Article

Many Canadian dog and cat foods fail to comply with the guaranteed analyses reported on packages

Stuart W. Burdett, Wilfredo D. Mansilla, Anna K. Shoveller

Abstract — We compared analyzed nutrient contents of Canadian-specific dry dog and cat foods to the guaranteed analyses on packages and to the Association of American Feed Control Officials (AAFCO) 2018 nutrient targets to assess compliance with the *Consumer Packaging and Labelling Act.* We also explored differences in macronutrient content between species (dog and cat) and life stage for adult pet foods (all life stages and senior). Extruded dog (n = 16) or cat (n = 11) foods advertised as all life stage or senior, sold only in Canada, and carrying an AAFCO nutritional adequacy statement were selected. Proximate analyses and amino acid analyses were completed on all diets. Of the 27 foods, 25 met or exceeded the AAFCO nutrient recommendations. Only 9 foods met all nutrient content claims listed in their guaranteed analyses. Nutrient content between species or life stages was not different ($P > 0.10$).

Résumé — Bon nombre d'aliments pour chiens et chats ne sont pas conformes aux garanties analyses rapportées sur bag. Nous avons comparé a analysé la teneur en éléments nutritifs du sec spécifiques au Canada chien et chat aliments pour la garantie d'analyses sur l'emballage et à l'Association of American Feed Control Officials (AAFCO) 2018 objectifs d'éléments nutritifs. Nous avons également examiné les différences de teneur en macronutriments entre espèces (chien et chat) ou de la vie des aliments pour animaux adultes (tous les stades de la vie et les cadres supérieurs). Chien extrudé (n = 16) ou de la nourriture pour chats (n = 11) annoncé comme tous les stades de la vie ou senior, vendu uniquement au Canada, et la réalisation d'un état nutritionnel approprié de l'AAFCO ont été sélectionnés. L'analyse immédiate et en acides aminés ont été effectuées sur tous les régimes alimentaires. De l'alimentation 27, 25 ont atteint ou dépassé les recommandations nutritionnelles de l'AAFCO. Cependant, seuls les régimes alimentaires 9 satisfait à toutes les allégations relatives à la teneur en éléments nutritifs énumérés dans leurs garanties d'analyses. Teneur en éléments nutritifs entre les espèces ou étapes de la vie n'était pas différent ($P > 0{,}10$).

(Traduit par les auteurs)

Can Vet J 2018;59:1181–1186

Introduction

In Canada, there is no enforcement for the nutrient composition of dog and cat foods, or their compliance with current United States of America (USA) or European standards for nutrient density. Although the Association of American Feed Control Officials (AAFCO) has no enforceable authority, it is responsible for setting model regulations for pet foods including labelling requirements, ingredient definitions, and nutrient requirements in the USA (1). Moreover, pet food manufacturers in the USA not only have to comply with federal regulating agencies such as the Federal Drug Administration (FDA), Federal Trade Commission (FTC), and United States Department of Agriculture (USDA), but also with State Feed Control Officials who may adopt some or all of the AAFCO standards and nutritional recommendations for different species and life stages. The AAFCO nutritional standards are based on the National Research Council (NRC) nutrient recommendations (2). The NRC compiles and reviews scientific literature on a variety of species during various life stages and provides recommendations regarding nutrient requirements. These recommendations are considered by AAFCO and used to set regulatory standards, and where applicable, increased nutrient recommendation levels account for the effects of digestibility among pet foods (3). The AAFCO additionally presents acceptable analytical variations specific for each nutrient in the

Department of Animal Biosciences, University of Guelph, Guelph, Ontario.

Address all correspondence to Dr. Anna K. Shoveller; e-mail: ashovell@uoguelph.ca

guaranteed analysis (GA). However, it is the responsibility of the manufacturer to ensure that they remain within the acceptable limits for analytical variation, as well as account for this and formulate products to contain enough nutrients to meet the acceptable range for the GA.

