional contrast kibbles and traditional kibble shapes such as triangular prisms (S14, mean score = 6.1; S15, mean score = 6.4) and cuboids (S4, mean score = 5.9). The results of the Fisher's protected LSD test show that the average score of sample S15 is significantly higher than the score of sample S4, but not significantly different to the score of sample S14 at the 95% confidence level.

Consumers rated lowest for Overall Liking: (1) single-kibble samples with colors in the shades of brown color category (extra-dark brown, shades of brown - from bright gold to medium brown), low-dimensional contrast kibble shapes and a kibble size in the two extremes of the size scale such as the extra-small spheres (S18, mean score = 3.0) and the extra-large cylinders (S7, mean score = 3.4); (2) single-kibble samples with colors in the shades of brown color category (amber brown, light brown), kibble sizes ranging from medium-to-large to extra-large, and a high-dimensional contrast kibble shape such as the sticks (S5, mean score = 3.2) and the discs (S6, mean score = 3.5); and (3) a single-kibble sample of dark green color, a kibble size in one of the ends of the size scale (large), and a high-dimensional contrast kibble shape - the flat cuboids (S20, mean score = 3.3). The results of the post-hoc test show that the average score of sample S18 is significantly lower than the score of sample S6 but not significantly different to the other samples at the 95% confidence level.

Size Liking

For Size Liking, a high degree of discrimination was found from the consumers. The average scores presented a range of 3.5 in the hedonic scale (minimum mean score = 2.8; maximum mean score = 6.3). Samples rated highest include: (1) single-kibble samples of medium size (S4, mean score = 6.2; S15, mean score = 6.2); (2) single-kibble samples of medium-to-large size (S14, mean score = 6.3; S17, mean score = 6.2); and (3) multiple-kibble samples containing kibbles with sizes ranging from small to medium-to-large (M2, mean score = 6.2; M4, mean score = 5.9; M6, mean score = 6.1; M8, mean score = 6.1). All these scores were found not to be significantly different to each other at the 95% confidence level according to the Fisher's protected LSD test.

The consumers rated lowest for Size Liking single-kibble samples of: (1) extra-small size (S18, mean score = 3.1); (2) small size (S8, mean score = 3.8); and (3) extra-large size (S5, mean score = 3.5; S7, mean score = 2.8). The results of the post-hoc test show that the average score of sample S7 is significantly lower than the score of samples S5 and S8, but not significantly different to the score of sample S18 at the 95% confidence level.

Shape Liking

A high degree of discrimination was found among the sample set. The mean scores presented a range of 4.0 in the hedonic scale (minimum mean score = 2.7; maximum mean score = 6.7). Samples rated highest in terms of Shape Liking include: (1) single-kibble samples of low-dimensional contrast kibbles and traditional shapes such as cuboids (S4, mean score = 6.7; S21, mean score = 6.4) and triangular prisms (S14, mean score = 6.5; S15, mean score = 6.5); and (2) multiple-kibble samples containing kibbles with low-dimensional contrast and traditional shapes such as cuboids (M2, mean score = 6.7), a mixture of cuboids and flat cylinders (M4, mean score

= 6.3), a mixture of cuboids, flat cylinders and puffs (M6, mean score = 6.3), and a mixture of cuboids, flat cylinders, puffs and triangular prisms (M8, mean score = 6.4). All these scores were found not to be significantly different to each other at the 95% confidence level according to the Fisher's protected LSD test.

Samples rated lowest for Shape Liking include: (1) single-kibble samples with a high-dimensional contrast kibble shape such as the sticks (S5, mean score = 2.7), the discs (S6, mean score = 3.3) and the flat cuboids (S20, mean score = 3.9); (2) single-kibble samples with a low-dimensional contrast shape and a kibble size in the two ends of the size scale such as the extra-small spheres (S18, mean score = 4.0) and the extra-large cylinders (S7, mean score = 4.0); and (3) a multiple-kibble sample containing kibbles with high-dimensional contrast (discs) and holes present in the center (M1, mean score = 3.6). Significant differences were found among these scores according to the post-hoc test, with the score of sample S5 being significantly lower than the scores of all the other samples at the 95% confidence level.

Color Liking

For Color Liking, a high degree of discrimination was found among the set of samples. The average scores presented a range of 3.9 in the hedonic scale (minimum mean score = 2.5; maximum mean score = 6.4). Samples rated highest by consumers include single-kibble samples of medium brown color (S13, mean score = 6.1; S14, mean score = 6.1; S15, mean score = 6.4). According to the Fisher's protected LSD test, all these scores were found not to be significantly different to each other at the 95% confidence level.

Samples rated lowest for Color Liking by consumers include: (1) the two single-kibble samples of green color (S19, mean score = 2.8; S20, mean score = 2.5); (2) a single-kibble sample of red color (S21, mean score = 3.3); (3) single-kibble samples with colors in one of the extremes of the shades of brown color category such as light brown (S6, mean score = 3.4) and extra-dark brown (S18, mean score = 3.6); and (4) a multiple-kibble sample containing kibbles with two of the previous characteristics - light brown and green colors (M3, mean score = 3.3). Significant differences were found among these scores according to the post-hoc test, with the score of sample S20 being not significantly different than the score of sample S19 only.

Analysis by consumer clusters

AHC analysis

Three consumer clusters were obtained from the AHC and Ward agglomeration methods. The distribution of the participants for each cluster is shown in Table 3.8. Cluster 1 represented the highest percentage of assessors (n = 62, 51.7%), nearly half of the participants in the study. Clusters 2 and 3 presented a similar distribution of consumers (n = 30, 25.0%; and n = 28, 23.3% respectively).

Demographics

Table 3.5 shows the demographics from all three consumer clusters in percentage of the total number of consumers for each cluster. Cluster 1 presented the highest proportion of females from all three clusters (77.4% females, 22.6% males) and the highest percentage of young participants (37.1% of 18-34, 62.9% of 35 or above). Cluster 2 was composed by mostly females (73.3% females, 26.7% males) and showed the lowest proportion of young consumers (16.7% of 18-34, 83.3% of 35 or above). Cluster 3 had the highest proportion of males (60.7% females, 39.3% males) and was composed by mostly older participants (25.0% of 18-34, 75.0% of 35 or above).

Table 3.5 Summary of demographics from the overall liking clusters (percentage of consumers).

	Cluster number	Male	Female
Gender	Cluster 1	22.6%	77.4%
	Cluster 2	26.7%	73.3%
	Cluster 3	39.3%	60.7%
Age (years)	**Cluster number**	**18-34**	**35 or above**
	Cluster 1	37.1%	62.9%
	Cluster 2	16.7%	83.3%
	Cluster 3	25.0%	75.0%

Analysis of Variance

Two-way Analysis of Variance (ANOVA) was performed using sample and consumer as main factors to determine significant differences in the liking scores among the samples for all four liking questions and for each cluster. The summary of the results is shown in Table 3.6. There is evidence of a significant effect by the two explanatory variables (sample and consumer) on the Overall Liking, Size Liking, Shape Liking, and Color Liking mean scores for all three clusters at the 95% confidence level (p-value < 0.0001 in all cases). The results of the Type III sum of squares analysis for the ANOVA models in all three clusters using sample as the factor under evaluation are presented in Table 3.7. The results indicate all p-values < 0.05 which show a significant effect of the sample on the average score for Overall Liking, Size Liking, Shape Liking, and Color Liking in all three clusters.

Table 3.6 Summary of the two-way ANOVA tests for all 3 clusters. Overall Liking, Size Liking, Shape Liking and Color Liking as dependent variables. Sample and Consumer as explanatory variables. A level of significance α = 0.05 was used.

Parameter	Cluster	Dependent variable			
		Overall Liking	Size Liking	Shape Liking	Color Liking
R^2	Cluster 1	0.382	0.429	0.457	0.321
	Cluster 2	0.300	0.290	0.344	0.330
	Cluster 3	0.328	0.345	0.442	0.420
F	Cluster 1	12.137	14.751	16.524	9.283
	Cluster 2	6.222	5.919	7.590	7.149
	Cluster 3	7.034	7.613	11.438	10.466
p-value	Cluster 1	< 0.0001	< 0.0001	< 0.0001	< 0.0001
	Cluster 2	< 0.0001	< 0.0001	< 0.0001	< 0.0001
	Cluster 3	< 0.0001	< 0.0001	< 0.0001	< 0.0001

Table 3.7 Type III Sum of Squares for the two-way ANOVA tests for all 3 clusters. Analysis of the impact of Sample on the model. Overall Liking, Size Liking, Shape Liking and Color Liking as dependent variables. Sample and Consumer as explanatory variables. A level of significance α = 0.05 was used.

Factor: SAMPLE						
Dependent variable	Cluster 1		Cluster 2		Cluster 3	
	F	p-value	F	p-value	F	p-value
Overall Liking	29.964	< 0.0001	8.164	< 0.0001	11.022	< 0.0001
Size Liking	29.578	< 0.0001	7.426	< 0.0001	11.590	< 0.0001
Shape Liking	37.910	< 0.0001	10.495	< 0.0001	17.247	< 0.0001
Color Liking	20.162	< 0.0001	8.121	< 0.0001	16.131	< 0.0001

Tukey's HSD tests were performed to determine significant differences among samples for each hedonic attribute on each consumer cluster. The results of the pairwise comparison tests are shown in Table 3.8. Based on the average scores for each acceptance attribute, the following results are obtained for each cluster.

Cluster 1

Overall Liking:

A high degree of discrimination was found among the sample set by consumers in cluster 1. The mean scores presented a range of 3.5 in the hedonic scale (minimum mean score = 2.6; maximum mean score = 6.1). Samples rated highest for Overall Liking include: (1) single-kibble samples with colors in the shades of brown color category (golden brown, medium brown), medium kibble sizes, low-dimensional contrast kibbles and traditional kibble shapes such as triangular prisms (S14, mean score = 6.0; S15, mean score = 5.9) and cuboids (S4, mean score = 5.9); (2) a single-kibble sample with color in the shades of brown color category (bright gold), medium-to-large kibble size, low-dimensional contrast kibbles and an innovative shape - the bones (S1, mean score = 5.5); and (3) multiple-kibble samples presenting high-color contrast and a combination of kibbles with shades of brown and red colors, kibble sizes ranging from small to medium-to-large, low-dimensional contrast kibbles and traditional kibble shapes such as cuboids (M2, mean score = 5.8; M4, mean score = 5.9; M6, mean score = 5.9; M8, mean score = 6.1). According to the Tukey's HSD test, all these scores were found not to be significantly different to each other at the 95% confidence level.