In Canada, regulation of pet food is only at the federal level and less rigorous than in the USA. The *Guide for the Labelling and Advertising of Pet Foods* highlights the standards for labelling, such as reporting the GA. The GA includes a minimum content on an "as is" basis for crude protein (CP), crude fat, and a reported maximum content for crude fiber and moisture. Nutrient profile claims are also contained within the guide; however, these standards are not required by law and are followed on a voluntary basis. Because of this and as a commercial strategy, many pet food companies in Canada include an AAFCO nutritional adequacy statement. Once a food is labelled with an AAFCO statement, companies are responsible for ensuring that the nutrient content meets the AAFCO nutrient profile and the GA provided on the package. The objective of this study was to assess whether Canadian pet food manufacturers were complying with the *Consumer Packaging and Labelling Act* in regard to nutrient content claims for moisture, protein, and the essential amino acids, ash, and fat. We compared analyzed nutrient content to individual GA reported on the package and to guaranteed AAFCO nutrient recommendations (3). We also explored differences in macronutrient content between species (dog and cat) and life stage for adult pet foods (all life stages and senior).

Materials and methods

Criteria for selection of diets

In total, 27 diets (16 dog, 11 cat; 21 all life stages and 6 senior formulations) were purchased from pet specialty retailers with Canada-wide distribution based on the following criteria: i) diets were manufactured and distributed solely within Canada and not marketed in the USA or any other foreign market to our knowledge; ii) diets were extruded, over-the-counter dog and cat foods intended and labelled as "all life stage" or "senior" formulations; and iii) diets claimed the product met or exceeded the AAFCO (3) nutrient profiles for the respective species and stage of life. No diets produced by the big 3 global pet food companies were included. Moreover, considering the influence of the American market on the Canadian market (~50% of pet food is imported from USA) and the high level of regulation and need for product registration in each USA state, products sold in the USA were not included.

Sampling and analysis

For each bag of pet food, two 250 g representative samples were taken immediately after opening. Samples of each food [blinded with no indication of brand or stock-keeping unit (SKU)] were delivered to the Central Analytical Laboratory at Royal Canin (Guelph, Ontario). Analysis of amino acids (AA) was performed in the Department of Animal Biosciences at the University of Guelph. Proximate analyses (PA) and AA content were determined in duplicate for all samples taken.

Proximate analyses. Dry matter (DM) content of samples was determined by weight loss in a 2-gram ground subsample after placing samples in an oven at 102°C ± 2°C for 24 h according to ISO standards (ISO 6496:1999, Animal feeding stuffs, Determination of moisture and other volatile matter.) Crude protein (CP) content in diet samples was determined using the Dumas method (4) [validated by ISO (ISO 16634-1, 2008, Food products, Determination of the total nitrogen content by combustion, according to the Dumas principle and calculation of the crude protein content)]. Crude fat content was determined by solvent extraction according to the Association of Official Agricultural Chemists (AOAC) method (5) validated by ISO (ISO 6492:1999, Animal feeding stuffs, Determination of fat content), and ash content was determined by calcination at 550°C for 8 h, according to ISO validated (ISO 5984:2002, Animal feeding stuffs, Determination of crude ash) AOAC method (6).

Amino acid analyses. Amino acid profiles of the diets (except Met, Cys, and Trp) were determined in duplicate using AOAC methods (7). Briefly ~0.1 g of ground sample was mixed with 5 mL of 6 M HCl containing 1% (w/v) phenol in a screw cap test tube. Tubes were purged of oxygen with nitrogen gas and sealed before they were placed in a heating block at 110°C for 24 h. After acid digestion, 1 mL of norvaline internal standard (5 mM, Sigma Aldrich, Oakville, Ontario) was added to each test tube. After filtration (syringe filter, 0.22 μm membrane filter), samples were stored at −20°C until further processing. Before derivatization, 100 μL acid samples were neutralized with 100 μL of 6 M NaOH. Neutralized samples and the standard were derivatized by ACCQ Tag Ultra derivatization kit (Waters Corporation, Milford, Massachusetts, USA) according to Boogers et al (8).

Calculations and statistical analysis

Descriptive statistics were used to measure the number of diets that were above or below the maximum or minimum nutrient densities labelled within the GA on the product packaging on an "as is" basis. Individual AA, CP, crude fat, and ash contents were standardized to DM and compared using descriptive statistics to determine the number of diets that were below the AAFCO (3) nutrient profiles (Table 1) for CP, crude fat, and essential AA. The MIXED procedure of SAS (SAS Version? SAS, Cary, North Carolina, USA) was used to determine differences among AA content, with species (dogs and cats) and life stage (all life stages and senior) as fixed effects. For all statistical analyses, differences were considered significant at $P \leq 0.05$ and a trend at $0.05 < P \leq 0.10$.