Consumers in cluster 1 rated lowest for Overall Liking: (1) single-kibble samples with colors in the shades of brown color category (extra-dark brown, shades of brown - from bright gold to medium brown), low-dimensional contrast kibble shapes and a kibble size in the two ends of the size scale such as the extra-small spheres (S18, mean score = 2.6) and the extra-large cylinders (S7, mean score = 3.2); (2) single-kibble samples with colors in the shades of brown color category (amber brown, light brown), kibble sizes ranging from medium-to-large to extra-large, and a high-dimensional contrast kibble shape such as the sticks (S5, mean score = 2.9) and the discs (S6, mean score = 2.9); (3) a single-kibble sample of dark green color, a kibble size in one of the ends of the size scale (large), and a high-dimensional contrast kibble shape - the flat cuboids (S20, mean score = 3.1); and (4) multiple-kibble samples containing kibbles with some of the previous characteristics - light brown color and a high-dimensional contrast kibble shape such as the discs (M1, mean score = 3.5), and a combination of light brown and green colors and the high-dimensional contrast discs (M3, mean score = 3.5). According to the post-hoc test, all these scores were found not to be significantly different to each other at the 95% confidence level.

Size Liking:

For Size Liking, a high degree of discrimination was found from the consumers. The average scores presented a range of 3.6 in the hedonic scale (minimum mean score = 2.7; maximum mean score = 6.3). Samples rated highest include: (1) single-kibble samples of medium size (S4, mean score = 6.0; S10, mean score = 5.6; S15, mean score = 5.6); (2) single-kibble samples of medium-to-large size (S1, mean score = 5.9; S14, mean score = 6.3; S17, mean score = 6.0); (3) a single-kibble sample of large size (S22, mean score = 5.8); and (4) multiple-kibble samples containing kibbles with sizes ranging from small to medium-to-large (M2, mean score = 6.1; M4, mean score = 5.8; M6, mean score = 6.1; M8, mean score = 6.1). All these scores were found not to be significantly different to each other according to the Tukey's HSD test.

The consumers in cluster 1 rated lowest for Size Liking single-kibble samples of: (1) extra-small size (S18, mean score = 2.7); (2) small size (S8, mean score = 3.3); (3) medium-to-large size (S6, mean score = 3.6); and (4) extra-large size (S5, mean score = 3.1; S7, mean score = 2.8). All these scores were found not to be significantly different to each other according to the post-hoc test.

Shape Liking:

A high degree of discrimination was found among the sample set. The mean scores presented a range of 4.3 in the hedonic scale (minimum mean score = 2.4; maximum mean score = 6.7). Samples rated highest in terms of Shape Liking include: (1) single-kibble samples of low-dimensional contrast kibbles and traditional shapes such as cuboids (S4, mean score = 6.7; S21, mean score = 6.1) and triangular prisms (S14, mean score = 6.4; S15, mean score = 6.1); and (2) multiple-kibble samples containing kibbles with low-dimensional contrast and traditional shapes such as cuboids (M2, mean score = 6.5), a mixture of cuboids and flat cylinders (M4, mean score = 6.2), a mixture of cuboids, flat cylinders and puffs (M6, mean score = 6.5), and a mixture of cuboids, flat cylinders, puffs and triangular prisms (M8, mean score = 6.5). All these scores were found not to be significantly different to each other according to the Tukey's HSD test.

Samples rated lowest for Shape Liking in cluster 1 include: (1) single-kibble samples with a high-dimensional contrast kibble shape such as the sticks (S5, mean score = 2.4), the discs (S6, mean score = 2.7) and the flat cuboids (S20, mean score = 3.6); (2) single-kibble samples with a low-dimensional contrast and a kibble size in the two ends of the size scale such as the extra-small spheres (S18, mean score = 3.5) and the extra-large cylinders (S7, mean score = 3.9); (3) single-kibble samples with holes present in the center of the kibbles (S9, mean score = 3.9; S12, mean score = 4.0); and (4) multiple-kibble samples containing kibbles with high-dimensional contrast (discs) and holes present in the center (M1, mean score = 3.5; M3, mean score = 3.8). Significant differences were found among these scores according to the post-hoc test, with the score of sample S5 being not significantly different than the scores of samples S6 and M1 only.

Color Liking:

For Color Liking, a high degree of discrimination was found among the set of samples. The average scores presented a range of 3.6 in the hedonic scale (minimum mean score = 2.4; maximum mean score = 6.0). Samples rated highest by consumers in cluster 1 include: (1) single-kibble samples with colors in the shades of brown color category such as golden brown (S4, mean score = 5.6; S8, mean score = 5.2) and medium brown (S13, mean score = 5.5; S14, mean score = 6.0; S15, mean score = 5.9); and (2) multiple-kibble samples presenting high-color contrast and a combination of kibbles of golden brown and red colors (M2, mean score = 5.2), a combination of kibbles with shades of brown (golden brown, dark brown) and red colors (M4, mean score = 5.4), and a combination of kibbles with shades of brown (golden brown, dark brown), red and green colors (M6, mean score = 5.4; M8, mean score = 5.7). According to the Tukey's HSD test, all these scores were found not to be significantly different to each other.

Samples rated lowest for Color Liking by consumers in cluster 1 include: (1) single-kibble samples with colors in the shades of brown color category such as light brown (S6, mean score = 3.0) and extra-dark brown (S18, mean score = 3.1); (2) the two single-kibble samples of green colors (S19, mean score = 2.9; S20, mean score = 2.4); a single-kibble sample of red color (S21, mean score = 3.5); and (4) a multiple-kibble sample containing kibbles with two of the previous characteristics - light brown and green colors (M3, mean score = 3.2). According to the post-hoc test, all these scores were found not to be significantly different to each other.

Cluster 2

Overall Liking:

A moderate degree of discrimination was found by consumers in cluster 2 among the sample set. The mean scores presented a range of 3.1 in the hedonic scale (minimum mean score = 3.9; maximum mean score = 7.0). Only 5 out of 30 samples presented a mean score lower than or equal to the neutral point (5.0 = "neither like nor dislike") which shows a high level of acceptability for Overall Liking by consumers in cluster 2 towards the set of samples. Samples rated highest for Overall Liking include: (1) single-kibble samples with colors in the shades of brown color category (golden brown, medium brown, amber brown), kibble sizes ranging from small to medium-to-large, low-dimensional contrast kibbles and traditional kibble shapes such as cuboids (S4, mean score = 6.9; S8, mean score = 6.4), triangular prisms (S14, mean score = 6.8; S15, mean score = 7.0), puffs (S10, mean score = 6.5), and flat cylinders (S13, mean score = 7.0); (2) a single-kibble sample with color in the shades of brown color category (medium brown), large kibble size, low-dimensional contrast kibbles and an innovative shape - the rack of ribs (S16, mean score = 6.5); and (3) multiple-kibble samples presenting high-color contrast and a combination of kibbles with shades of brown and red colors, kibble sizes ranging from small to medium-to-large, low-dimensional contrast kibbles and traditional kibble shapes such as cuboids (M2, mean score = 7.0; M4, mean score = 6.8; M8, mean score = 6.4). According to the Tukey's HSD test, all these scores were found not to be significantly different to each other at the 95% confidence level.

Samples rated lowest for Overall Liking by consumers in cluster 2 include: (1) single-kibble samples with colors in the shades of brown color category (extra-dark brown, shades of brown - from bright gold to medium brown), low-dimensional contrast kibble shapes and a kibble size in the two ends of the size scale such as the extra-small spheres (S18, mean score = 3.9) and the extra-large cylinders (S7, mean score = 4.4); (2) single-kibble samples with colors in the shades of brown color category (amber brown, light brown), kibble sizes ranging from medium-to-large to extra-large, and a high-dimensional contrast kibble shape such as the sticks (S5, mean score = 4.8) and the discs (S6, mean score = 4.8); and (3) a single-kibble sample of dark green color, a kibble size in one of the ends of the size scale (large), and a high-dimensional contrast kibble shape - the flat cuboids (S20, mean score = 4.8). According to the post-hoc test, all these scores were found not to be significantly different to each other at the 95% confidence level.

Size Liking:

For Size Liking, a moderate degree of discrimination was found. The average scores presented a range of 3.8 in the hedonic scale (minimum mean score = 3.4; maximum mean score = 7.2). Only 3 samples presented average scores lower than or equal to the neutral point (5.0 = “neither like nor dislike”) which shows a high degree of acceptability for Size Liking by consumers in cluster 2 towards the set of samples. Samples rated highest include: (1) single-kibble samples of small-to-medium size (S19, mean score = 6.6; S21, mean score = 6.9); (2) single-kibble samples of medium size (S4, mean score = 6.8; S10, mean score = 6.8; S15, mean score = 7.2); (3) a single-kibble sample of medium-to-large size (S14, mean score = 6.6); (4) a single-kibble sample of large size (S22, mean score = 6.6); and (5) multiple-kibble samples containing kibbles with sizes ranging from small to medium-to-large (M2, mean score = 7.0; M4, mean score = 6.9; M6, mean score = 6.6; M8, mean score = 6.8). All these scores were found not to be significantly different to each other according to the Tukey's HSD test.

Participants in cluster 2 rated lowest for Size Liking single-kibble samples of: (1) extra-small size (S18, mean score = 4.7); and (2) extra-large size (S7, mean score = 3.4; S5, mean score = 5.0). The results of the post-hoc test show that the average score of sample S7 is significantly lower than the score of sample S5, but not significantly different to the score of sample S18.

Shape Liking:

For Shape Liking, a high level of discrimination by the consumers was found among the sample set. The mean scores presented a range of 3.4 in the hedonic scale (minimum mean score = 4.0; maximum mean score = 7.4). Only 5 out of 30 samples presented average scores lower than or equal to the neutral point (5.0 = “neither like nor dislike”) which indicates a high level of acceptability for Shape Liking by participants in cluster 2. Samples rated highest include: (1) single-kibble samples with traditional shapes and low-dimensional contrast kibbles such as cuboids (S4, mean score = 7.1; S21, mean score = 7.2), triangular prisms (S15, mean score = 7.2) and flat cylinders (S13, mean score = 6.9); and (2) multiple-kibble samples containing kibbles with low-dimensional contrast and traditional shapes such as cuboids (M2, mean score = 7.4), a combination of cuboids and flat cylinders (M4, mean score = 7.0), and a combination of cuboids, flat cylinders, puffs and triangular prisms (M8, mean score = 6.9). All these scores were found not to be significantly different to each other according to the Tukey's HSD test.