Results

Comparison with guaranteed analysis

All diets sampled included a GA for CP and crude fat, but only 20 included ash and 26 included moisture on their product packaging. Among the 27 diets that reported minimum CP and crude fat contents, 3 had lower CP concentrations and 7 had lower crude fat content than the labelled minimum. Of the 20 diets that reported maximum ash content, 11 contained concentrations of ash above their product's guaranteed maximum. All of the 26 diets that reported maximum moisture contents were below these levels. In general, of the 27 diets analyzed,

Table 1. Association of American Feed Control Officials dog and cat food nutrient profiles (%).[a]

	Species			
	Cats		Dogs	
Nutrient	Growth	Maintenance	Growth	Maintenance
Crude protein	30.0	26.0	22.5	18.0
Crude fat	9.0	9.0	8.5	5.5
Arginine	1.24	1.04	1.0	0.51
Histidine	0.33	0.31	0.44	0.19
Isoleucine	0.56	0.52	0.71	0.38
Leucine	1.28	1.24	1.29	0.68
Lysine	1.20	0.83	0.90	0.63
Phenylalanine	0.52	0.42	0.83	0.45
Phenylalanine + Tyrosine	1.92	1.53	1.30	0.74
Threonine	0.73	0.73	1.04	0.48
Valine	0.64	0.62	0.68	0.49

[a] Nutrient content reported on a dry matter basis, presumes a caloric density of 4000 kcal metabolizable energy (ME)/kg, as determined in accordance with Model Regulation PF9. Formulations > 4000 kcal ME/kg must be corrected for energy density; formulations < 4000 kcal ME/kg need not be corrected for energy. Formulations of low-energy density should not be considered adequate for reproductive needs based on comparison to the profiles alone.

only 9 successfully met all the claims listed in their GA label (Table 2).

Comparison with AAFCO profiles

Crude protein, crude fat, and AA concentrations in 25 of the 27 diets had nutrient profiles that met or exceeded the nutrient recommendations set forth by the AAFCO (Table 3). The 2 diets that failed to meet or exceed the AAFCO nutrient profiles were below the AAFCO recommendation of 1.04% for threonine (3).

Species and life-stage effect

Crude protein, crude fat, and ash contents were not different between species (dog *versus* cat; $P > 0.10$) or life stages (all life stage *versus* senior; $P > 0.10$). Dog food tended to have a greater tyrosine content than cat food ($0.05 < P < 0.10$; Table 4). All other AA were similar between species and life stage ($P > 0.1$).

Discussion

The lack of nutritional standards and pre-market product review on pet foods in Canada has left the Canadian industry vulnerable to inadequate diet formulations and misleading product labels. Therefore, we tested different pet food products for CP, crude fat, and individual AA content to compare with the product GA and nutrient recommendations from the AAFCO (3). Crude fiber was not analyzed in the present study as the current recommendations suggest moving towards dietary fiber, not crude fiber. It would have been interesting to analyze products for sulfur-containing amino acids (methionine, cysteine, taurine) and the methyl accepting and donating compounds (choline, betaine, B12, carnitine, creatine, and folate); however, due to limiting funding we only were able to analyze a limited number of nutrients. We, therefore, focused on nutrients listed in the product's GA's and non-sulfur containing amino acids. We also sought to compare nutrient concentration between species (dog and cats) and life stages (all life stages and senior).

When comparing individual nutrient content among diets with the GA on their package label, 18 of the 27 diets had GA claims that were not met and were therefore in violation of the *Consumer Packaging and Labelling Act*. This may be partially attributed to an inadequate quality assurance program that monitors batch-to-batch nutrient variation in raw materials. Pet food manufacturers should maintain an up-to-date database of all their raw materials by analyzing and tracking the nutrient content of incoming ingredients. Upon arrival, the new raw material should be tested for nutrient content and compared with their databases. If the new batch is within their analytical variation, they should use a Z-score corrected quantity of that ingredient to ensure the end-product meets the GA (9). Accurate quantification of the raw material's mathematical mean nutrient content and associated variability, therefore, are essential to ensure the formulated product will meet the pre-set maximum and minimums that are reported on package.

Failure to accurately account for nutrient variation can result in under- or over-estimation of nutrients in the GA and may have a detrimental impact on animal health. Hill et al (10) compared the variation between the GA and measured nutrient concentrations of dog and cat foods marketed in the USA. They determined that on average, CP and crude fat were underestimated by 1.5% and 1.0%, and the ash and moisture concentrations were overestimated by 0.5% and 4.0%, respectively. Additionally, they determined that the variation between the PA and the GA resulted in a small but significant underestimation of calculated metabolizable energy density of the diets (10). The present study found similar variation between the GA and the PA. On average, the CP, crude fat, and ash were underestimated by 1.62%, 0.83%, and 0.43%, respectively, while moisture content was underestimated by 2.92%. Therefore, more precise pet food formulation practices are necessary to ensure not only the accurate reporting of the products' GA, but also to prevent obesity and other health issues in companion animals.

In Canada, it is not required by law to include an AAFCO nutritional adequacy statement on pet food products. However, once a claim has been added on the product label, it is required to conform to the *Consumer Packaging and Labelling Act (R.S.C., 1985, c. C-38),* which states that "No dealer shall apply to any prepackaged product or sell, import into Canada, or advertise any prepackaged product that has applied to it a label containing

Table 2. Comparison of the proximate analyses (PA, as fed basis) and labelled guaranteed analyses (GA, as fed basis) of dry extruded dog and cat diets.[a]

	Crude protein (min)		Crude Fat (min)		Ash (max)		Moisture (max)	
Species	GA	PA	GA	PA	GA	PA	GA	PA
Dog	29.0 (28.61, 29.39)	30.04	17.0 (16.15, 17.85)[b]	14.0	7.50 (7.17, 7.84)	7.40	12.0 (11.28, 12.72)	7.90
Dog	29.0 (28.61, 29.39)	30.8	17.0 (16.15, 17.85)	19.3	7.50 (7.17, 7.84)[b]	10.3	12.0 (11.28, 12.72)	7.80
Dog	25.0 (24.65, 25.35)	27.1	15.0 (14.25, 15.75)	17.1	NP	NP	10.0 (9.40, 10.60)	6.00
Dog	34.0 (33.56, 34.44)	36.4	18.0 (17.10, 18.90)	19.0	NP	NP	10.0 (9.40, 10.60)	7.30
Dog	24.0 (23.66, 24.34)	25.3	13.0 (12.35, 13.65)	12.7	8.00 (7.66, 8.35)[b]	10.9	10.0 (9.40, 10.60)	5.50
Dog	38.0 (37.52, 38.48)[b]	37.3	18.0 (17.10, 18.90)[b]	17.0	NP	NP	10.0 (9.40, 10.60)	8.30
Dog	36.0 (35.54, 36.46)[b]	33.5	16.0 (15.20, 16.80)	18.2	8.00 (7.66, 8.35)[b]	13.3	10.0 (9.40, 10.60)	5.50
Dog	38.0 (37.52, 38.48)	38.0	18.0 (17.10, 18.90)[b]	15.0	NP	NP	10.0 (9.40, 10.60)	5.30
Dog	38.0 (37.52, 38.48)	39.2	18.0 (17.10, 18.90)[b]	16.5	NP	NP	10.0 (9.40, 10.60)	5.30
Dog	29.0 (28.61, 29.39)	31.1	17.0 (16.15, 17.85)[b]	16.0	7.50 (7.17, 7.84)	5.50	12.0 (11.28, 12.72)	7.60
Dog	26.0 (25.64, 26.36)	27.8	15.0 (14.25, 15.75)	18.0	10.0 (9.63, 10.38)	6.40	NP	NP
Dog	21.0 (20.69, 21.31)	25.7	8.00 (7.60, 8.40)	11.2	NP	NP	10.0 (9.40, 10.60)	10.4
Dog	18.0 (17.72, 18.28)	24.1	8.00 (7.60, 8.40)[b]	7.40	6.00 (5.69, 6.32)[b]	7.70	10.0 (9.40, 10.60)	7.60
Dog	38.0 (37.52, 38.48)[b]	37.3	15.0 (14.25, 15.75)	17.1	8.00 (7.66, 8.35)	7.40	10.0 (9.40, 10.60)	10.3
Dog	33.0 (32.57, 33.43)	36.0	14.0 (13.30, 14.70)	15.2	7.00 (6.67, 7.33)[c]	7.40	12.0 (11.28, 12.72)	10.5
Dog	20.0 (19.70, 20.30)	21.1	8.00 (7.60, 8.40)	11.1	NP	NP	10.0 (9.40, 10.60)	3.70
Cat	32.0 (31.58, 32.42)	32.3	19.0 (18.05, 19.95)	20.5	6.00 (5.69, 6.32)[b]	8.50	10.0 (9.40, 10.60)	7.80
Cat	31.0 (30.59, 31.41)	32.8	12.0 (11.40, 12.60)	14.7	6.00 (5.69, 6.32)[b]	6.90	10.0 (9.40, 10.60)	7.40
Cat	42.0 (41.48, 42.52)	44.5	20.0 (19.00, 21.00)	20.8	8.50 (8.15, 8.85)[b]	9.70	10.0 (9.40, 10.60)	7.80
Cat	31.0 (30.59, 31.41)	33.9	16.0 (15.20, 16.80)	16.8	8.00 (7.66, 8.35)[b]	8.70	10.0 (9.40, 10.60)	8.70
Cat	40.0 (39.50, 40.50)	40.3	18.0 (17.10, 18.90)	20.8	9.00 (8.64, 9.36)	8.50	12.0 (11.28, 12.72)	8.30
Cat	32.0 (31.58, 32.42)	36.6	20.0 (19.00, 21.00)	20.2	8.00 (7.66, 8.35)	8.10	10.0 (9.40, 10.60)	7.30
Cat	35.0 (34.55, 35.45)	37.4	20.0 (19.00, 21.00)	19.5	7.00 (6.67, 7.33)[b]	7.70	10.0 (9.40, 10.60)	6.80
Cat	42.0 (41.48, 42.52)	42.2	20.0 (19.00, 21.00)[b]	15.9	7.50 (7.17, 7.84)	7.40	10.0 (9.40, 10.60)	7.30
Cat	34.0 (33.56, 34.44)	34.2	11.0 (10.45, 11.55)	12.0	6.00 (5.69, 6.32)[b]	6.40	10.0 (9.40, 10.60)	8.50
Cat	30.0 (29.60, 30.40)	29.8	9.00 (8.55, 9.45)	10.0	8.00 (7.66, 8.35)	7.30	10.0 (9.40, 10.60)	9.00
Cat	28.0 (27.62, 28.38)	32.3	9.00 (8.55, 9.45)	16.1	7.00 (6.67, 7.33)	7.10	10.0 (9.40, 10.60)	6.80