Samples rated lowest by participants in cluster 2 for Shape Liking include: (1) single-kibble samples with a high-dimensional contrast kibble shape such as the sticks (S5, mean score = 4.0), the discs (S6, mean score = 4.5) and the flat cuboids (S20, mean score = 5.2); (2) single-kibble samples with a low-dimensional contrast kibble shape and a kibble size in the two ends of the size scale such as the extra-large cylinders (S7, mean score = 4.4), the large cylindrical 'X' (S3, mean score = 5.3) and the extra-small spheres (S18, mean score = 4.8); (3) a multiple-kibble sample containing kibbles with high-dimensional contrast (discs) and holes present in the center of the kibbles (M1, mean score = 4.8). All these scores were found not to be significantly different to each other according to the post-hoc test.

Color Liking:

For Color Liking, a high level of discrimination by the participants was found. The average scores presented a range of 3.5 in the hedonic scale (minimum mean score = 3.7; maximum mean score = 7.2). Samples rated highest by consumers in cluster 2 include: (1) single-kibble samples with colors in the shades of brown color category such as golden brown (S4, mean score = 6.2; S8, mean score = 6.5) and medium brown (S13, mean score = 7.0; S14, mean score = 6.7; S15, mean score = 7.2; S16, mean score = 6.7); and (2) multiple-kibble samples presenting high-color contrast and a combination of kibbles of golden brown and red colors (M2, mean score = 6.2), and a combination of kibbles with shades of brown (golden brown, dark brown) and red colors (M4, mean score = 6.2). According to the Tukey's HSD test, all these scores were found not to be significantly different to each other.

Participants in cluster 2 rated lowest for Color Liking: (1) single-kibble samples with colors in the shades of brown color category such as light brown (S6, mean score = 4.1) and extra-dark brown (S18, mean score = 3.8); (2) single-kibble samples of green colors (S19, mean score = 3.7; S20, mean score = 3.8); (3) a single-kibble sample of red color (S21, mean score = 4.4); and (4) multiple-kibble samples containing kibbles with two of the previous characteristics - light brown color (M1, mean score = 4.9) and a combination of light brown and green colors (M3, mean score = 4.7). According to the post-hoc test, all these scores were found not to be significantly different to each other.

Cluster 3

Overall Liking:

A high degree of discrimination was found by the participants in cluster 3 among the samples. The mean scores presented a range of 4.6 in the hedonic scale (minimum mean score = 2.1; maximum mean score = 6.7). Only 4 out of 30 samples presented a mean score greater than or equal to the neutral point (5.0 = "neither like nor dislike") which indicates a low level of acceptability for Overall Liking by the participants towards the set of samples. The consumers in cluster 3 rated highest single-kibble samples with colors in the shades of brown color category (medium brown, dark brown), medium kibble sizes (from small-to-medium to medium-to-large), low-dimensional contrast kibbles and traditional kibble shapes such as triangular prisms (S14, mean score = 5.7; S15, mean score = 6.7), cuboids (S17, mean score = 5.3), and flat cylinders (S13, mean score = 6.0). According to the Tukey's HSD test, all these scores were found not to be significantly different to each other at the 95% confidence level.

Consumers in cluster 3 rated lowest for Overall Liking: (1) a single-kibble sample with color in the shades of brown color category (amber brown), a kibble size in one of the ends of the size scale (extra-large), and a high-dimensional contrast kibble shape - the sticks (S5, mean score = 2.4); (2) single-kibble samples with colors in the shades of brown color category (extra-dark brown, shades of brown - from bright gold to medium brown), low-dimensional contrast kibble shapes and a kibble size in the two ends of the size scale such as the extra-small spheres (S18, mean score = 2.9) and the extra-large cylinders (S7, mean score = 2.6); (3) single-kibble samples of green colors (S19, mean score = 2.7; S20, mean score = 2.4); (4) single-kibble samples of red colors (S21, mean score = 2.7; S22, mean score = 2.8); (5) a single-kibble sample with color in the shades of brown color category (bright gold), a kibble size in one of the ends of the size scale (large), and an innovative kibble shape - the clovers (S2, mean score = 2.9); (6) a multiple-kibble sample containing kibbles with colors in the shades of brown color category (light brown, medium brown) and low-color contrast, medium kibble sizes, high-dimensional contrast kibble shapes (discs) and innovative kibble shapes with holes in the center (M1, mean score = 2.8); (7) a multiple-kibble sample containing kibbles with colors in the shades of brown color category (golden brown, bright gold, light brown, medium brown), low-color contrast, and innovative kibble shapes - clovers and cylindrical 'X' (M7, mean score = 2.1); and (8) multiple-kibble samples containing kibbles with a combination of green and shades of brown colors (M3, mean score = 3.0; M5, mean score = 2.9). According to the post-hoc test, all these scores were found not to be significantly different to each other at the 95% confidence level.

Size Liking:

For Size Liking, a high level of discrimination by the participants was found. The average scores presented a range of 4.4 in the hedonic scale (minimum mean score = 2.1; maximum mean score = 6.5). Samples rated highest include: (1) a single-kibble sample of small-to-medium size (S19, mean score = 5.8); (2) single-kibble samples of medium size (S4, mean score = 5.9; S15, mean score = 6.5); (3) single-kibble samples of medium-to-large size (S14, mean score = 6.0; S17, mean score = 6.5); and (4) multiple-kibble samples containing kibbles with sizes ranging from small to medium-to-large (M2, mean score = 5.7; M8, mean score = 5.6). All these scores were found not to be significantly different to each other according to the Tukey's HSD test.

The participants in cluster 3 rated lowest for Size Liking: (1) single-kibble samples of extra-small size (S18, mean score = 2.3); (2) single-kibble samples of small size (S8, mean score = 2.9); (3) single-kibble samples of small-to-medium size (S11, mean score = 3.7; S12, mean score = 3.8); (4) single-kibble samples of extra-large size (S5, mean score = 2.7; S7, mean score = 2.1); and (5) a multiple-kibble sample containing kibbles with sizes ranging from medium to large (M7, mean score = 3.2). All these scores were found not to be significantly different to each other according to the post-hoc test.

Shape Liking:

A high degree of discrimination was found among the sample set. The mean scores presented a range of 4.6 in the hedonic scale (minimum mean score = 1.9; maximum mean score = 6.5). Samples rated highest for Shape Liking include: (1) single-kibble samples of low-dimensional contrast kibbles and traditional shapes such as triangular prisms (S15, mean score = 6.5; S14, mean score = 6.1), cuboids (S4, mean score = 6.2; S17, mean score = 6.1; S21, mean score = 6.0), flat cylinders (S13, mean score = 6.4), and puffs (S19, mean score = 6.1); and (2) multiple-kibble samples containing kibbles with low-dimensional contrast and traditional shapes such as cuboids (M2, mean score = 6.1) and a mixture of cuboids, flat cylinders, puffs and triangular prisms (M8, mean score = 5.9). All these scores were found not to be significantly different to each other according to the Tukey's HSD test.

Samples rated lowest for Shape Liking include: (1) single-kibble samples with a high-dimensional contrast kibble shape such as the sticks (S5, mean score = 1.9), the discs (S6, mean score = 3.3) and the flat cuboids (S20, mean score = 3.1); (2) single-kibble samples with an innovative shape such as clovers (S2, mean score = 2.7), flat 'X' (S11, mean score = 3.3) and steaks (S22, mean score = 3.4); (3) a single-kibble sample with a low-dimensional contrast (cylinders) and an extra-large kibble size (S7, mean score = 3.6); (4) multiple-kibble samples containing kibbles with high-dimensional contrast (discs) and holes present in the center (M1, mean score = 2.7; M3, mean score = 3.4; M5, mean score = 3.1); and (5) a multiple-kibble sample containing innovative shapes (clovers, cylindrical 'X'), high-dimensional contrast kibbles (discs) and kibbles with holes present in the center (M7, mean score = 2.3). All these scores were found not to be significantly different to each other according to the post-hoc test.

Color Liking:

For Color Liking, a high degree of discrimination was found among the set of samples. The mean scores presented a range of 5.3 in the hedonic scale (minimum mean score = 1.6; maximum mean score = 6.9). Only 6 out of 30 samples presented average scores greater than or equal to the neutral point (5.0 = “neither like nor dislike”) which shows a low degree of acceptability for Color Liking by the consumers in cluster 3 towards the set of samples. Samples rated highest by the participants include single-kibble samples with colors in the shades of brown color category such as medium brown (S12, mean score = 5.3; S13, mean score = 6.6; S14, mean score = 5.8; S15, mean score = 6.9; S16, mean score = 5.1) and dark brown (S17, mean score = 5.0). The results of the Tukey's HSD test show that the average score of sample S15 is significantly higher than the score of sample S17 but not significantly different to the other samples.

The participants in cluster 3 rated lowest for Color Liking: (1) the two single-kibble samples of green colors (S19, mean score = 1.6; S20, mean score = 1.6); (2) the two single-kibble samples of red colors (S21, mean score = 1.8; S22, mean score = 2.2); (3) a single-kibble sample of amber brown color (S10, mean score = 2.5); and (4) multiple-kibble samples containing a combination of green and shades of brown colors (M3, mean score = 2.3; M5, mean score = 2.4). According to the post-hoc test, all these scores were found not to be significantly different to each other at the 95% confidence level.

Table 3.8 Summary of the Tukey's Honest Significant Difference post-hoc comparison tests for the ANOVA models in all 3 clusters. Overall Liking, Size Liking, Shape Liking and Color Liking as dependent variables. Analysis of Sample as factor for multiple comparisons. A level of significance α = 0.05 was used. For each of the dependent variables, samples not sharing the same letter differ significantly (on each column).

Sample	Dependent variable			
	Overall Liking	Size Liking	Shape Liking	Color Liking
S14	6.0 a	6.3 a	6.4 abc	6.0 a
M8	6.1 a	6.1 a	6.5 ab	5.7 abc
S4	5.9 ab	6.0 a	6.7 a	5.6 abcd
M6	5.9 ab	6.1 a	6.5 ab	5.4 abcdef
M2	5.8 abc	6.1 a	6.5 ab	5.2 abcdefg
M4	5.9 ab	5.8 a	6.2 abcd	5.4 abcdef
S15	5.9 ab	5.6 a	6.1 abcd	5.9 ab
S1	5.5 abcd	5.9 a	5.8 abcdef	4.7 bcdefghij
S17	5.0 bcdefg	6.0 a	5.6 bcdef	4.3 fghijkl
S16	5.3 abcde	5.4 abc	5.2 defgh	5.0 abcdefgh
S22	4.8 cdefgh	5.8 a	5.4 cdefg	4.1 ghijklm
S13	4.8 cdefgh	4.0 efg	5.2 defgh	5.5 abcde
S3	5.1 abcdef	5.5 abc	4.8 fghi	4.5 defghijk
S10	4.6 defghi	5.6 a	5.7 abcdef	3.7 jklmn
S21	4.5 efghij	5.5 ab	6.1 abcd	3.5 klmno
S2	4.9 bcdefgh	5.2 abcd	4.5 ghij	4.4 efghijk
M7	4.6 defghi	5.2 abcd	4.5 ghijk	4.7 cdefghij
S8	4.1 ghijkl	3.3 fghi	5.1 efgh	5.2 abcdefg
S11	4.2 fghijk	3.8 efgh	4.5 ghij	4.9 abcdefghi
S19	3.7 ijklmn	5.5 ab	6.0 abcde	2.9 no
M5	4.2 fghijk	4.5 bcde	4.3 hijk	3.9 ijklmn
S12	3.9 hijklm	3.9 efg	4.0 ijk	4.5 defghijk
S9	4.1 ghijkl	4.4 cde	3.9 ijk	4.1 ghijklm
M1	3.5 jklmno	4.3 def	3.5 klm	3.9 hijklmn
M3	3.5 jklmno	4.3 def	3.8 ijk	3.2 lmno
S7	3.2 klmno	2.8 hi	3.9 ijk	3.9 ijklmn
S20	3.1 lmno	4.2 def	3.6 jkl	2.4 o
S5	2.9 mno	3.1 ghi	2.4 m	3.9 ijklmn
S6	2.9 no	3.6 efghi	2.7 lm	3.0 no
S18	2.6 o	2.7 i	3.5 jkl	3.1 mno
MIN	2.6	2.7	2.4	2.4
MAX	6.1	6.3	6.7	6.0
Range	3.5	3.6	4.3	3.6
p-value	**< 0.0001**	**< 0.0001**	**< 0.0001**	**< 0.0001**
Significant	**Yes**	**Yes**	**Yes**	**Yes**
Number of consumers	62			
Percentage of consumers	51.7%			

(a) Cluster 1

Sample	Dependent variable			
	Overall Liking	**Size Liking**	**Shape Liking**	**Color Liking**
S15	7.0 ab	7.2 a	7.2 ab	7.2 a
M2	7.0 a	7.0 ab	7.4 a	6.2 abcde
S4	6.9 ab	6.8 ab	7.1 abc	6.2 abcde
M4	6.8 ab	6.9 ab	7.0 abc	6.2 abcde
S13	7.0 ab	6.4 abc	6.9 abcd	7.0 ab
S14	6.8 ab	6.6 ab	6.8 abcdef	6.7 abc
M8	6.4 abc	6.8 ab	6.9 abcd	5.7 abcdefg
S10	6.5 abc	6.8 ab	6.8 abcde	5.4 bcdefgh
S8	6.4 abc	5.8 abcd	6.8 abcde	6.5 abcd
S16	6.5 abc	6.1 abcd	6.4 abcdef	6.7 abc
M6	6.3 abcd	6.6 ab	6.6 abcdef	5.6 abcdefg
S21	5.9 abcd	6.9 ab	7.2 ab	4.4 fgh
S17	6.0 abcd	6.4 abc	6.7 abcdef	5.7 abcdefg
S1	6.2 abcd	6.3 abc	6.4 abcdef	5.4 bcdefgh
S22	6.1 abcd	6.6 ab	6.1 abcdefg	5.2 cdefgh
M5	6.0 abcd	6.5 abc	6.0 abcdefgh	5.4 bcdefgh
S11	5.9 abcd	5.8 abcd	5.9 abcdefgh	5.9 abcdef
S9	5.9 abcd	6.2 abcd	5.8 bcdefgh	5.3 cdefgh
S19	5.3 cdef	6.6 ab	6.7 abcdef	3.7 h
M7	5.5 bcde	5.5 bcd	5.3 defghi	5.6 abcdefg
M3	5.7 abcde	5.9 abcd	5.4 defghi	4.7 efgh
S12	5.6 abcde	5.4 bcd	5.6 cdefgh	5.4 bcdefgh
S2	5.9 abcde	5.7 abcd	5.4 defghi	4.8 defgh
S3	5.9 abcde	5.5 bcd	5.3 efghi	5.1 cdefgh
M1	5.3 cdef	5.8 abcd	4.8 ghi	4.9 defgh
S20	4.8 def	5.6 abcd	5.2 fghi	3.8 h
S6	4.8 def	5.5 bcd	4.5 hi	4.1 gh
S5	4.8 def	5.0 cd	4.0 i	4.8 defgh
S7	4.4 ef	3.4 e	4.4 hi	5.1 cdefgh
S18	3.9 f	4.7 de	4.8 ghi	3.8 h
MIN	3.9	3.4	4.0	3.7
MAX	7.0	7.2	7.4	7.2
Range	3.1	3.8	3.4	3.5
p-value	**< 0.0001**	**< 0.0001**	**< 0.0001**	**< 0.0001**
Significant	**Yes**	**Yes**	**Yes**	**Yes**
Number of consumers	30			
Percentage of consumers	25.0%			

(b) Cluster 2

Sample	Dependent variable			
	Overall Liking	**Size Liking**	**Shape Liking**	**Color Liking**
S15	6.7 a	6.5 a	6.5 a	6.9 a
S14	5.7 abc	6.0 ab	6.1 ab	5.8 abc
S17	5.3 abcd	6.5 a	6.1 ab	5.0 bcdef
S13	6.0 ab	5.0 abcdef	6.4 ab	6.6 ab
S4	4.8 bcde	5.9 ab	6.2 ab	4.1 cdefghi
S16	4.7 bcdef	5.2 abcde	4.6 bcdef	5.1 abcde
M4	4.0 cdefg	5.2 abcde	5.5 abcd	3.2 fghijkl
M8	3.6 defgh	5.6 abcd	5.9 abc	2.9 ghijkl
M2	3.6 defgh	5.7 abc	6.1 ab	2.8 ghijkl
S1	4.2 cdefg	4.9 abcdef	4.0 defgh	3.9 cdefghij
M6	3.5 defgh	5.4 abcde	5.5 abcd	2.8 ghijkl
S12	3.7 defgh	3.8 defghij	3.9 defgh	5.3 abcd
S3	3.8 defgh	4.8 abcdef	3.7 defgh	3.7 defghij
S9	3.3 efgh	4.6 bcdefg	3.9 defgh	4.9 bcdef
S8	3.6 defgh	2.9 ghij	4.9 abcde	4.8 bcdef
S10	3.1 efgh	5.2 abcde	5.0 abcde	2.5 hijkl
S19	2.7 gh	5.8 abc	6.1 ab	1.6 l
S11	3.6 defgh	3.7 efghij	3.3 efghi	4.3 cdefgh
S21	2.7 gh	5.4 abcde	6.0 abc	1.8 kl
S6	3.4 efgh	4.7 abcdef	3.3 efghi	3.7 defghij
S18	2.9 fgh	2.3 ij	4.2 cdefg	4.6 cdefg
S22	2.8 gh	4.9 abcdef	3.4 efghi	2.2 jkl
M3	3.0 fgh	4.3 bcdefgh	3.4 efghi	2.3 ijkl
M1	2.8 gh	4.0 cdefghi	2.7 ghi	3.6 defghijk
S2	2.9 fgh	4.3 bcdefgh	2.7 ghi	3.3 efghijkl
S7	2.6 gh	2.1 j	3.6 efghi	3.6 defghijk
M5	2.9 fgh	3.9 defghij	3.1 fghi	2.4 ijkl
S20	2.4 gh	4.4 bcdefgh	3.1 fghi	1.6 l
M7	2.1 h	3.2 fghij	2.3 hi	3.0 ghijkl
S5	2.4 gh	2.7 hij	1.9 i	2.9 ghijkl
MIN	2.1	2.1	1.9	1.6
MAX	6.7	6.5	6.5	6.9
Range	4.6	4.4	4.6	5.3
p-value	**< 0.0001**	**< 0.0001**	**< 0.0001**	**< 0.0001**
Significant	**Yes**	**Yes**	**Yes**	**Yes**
Number of consumers	28			
Percentage of consumers	23.3%			

(c) Cluster 3

Correspondence Analysis

The results from the tests of independence between samples and terms from the CATA question using the Chi-square distance are shown in Table 3.9. There is evidence of a difference on the distribution of the functional terms consumers link to the samples on each cluster (p-value < 0.0001).

Table 3.9 Chi-square distance tests of independence between samples and terms from the CATA question for all three clusters. A level of significance α = 0.05 was used.

Cluster No.	1	2	3
Chi-square (Observed value)	2315.889	1146.630	1551.297
Chi-square (Critical value)	392.501	392.501	392.501
DF	348	348	348
p-value	< 0.0001	< 0.0001	< 0.0001

Contingency tables were built to show the number of times each term from the CATA question was checked by the participants for each sample and for each of the consumer clusters. Figure 3.1 shows the Correspondence Analysis (CA) maps that were constructed from the results of the contingency tables. The following insights are obtained from each consumer cluster based on the distribution of samples and functional terms.

Cluster 1

As seen in Figure 3.1, 62.2% of the total variation is explained by the first two dimensions. Positive terms such as "Has all the nutrients that my dog(s) needs", "Good for dog's health", "My dog will like it" and "Has natural ingredients/raw materials" are found close to each other on the CA map and are associated with: (1) single-kibble samples with colors in the shades of brown color category (from golden brown to dark brown), medium sizes, and traditional shapes with low-dimensional contrast such as cuboids (S4, S17), triangular prisms (S14, S15) and puffs (S10); (2) a single-kibble sample of medium brown color, large size and an innovative shape - rack of ribs (S16); (3) a single-kibble sample of medium green color, small-to-medium size and a traditional shape with low-dimensional contrast - puffs (S19); and (4) a multiple-kibble sample containing low-dimensional contrast kibbles with traditional looking-shapes, medium-sized kibbles and a high-color contrast (M2). The positive term "Has variety of ingredients/raw materials" is associated with: (1) the two single-kibble samples of red color (S21, S22); and (2) multiple-kibble samples containing low-dimensional contrast kibbles with traditional shapes, small and medium kibble sizes, and a high-color contrast including red (M4, M6, M8) and green (M6, M8) kibbles.

Samples S21, S22, M4, M6 and M8 all contain red kibbles and are related with the term "Has artificial color(s)". Samples M3, M5 and M7 show the largest variety in terms of number of different shapes present and are the closest related with "Has too much variety of shapes". Likewise, samples M4, M6 and M8 show the largest variety in terms of number of different colors present and are the closest to "Has too much variety of colors". The term "I don’t like the shape of this sample" is associated with: (1) samples containing kibbles with a high-dimensional contrast shape such as discs (S6, M1) and sticks (S5); and (2) single-kibble samples with holes in the center (S9, S12, M1). Samples of extra-large (S5, S7) and extra-small (S18) kibble sizes are related with the term "Consumption may cause choking hazard". Two of the samples containing kibbles of light brown color (S6, M1) are associated with the term "Color is too pale". Two of the samples containing kibbles of green colors (S20, M3) are related with "Looks like fake food". The term "My dog will not eat it" is associated with: (1) single-kibble samples with the smallest kibble size among the sample set (S8, S12, S18); and (2) single-kibble samples with innovative shapes such as clovers (S2), cylindrical 'X' (S3), flat 'X' (S11), and samples with holes present in the center of the kibbles (S9, S12).

Cluster 2

Figure 3.1 shows that 56.1% of the total variation is explained by the first two dimensions. Positive terms such as "My dog will like it", "Has natural ingredients/raw materials", "Has all the nutrients that my dog(s) needs", and "Good for dog's health" are found close to each other on the CA map and are related with: (1) single-kibble samples with colors in the shades of brown color category (from golden brown to dark brown), medium sizes, and traditional shapes with low-dimensional contrast such as cuboids (S4, S17), triangular prisms (S14, S15) and puffs (S10); (2) a single-kibble sample of medium brown color, large size and an innovative shape - rack of ribs (S16); (3) a single-kibble sample of medium green color, small-to-medium size and a traditional shape with low-dimensional contrast - puffs (S19); (4) a single-kibble sample of red color, small-to-medium size and a traditional shape with low-dimensional contrast - cuboids (S21); and (5) a multiple-kibble sample containing low-dimensional contrast kibbles with traditional shapes, medium-sized kibbles and a high-color contrast (M2). The positive term "Has variety of ingredients/raw materials" is associated with: (1) the two single-kibble samples of red color (S21, S22); (2) a single-kibble sample of amber brown color, medium size and a traditional shape with low-dimensional contrast - puffs (S10); and (3) multiple-kibble samples containing small and medium kibble sizes and a high-color contrast including red (M2, M4, M6, M8) and green (M3, M5, M6, M8) kibbles.

Samples M6 and M8 are the closest to "Has too much variety of colors" and they both show the largest variety in terms of number of different colors present. Samples M5 and M7 show the largest variety in terms of number of different shapes present and are the closest to the term "Has too much variety of shapes". The term "Has artificial color(s)" is associated with samples containing kibbles of red (S22, M4, M6, M8) and green (M3, M5, M6, M8) colors. The light brown discs (S6) are related to the term "Color is too pale". The term "Looks like fake food" is associated with single-kibble samples with innovative shapes such as bones (S1), clovers (S2), cylindrical 'X' (S3), flat 'X' (S11), and kibbles with holes in the center (S9, S12). The term "My dog will not eat it" is associated with: (1) the single-kibble sample with the smallest kibble size among the sample set (S18); and (2) single-kibble samples with innovative shapes such as bones (S1), clovers (S2), cylindrical 'X' (S3), and samples with holes present in the center of the kibbles (S9, S12). Samples of extra-large (S5, S7), large (S2, S3) and extra-small (S18) kibble sizes are related with "Consumption may cause choking hazard". The term "I don't like the shape of this sample" is associated with: (1) samples containing kibbles with a high-dimensional contrast shape such as discs (S6, M1) and sticks (S5); and (2) single-kibble samples with innovative shapes such as clovers (S2) and cylindrical 'X' (S3).

Cluster 3

As seen in Figure 3.1, 62.2% of the total variation is explained by the first two dimensions. All five positive terms are found close to each other on the CA map and are associated with: (1) single-kibble samples with colors in the shades of brown color category (from golden brown to dark brown), medium sizes, and traditional shapes with low-dimensional contrast such as triangular prisms (S14, S15), cuboids (S4, S17), and flat cylinders (S13); and (2) a single-kibble sample of medium brown color, large size and an innovative shape - rack of ribs (S16).

The term "Has artificial color(s)" is associated with samples containing kibbles of green (M3, M5, M6, M8) and red (S21, S22, M2, M4, M6, M8) colors. Samples M5 and M7 are the closest to the term "Has too much variety of shapes" and they both show the largest variety in terms of number of different shapes present. Samples with the largest variety in number of different colors present (M4, M6, M8) are the closest to the term "Has too much variety of colors". The term "Looks like fake food" is associated with single-kibble samples of red (S21, S22) and green (S19, S20) colors. Single-kibble samples of bright gold (S1, S2, S7) and golden brown (S3) colors are related with the term "Color is too pale". Samples of extra-large (S5, S7) and large (S2, S3) sizes are linked with "Consumption may cause choking hazard". The term "I don’t like the shape of this sample" is associated with: (1) a sample containing kibbles with a high-dimensional contrast shape - the sticks (S5); and (2) single-kibble samples with innovative shapes such as bones (S1), clovers (S2), cylindrical 'X' (S3) and flat 'X' (S11). The term "My dog will not eat it" is linked with: (1) single-kibble samples with innovative shapes such as bones (S1), cylindrical 'X' (S3), and flat 'X' (S11); (2) the single-kibble sample with the smallest kibble size among the sample set (S18); and (3) a single-kibble sample of dark green color and a high-dimensional contrast kibble shape - the flat elongated cuboids (S20).

(a) Cluster 1

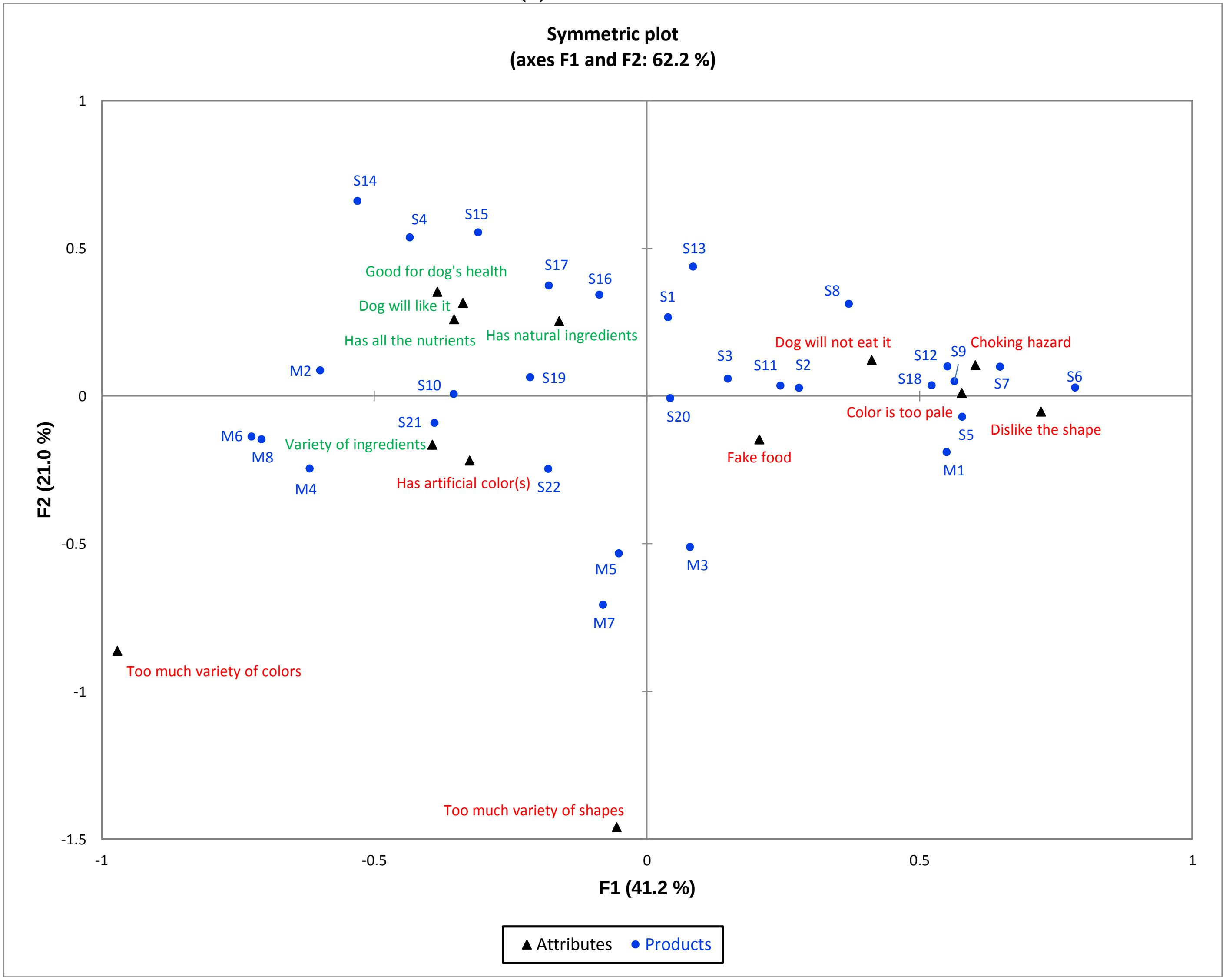
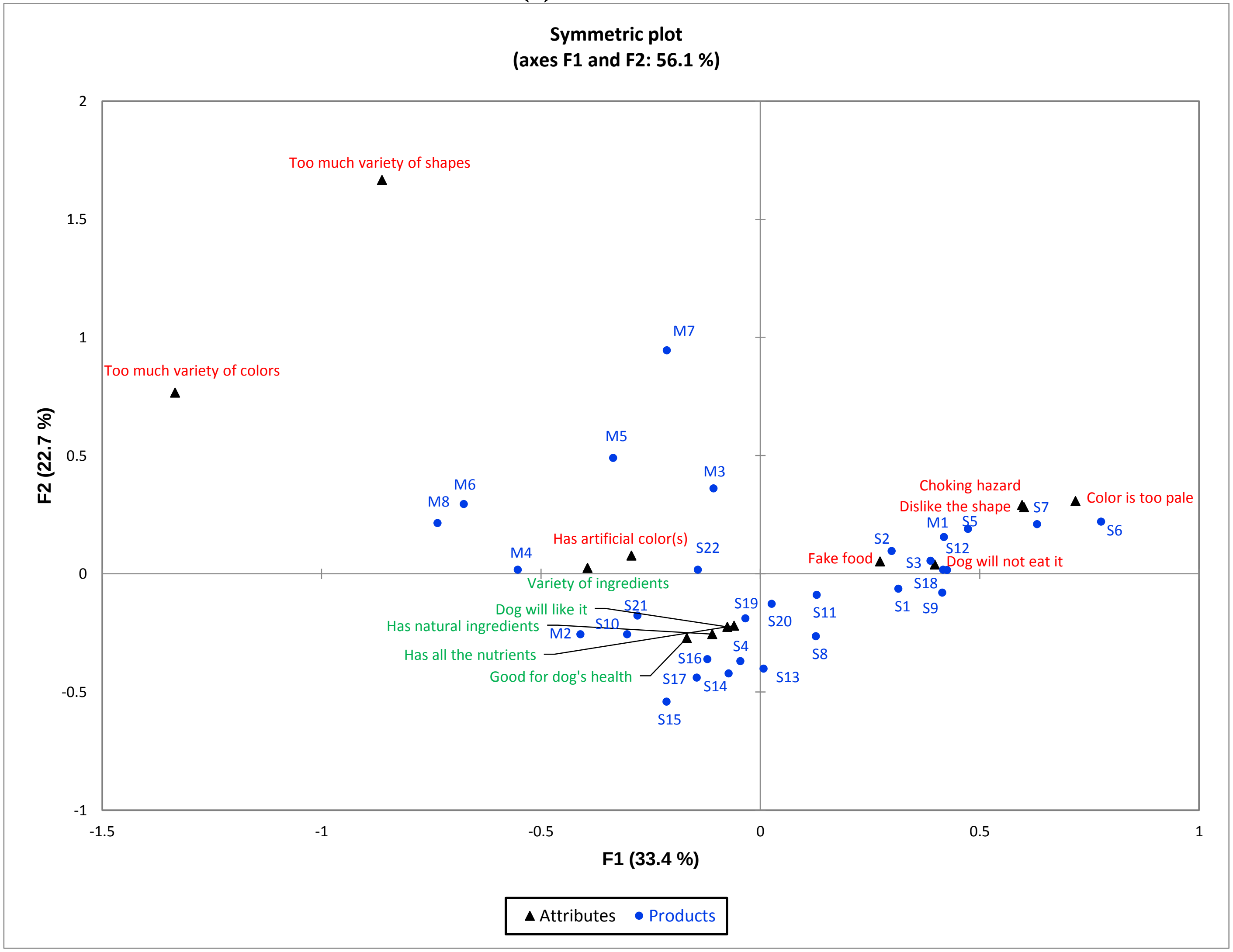


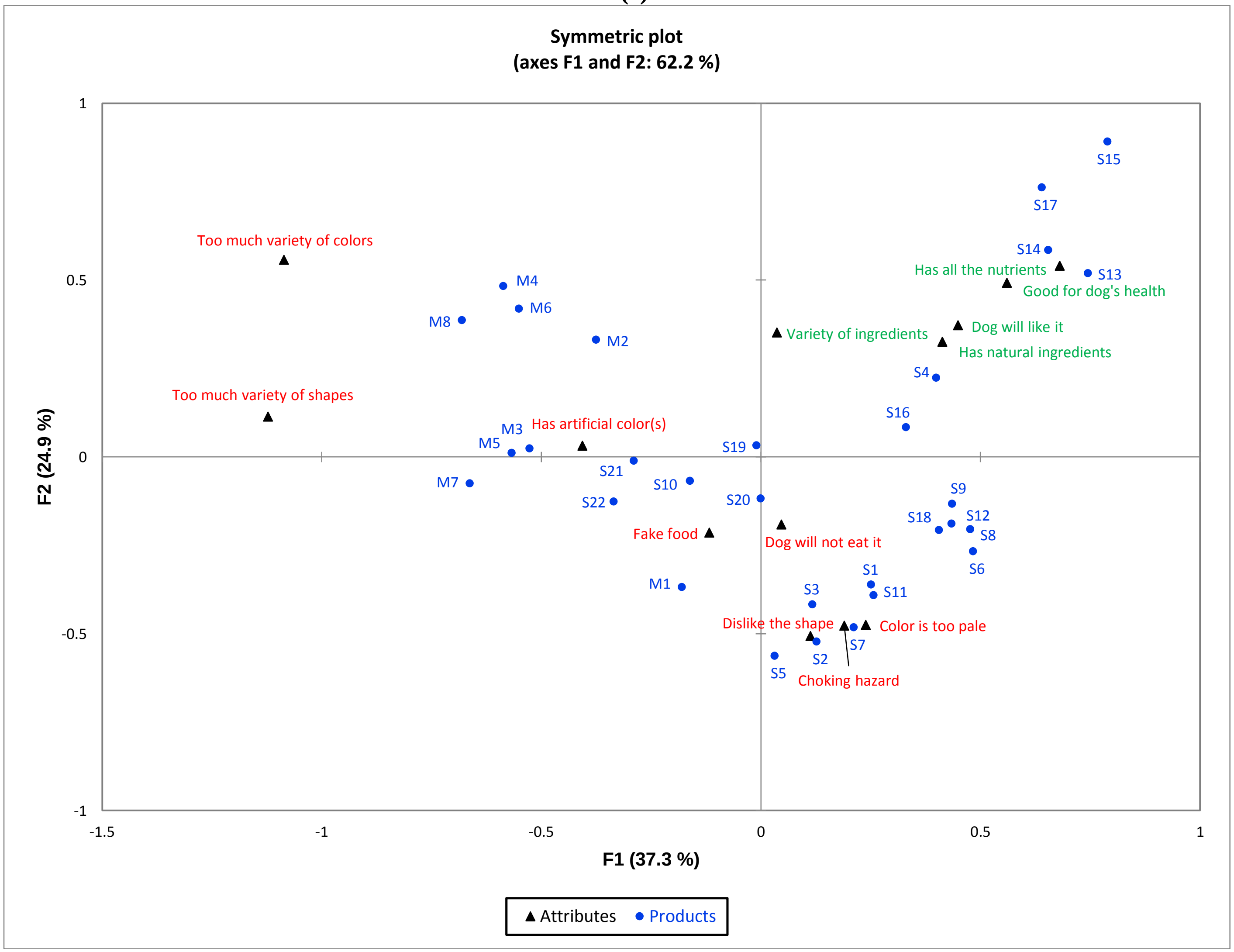
Figure 3.1 Correspondence Analysis maps between the thirty samples and the thirteen functional terms from the check-all-that-apply question for all three consumer clusters. Positive terms shown in green; negative terms shown in red.

(b) Cluster 2



Symmetric plot
(axes F1 and F2: 56.1 %)
F2 (22.7 %)
F1 (33.4 %)
2
1.5
1
0.5
0
-0.5
-1
-1.5
-1
-0.5
0
0.5
1
Too much variety of shapes
Too much variety of colors
M7
M5
M3
M6
M8
M4
Has artificial color(s)
S22
Variety of ingredients
Dog will like it
S21
Has natural ingredients
S10
M2
Has all the nutrients
Good for dog's health
S19
S20
S4
S16
S17
S14
S13
S15
S11
S8
Choking hazard
Dislike the shape
S7
Color is too pale
M1
S5
S6
S2
S12
Fake food
S3
Dog will not eat it
S18
S1
S9
Attributes
Products

(c) Cluster 3



Symmetric plot
(axes F1 and F2: 62.2 %)
F1 (37.3 %)
F2 (24.9 %)
Too much variety of colors
Too much variety of shapes
Has artificial color(s)
Fake food
Dog will not eat it
Dislike the shape
Color is too pale
Choking hazard
Has all the nutrients
Good for dog's health
Variety of ingredients
Dog will like it
Has natural ingredients
M1
M2
M3
M4
M5
M6
M7
M8
S1
S2
S3
S4
S5
S6
S7
S8
S9
S10
S11
S12
S13
S14
S15
S16
S17
S18
S19
S20
S21
S22
Attributes
Products

Discussion

Several findings can be pointed out from this research. First, the results show that the number of kibbles, color(s), shape(s), and size(s) present in dry dog food are all factors the affect the acceptability of the appearance of the product by dog owners. A previous study (15) had reported that the size and the color of the kibbles influence the liking of dry dog food by consumers. The participants overall liked best single-kibble samples of medium brown colors, kibble sizes in the middle portion of the size scale, low-dimensional contrast kibbles and traditional kibble shapes such as triangular prisms and cuboids. These results are in agreement with a previous study that had found that samples containing kibbles with a high uniformity of shape were liked better than samples with kibbles presenting a low uniformity of shape (15). The consumers overall disliked the single-kibble sample of extra-small size that presented the darkest brown color in the set of samples which in accordance with the results of previous works (15,16). This sample was perceived by dog owners as a food their dogs would not consume from the results of the Correspondence Analysis. This finding could be a potential topic for further research on the consumer perception of the size of dry dog food. Also, the participants overall rated low kibbles of extra-large size which was previously reported in another study (16). The results of the Correspondence Analysis evidence that consumers see large-sized kibbles to present a threat of chocking for their dogs. Moreover, a single-kibble sample with a high-dimensional contrast kibble shape (sticks) was rated among the lowest by the participants overall which is in agreement with a previous work (15). The results of the Correspondence Analysis show that consumers did not like the shape of the sticks-like kibbles. In addition, the consumers overall disliked multiple-kibble samples presenting low-color contrast and containing kibbles with light brown color. These results are in accordance with previous research that had found that dry dog food kibbles of light brown color were disliked by consumers (15). Also, it should be noted that the participants overall disliked single-kibble samples of green colors which was not reported in previous research on the appearance of dry dog food. The results from the Correspondence Analysis indicate that consumers perceived samples with kibbles of green colors to look like fake food and to contain artificial colors. This association with the green color by consumers is an interesting finding that could be addressed in further research on the human perception of the appearance of pet foods.

It should be noted that about ¾ of the participants received well overall multiple-kibble samples containing kibbles with a low-dimensional contrast, traditional kibble shapes such as cuboids, a high-color contrast and a combination of kibbles with shades of brown and red colors. This finding is in agreement with the results of previous studies conducted with consumers in the US (15) and Thailand (16) which show that multiple-kibble samples were well received by the participants. This results evidence once again a similar trend in the liking of the appearance of dry dog food by consumers in different countries. As suggested by Koppel et al. (16), multiple-kibble samples are perhaps seen as having more variety of nutrients by dog owners. This suggestion is in agreement with the results from the Correspondence Analysis performed in the present work where positive beliefs were associated with multiple-kibble samples by around ¾ of the consumers.

On the other hand, some differences can be found in the preferences consumers have towards the visual characteristics of dry dog food in different countries. Previous research (16) reported that consumers in Thailand liked best a bone-shaped kibble and received well dry dog foods that have a shape that is different from the traditional cylinder-shaped kibbles. These results differ from the findings of the present study where consumers showed preference for traditional low-dimensional contrast kibble shapes. Nevertheless, some similarities in the preferences of dog owners towards the visual characteristics of dry dog food have been identified across countries which can provide guidelines for pet food manufacturers to use for developing products targeting different markets worldwide. Previous studies have shown the differences/similarities that may occur in the consumer perception and preferences when consumer products are tested across different countries (18-21). These studies evidence how important it is to understand the preferences and needs of the target population on each market to accomplish the development of successful products. The results of this work and the differences found when comparing the results with previous research in other countries show the importance of conducting further studies on specific markets to achieve a successful marketing of pet foods.

A previous article (6) reviewed that price, brand, packaging, advertising claims, nutritional value and ingredients, and specific characteristics of the product such as appearance (number of different kibbles, color(s), shape(s), size(s)) and aroma are all factors that influence the purchase decision of dry dog food by dog owners. In addition, other factors such as health benefits, digestive effect and characteristics of the stool, the dog's response to the food and the amount consumed by the pet play an important role on influencing the purchase decision. Therefore, manufacturers should attempt to meet the consumers' requirements for all the factors influencing the purchase decision of dry dog food as repurchase depends on the product's ability to meet both the dog owners' and the pet's needs. As the results of this research suggest, specific visual characteristics of dry dog food that are well received by the consumers may increase their overall degree of satisfaction with the product and improve the chance of repurchase.

From the results of the Correspondence Analysis, it is clear that the consumers related specific visual characteristics with positive beliefs such as "Has natural ingredients", "Good for dog's health", "Has variety of ingredients" and "Has all the nutrients that my dog(s) needs". Likewise, the consumers associated specific characteristics with negative statements. Previous research (22) reported that premium human food purchasers are more likely to purchase premium pet food to feed their pets. These findings combined suggest dry dog food with appearance properties that are well received by consumers may be perceived as being more premium quality by dog owners. Furthermore, we can hypothesize the same human-pet food association may apply to pet foods other than dry dog food as the market continues to diversify following a trend of humanization of pet foods. Consumers are demanding more specialized premium pet foods and further research is necessary to investigate this hypothesis with the potential of several pet food categories to be explored.

This study took place in Manhattan, Kansas, USA, and citizens from the Manhattan, KS, area participated in the consumer session. The results from this research are expected to provide a good representation of consumers in rural areas of the Midwest in the US but do not necessarily reflect the preferences of urban consumers from other areas of the country. Nevertheless, the analysis performed by consumer clusters allows to present the results from different consumer groups and permits a better representation of the variation in preferences that can be found in the US market. USA is the largest pet food market in the world with an expected pet food retail sales value of US$27 billion in 2018 (3) and the results from this research may help manufacturers who market their products in North America meet consumers' needs with increased benefits to the pet food industry and the well-being of dog owners. Furthermore, the present study creates an opportunity for further research on the consumer acceptance and perception of the appearance of pet foods other than dry dog food.

Conclusions

The acceptance of the appearance of dry dog foods by dog owners is affected by the number of different kibbles present in the samples and by their visual characteristics in terms of size(s), shape(s) and color(s) of the kibbles present. Dry dog food manufacturers should take special consideration with meeting the consumers' expectations regarding the visual characteristics of the kibbles in order to enhance the acceptability of their products. It is recommended for dry dog food manufacturers who market their products in the US to focus on the production of single-kibble samples of medium brown colors, medium kibble sizes, low-dimensional contrast kibbles and traditional kibble shapes such as triangular prisms and cuboids. In addition, the results showed that dry dog food companies should avoid the production of extra-small and extra-large sized kibbles, kibbles with a high-dimensional contrast shape such as sticks, green-colored kibbles, and multiple-kibble samples containing kibbles with a low-color contrast and a high-dimensional contrast kibble shape such as discs. Besides, about ¾ of the participants received well overall multiple-kibble samples containing kibbles with a low-dimensional contrast, traditional kibble shapes such as cuboids, a high-color contrast and a combination of kibbles with shades of brown and red colors. On the other hand, about ¼ of the consumers disliked kibbles of red colors.

Acknowledgments

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Appendix A - Pictures of the samples

Figure A.1 Sample S1

Figure A.2 Sample S2


Figure A.3 Sample S3


Figure A.4 Sample S4

Figure A.5 Sample S5

Figure A.6 Sample S6

Figure A.7 Sample S7

Figure A.8 Sample S8

Figure A.9 Sample S9

Figure A.10 Sample S10

Figure A.11 Sample S11

Figure A.12 Sample S12

Figure A.13 Sample S13

Figure A.14 Sample S14

Figure A.15 Sample S15

Figure A.16 Sample S16

Figure A.17 Sample S17

Figure A.18 Sample S18

Figure A.19 Sample S19

Figure A.20 Sample S20

Figure A.21 Sample S21

Figure A.22 Sample S22

Figure A.23 Sample M1

Figure A.24 Sample M2

Figure A.25 Sample M3

Figure A.26 Sample M4

Figure A.27 Sample M5

Figure A.28 Sample M6

Figure A.29 Sample M7

Figure A.30 Sample M8

Appendix B - Physical measurements for single-kibble samples

Approximate kibble size

For each single-kibble sample, the size of the kibbles was measured three times using three different kibbles. The size of the kibbles was measured based on the largest dimension for each of the samples, regardless of the shape. An approximate kibble size range is shown in Table B.1 for each of the kibble size categories used.

Table B.1 Approximate kibble size range for single-kibble samples (mm).

Kibble size range (mm)		Relative size(s) score (1-7)	Relative size (based on largest dimension)
MIN.	MAX.		
7	8	1	Extra-small
9	10	2	Small
10	14	3	Small-to-medium
14	16	4	Medium
15	18	5	Medium-to-large
18	22	6	Large
22	30	7	Extra-large

All kibble sizes were measured based on the largest dimension for each of the kibbles, regardless of the shape.

Color measurements

For each single-kibble sample, the color of the kibbles was measured using a Konica Minolta CR-410 Chroma Meter®. The absolute color values were measured using the CIELAB color space. Three measurements were performed for each sample and the average L*a*b* values are shown in Table B.2.

Table B.2 Average colorimetric values for each of the single-kibble samples.

Sample	L*	a*	b*
S1	42.33	7.19	25.98
S2	41.80	11.29	28.61
S3	41.46	8.16	28.50
S4	40.60	9.66	23.54
S5	36.67	15.04	23.75
S6	46.01	5.67	19.72
S7	36.36	10.13	22.04
S8	52.75	7.53	30.73
S9	33.44	6.29	15.53
S10	33.48	18.05	22.85
S11	33.17	9.84	22.67
S12	38.18	6.52	18.16
S13	34.75	7.97	17.35
S14	34.71	10.19	17.64
S15	31.12	8.28	16.28
S16	33.52	10.21	15.46
S17	30.45	5.37	13.33
S18	24.44	5.73	8.00
S19	38.09	3.46	23.73
S20	35.25	1.96	16.17
S21	30.23	18.88	12.85
S22	35.90	17.43	12.23

Absolute color values are reported using the CIELAB color space.

Appendix C - Questionnaires used for the study held in Poland (Chapter 2)

Consumer questionnaire

Ankieta 'selekcyjna'

Screening Questionnaire

Numer uczestnika ___________________________

Consumer Number_________

1. Czy masz psa w domu?

1. Do you have any dogs in your home?

   A. Tak (YES)

   B. Nie (NO)

2. Czy karmisz go suchą karmą?

2. Do you feed your dog with dry food?

   A. Tak (YES)

   B. Nie (NO)

3. Jesteś osobą, która decyduje lub pomaga w wyborze jedzenia (sposobu żywienia) Twojego psa?

3. Are you the one who decide or help to decide about the food that will be fed to your dog?

   A. Tak (YES)

   B. Nie (NO)

4. Wiek

4. Which of the following best describes your age?

A. Poniżej 18 lat/Under 18 years

B. 18-34 lat/18-34 years

C. 35 lat i więcej/35 years or over

5. Płeć

5. Gender

A. Mężczyzna/Male

B. Kobieta/Female

6. Czy kiedykolwiek stwierdzono u Ciebie zaburzenia związane z rozpoznawaniem barw?

6. Have you ever been diagnosed with color blindness or color vision deficiency?

A. Tak (YES)

B. Nie (NO)

Ankieta Uczestnika

Consumer Questionnaire

Numer uczestnika ___________________________________

Consumer Number ____________

Proszę zaznaczyć odpowiedź

Please circle your selected answer

1. Ile masz psów?

1. How many dog(s) do you have in your house?

1) jednego psa/ 1
2) dwa psy/ 2
3) trzy psy/ 3
4) cztery psy/ 4
5) pięć i więcej psów/5 or more

2. Jaki ma/mają typ rasowy? (możesz wybrać więcej niż jedną odpowiedź, jeśli masz więcej niż 1 psa)

2. What is/are your dog's breed type? (can choose more than 1 answers if you keep more than 1 dog)

1) rasowy/purebred
2) mieszaniec/mixed breed

3. W jakim wieku jest/są twoje psy? (możesz wybrać więcej niż jedną odpowiedź, jeśli masz więcej niż 1 psa)

3. Please indicate your dog's age range? (can choose more than 1 answer if you keep more than 1 dogs)

a. 1 rok lub poniżej/1 year or under

b. 2-4 lat/years

c. 5-8 lat/years

d. 9 lat i więcej/9 years or over

4. Jaka jest wielkość Twojego psa/psów? (możesz wybrać więcej niż jedną odpowiedź, jeśli masz więcej niż 1 psa)

4. What is/are the size of your dog(s)? (can choose more than 1 answer if you have more than 1 dog)

1) Bardzo mały (0,5 - 5,0 kg)/ very small size

2) Mały (5,1 - 11,0 kg)/ small size

3) Średni (11,1 - 20,0 kg)/ medium size

4) Duży (20,1 - 40,0 kg)/ large size

5) Bardzo duży (powyżej 40 kg)/ very large size

5. Czy Twoje psy mają problemy zdrowotne, które mogą mieć wpływ na wybór jedzenia?

5. Does/Do your dog(s) have any health problems which affect the food selection for your dog(s)?

1) Tak Jeśli tak, proszę wymienić/ Yes, If yes, please specify

2) Nie/No

6. Jaką kwotę wydajesz miesięcznie na jedzenie dla jednego psa?

6. How much money do you spend on dog food for <u>each dog per month</u>?

1) Mniej niż/less than/ 50 zł

2) 50 - 200 zł

3) Więcej niż/more than/ 200 zł

7. Czy uważasz, że masz dużą wiedzę o karmach i zdrowiu psów?

7. Do you think you know a lot about pet food and pet's health?

1) Tak/YES

2) Nie/NO

8. Na co zwracasz uwagę wybierając jedzenie dla psa (nie więcej niż 3 odpowiedzi)

8. What is/are important factor(s) that you consider when choosing dog food? (choose no more than 3 answers)

1) Ogólnie ma poprawiać zdrowie psa/Improve dog's health in general

2) Marka/Brand

3) Cena/Price

4) Wygląd produktu/ Appearance of the product

5) Czy pies lubi tę karmę/ Dog(s) like(s) that food

6) Składniki/surowce - Ingredients/Raw materials

7) Pies musi jeść tę karmę bo ma problemy zdrowotne/Dog(s) need(s) that food because of a health problem

8) Inne, wymień…/Others, please specify...

9. Gdzie kupujesz psią karmę? (można wybrać więcej niż jedną odpowiedź)

9. Where do you buy dog food? (can choose more than 1 answer)

1) W internetowym sklepie zoologicznym/Online

2) W przychodni/lecznicy weterynaryjnej/ Clinic/Veterinary hospitals

3) W sklepie osiedlowym/Small market in living area

4) W supermarkecie/Super markets /convenience stores

5) W sklepie zoologicznym/Pet shops/Pet stores

6) Na bazarku/Market fairs

7) Inne, wymień…/ Others, please specify

Wstaw X w kwadrat przy odpowiedzi, która najlepiej wyraża Twoje stanowisko

Please answer by making an X in the box (☐) that best represents your opinion

10. Uważam, że karma dla psa powinna zawierać mięso, warzywa i ziarna zbóż.

10. I think dog food should contain meat, vegetables and cereal grain.

☐	☐	☐	☐	☐
Zdecydowanie się nie zgadzam	Nie zgadzam się	Ani się zgadzam ani nie zgadzam	Zgadzam się	Zdecydowanie się zgadzam

☐	☐	☐	☐	☐
Strongly Disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree

11. Uważam, że głównym składnikiem karmy dla psów powinno być mięso

11. I think dog food should have meat as a main ingredient.

☐	☐	☐	☐	☐
Zdecydowanie się nie zgadzam	Nie zgadzam się	Ani się zgadzam ani nie zgadzam	Zgadzam się	Zdecydowanie się zgadzam

☐ Strongly Disagree ☐ Disagree ☐ Neither agree nor disagree ☐ Agree ☐ Strongly Agree

12. Uważam, że psy mogą jeść 'ludzkie' jedzenie oraz resztki ze stołu

12. I think dogs can eat human food or human food left-overs.

☐ Zdecydowanie się nie zgadzam ☐ Nie zgadzam się ☐ Ani się zgadzam ani nie zgadzam ☐ Zgadzam się ☐ Zdecydowanie się zgadzam

☐ Strongly Disagree ☐ Disagree ☐ Neither agree nor disagree ☐ Agree ☐ Strongly Agree

13. Niepokoiłbym/(abym) się, gdyby mój pies jadł karmę zawierającą konserwanty

13. I will be worried if my dog eat foods that contains preservatives.

☐ Zdecydowanie się nie zgadzam ☐ Nie zgadzam się ☐ Ani się zgadzam ani nie zgadzam ☐ Zgadzam się ☐ Zdecydowanie się zgadzam

☐ Strongly Disagree ☐ Disagree ☐ Neither agree nor disagree ☐ Agree ☐ Strongly Agree

Dog food questionnaire

Ankieta Produktu

Food Questionnaire

Numer Uczestnika ______________________________

Consumer number_____________

Numer próbki ___________________________________

Sample____________

Zaznacz, która odpowiedź najlepiej wyraża Twoją opinię

Please answer by making an X in the box (☐) that best represents your opinion

1. Jakie są Twoje OGÓLNE spostrzeżenia dotyczące tej karmy?

1. How much do you GENERALLY LIKE/DISLIKE this sample?

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

Wyjątkowo mi się nie podoba	Obojętna	Wyjątkowo mi się podoba

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

Dislike extremely	Neither like nor dislike	Like Extremely

2. Czy odpowiada Ci WIELKOŚĆ tej karmy?

2. How much do you LIKE/DISLIKE the SIZE of this sample

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

Wyjątkowo mi się nie podoba	Obojętna	Wyjątkowo mi się podoba

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

Dislike extremely	Neither like nor dislike	Like Extremely

3. Czy podoba Ci się KSZTAŁT tej karmy?

3. How much do you LIKE/DISLIKE the SHAPE of this sample?

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

Wyjątkowo mi się nie podoba	Obojętna	Wyjątkowo mi się podoba

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

Dislike extremely	Neither like nor dislike	Like Extremely

4. Czy podoba Ci się KOLOR tej karmy?

4. How much do you LIKE/DISLIKE the COLOR of this sample?

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

Wyjątkowo mi się nie podoba	Obojętna	Wyjątkowo mi się podoba

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

Dislike extremely	Neither like nor dislike	Like Extremely

5. Zaznacz, która odpowiedź najlepiej przedstawia Twoją opinię (można wybrać więcej niż jedną odpowiedź)

5. Please answer by making an X in the box (☐) that best represents your opinion (can choose more than 1 answer)

Uważam, że ta karma ma następujące właściwości:

I think this sample has the following characteristics ....

- ☐ Wyprodukowano ją z naturalnych składników/surowców/Has natural ingredients/raw materials
- ☐ Jest zdrowa dla psa/Good for dog's health
- ☐ Jest jak sztuczne jedzenie/Looks like fake food
- ☐ Mój pies ją polubi/My dog will like it
- ☐ Kolor jest zbyt blady/jasny/Color is too pale
- ☐ Może spowodować ryzyko zadławienia/Its consumption may cause choking hazard
- ☐ Ma dużo różnych składników/surowców/Has varieties of ingredients/raw materials
- ☐ Mój pies nie będzie jej jeść/My dog will not eat it
- ☐ Nie podoba mi się kształt tych granulek/I don't like the shape of this sample
- ☐ Zawiera sztuczne barwniki/Has artificial colorant(s)
- ☐ Zawiera wszystkie składniki odżywcze, których potrzebuje mój pies/psy/Has all nutrients that my dog(s) needs
- ☐ Ma zbyt różnorodny kształt/Has too much varieties of shapes
- ☐ Jest zbyt kolorowa/Has too much varieties of colors

Appendix D - Questionnaires used for the study held in the US (Chapter 3)

Consumer questionnaire

Consumer Questionnaire

Consumer Number:

Please circle your selected answer

1. How many dog(s) do you have in your house?

   1) 1 dog

   2) 2 dogs

   3) 3 dogs

   4) 4 dogs

   5) 5 dogs or more

2. What is/are your dog's breed type? (can choose more than 1 answer if you have more than 1 dog)

   1) purebred

   2) mixed breed

3. Please indicate your dog's age range? (can choose more than 1 answer if you have more than 1 dog)

   a. 1 year or under

   b. 2-4 years

   c. 5-8 years

d. 9 years or over

4. What is/are the size of your dog(s)? (can choose more than 1 answer if you have more than 1 dog)
   1) very small size (1 - 11 lb)
   2) small size (11.1 - 25 lb)
   3) medium size (25.1 - 44 lb)
   4) large size (44.1 - 88 lb)
   5) very large size (more than 88 lb)
5. Does/Do your dog(s) have any health problems which affect to the food selection for your dog(s)?
   1) Yes. If yes, please specify___________________
   2) No
6. How much money do you spend on dog food for <u>each dog per month</u>?
   1) Less than $15
   2) $15 - $50
   3) More than $50
7. Do you think you know well about pet food and pet's health?
   1) Yes
   2) No
8. What is/are important factor(s) that you consider when choosing dog food? (can choose not more than 3 answers)
   1) Improve dog's health in general
   2) Brand
   3) Price

4) Appearance of the product

5) Dog(s) like(s) that food

6) Ingredients/Raw materials

7) Dog(s) need(s) that food because of a health condition

8) Others, please specify ___________________________________

9. Where do you buy dog food? (can choose more than 1 answer)

1) Online

2) Clinic/Veterinary hospitals

3) Small market in living area

4) Supermarkets /convenience stores

5) Pet shops/Pet stores

6) Market fairs

7) Others, please specify ___________________________________

Please answer by making an X in the box (☐) that best represents your opinion

10. I think dog food should contain meat, vegetables and cereal grain.

☐	☐	☐	☐	☐
Strongly Disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree

11. I think dog food should have meat as a main ingredient.

☐	☐	☐	☐	☐
Strongly Disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree

12. I think dogs should eat human food or left-overs from humans.

☐ Strongly Disagree ☐ Disagree ☐ Neither agree nor disagree ☐ Agree ☐ Strongly Agree

13. I will be worried if my dog eats foods containing preservatives.

☐ Strongly Disagree ☐ Disagree ☐ Neither agree nor disagree ☐ Agree ☐ Strongly Agree

Dog food questionnaire

Food Questionnaire Consumer number:

Sample:

Please answer by making an X in the box (☐) that best represents your opinion.

How much do you LIKE/DISLIKE this sample in OVERALL?

☐ Dislike Extremely ☐ ☐ ☐ ☐ Neither like nor dislike ☐ ☐ ☐ ☐ Like Extremely

How much do you LIKE/DISLIKE the SIZE of this sample?

☐ Dislike Extremely ☐ ☐ ☐ ☐ Neither like nor dislike ☐ ☐ ☐ ☐ Like Extremely

How much do you LIKE/DISLIKE the SHAPE of this sample?

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

Dislike Extremely | Neither like nor dislike | Like Extremely

How much do you LIKE/DISLIKE the COLOR of this sample?

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

Dislike Extremely | Neither like nor dislike | Like Extremely

Please answer by making an X in the box (☐) that best represents your opinion (can choose more than 1 answer)

I think this sample has the following characteristics:

☐ Has natural ingredients/raw materials

☐ Good for dog's health

☐ Looks like "fake" food

☐ My dog will like it

☐ Color is too pale

☐ Consumption may cause choking hazard

☐ Has varieties of ingredients/raw materials

☐ My dog will not eat it

☐ I don't like the shape of this sample

☐ Has artificial color(s)

☐ Has all nutrients that my dog(s) need

☐ Has too much variety of shapes

☐ Has too much variety of colors

Appendix E - SAS® code used for the Analysis of Variance of all four liking attributes and for all 120 consumers in the US study (Chapter 3)

```
data USAFQ;
input sample$ consumer$ overall size shape color;
cards;
(…..DATA ENTRY…..
.
.
.
.
.
…..)
;
proc glimmix;
class sample consumer;
model overall = sample/ddfm=sat;
random consumer;
lsmeans sample/ pdiff lines;
run;

proc glimmix;
```

```
class sample consumer;
model size = sample/ddfm=sat;
random consumer;
lsmeans sample/ pdiff lines;
run;

proc glimmix;
class sample consumer;
model shape = sample/ddfm=sat;
random consumer;
lsmeans sample/ pdiff lines;
run;

proc glimmix;
class sample consumer;
model color = sample/ddfm=sat;
random consumer;
lsmeans sample/ pdiff lines;
run;
ods rtf close; quit;
```