[a] Nutrient content reported on an "as is" basis.
[b] Quantified nutrient content failed to comply with the diets labelled guaranteed nutrient content.
GA — Guaranteed analysis (GA ± Acceptable AV based on AAFCO); PA — proximate analysis; NP — Not present on product packaging.
Values within parenthesis are the acceptable ranges for the GA ± Acceptable AV based on AAFCO.

Table 3. Crude protein (CP, DM basis), crude fat (DM basis), and amino acid composition (%, DM basis) of dry extruded cat and dog diets.[a]

Species	Life stage	Crude protein	Crude fat	Arginine	Histidine	Isoleucine	Leucine	Lysine	Threonine	Valine	Phenylalanine	Phenylalanine + Tyrosine
Dog	ALS	32.75	15.11	2.39	0.85	1.23	2.35	1.45	1.26	1.62	1.75	3.18
Dog	ALS	33.15	20.75	1.86	0.65	0.87	1.93	1.05	1.02[b]	1.27	1.40	2.60
Dog	ALS	28.73	18.13	2.09	0.78	1.01	1.98	1.37	1.10	1.30	1.43	2.49
Dog	ALS	39.06	20.39	2.89	0.98	1.51	2.77	1.94	1.53	1.94	1.99	3.53
Dog	ALS	26.78	13.39	1.93	0.54	0.76	1.65	1.16	0.97[b]	1.17	1.16	2.12
Dog	ALS	40.32	18.35	2.72	0.97	1.41	2.89	1.95	1.61	1.96	2.08	3.63
Dog	ALS	40.01	15.74	2.31	0.82	1.34	2.39	1.81	1.36	1.80	1.77	3.12
Dog	ALS	41.21	17.37	2.94	0.99	1.30	2.90	1.99	1.60	1.87	2.09	3.66
Dog	ALS	35.34	19.20	2.47	0.79	1.12	2.15	1.49	1.15	1.49	1.57	2.77
Dog	ALS	33.41	17.22	2.30	0.74	1.07	2.28	1.54	1.23	1.39	1.67	2.94
Dog	ALS	29.57	19.09	2.15	0.86	1.14	2.36	1.46	1.21	1.53	1.57	2.80
Dog	Senior	28.30	12.30	1.81	0.66	1.00	1.85	1.07	0.97	1.29	1.40	2.51
Dog	Senior	25.93	7.91	1.55	0.77	0.98	1.69	1.46	1.00	1.27	1.22	2.23
Dog	Senior	41.09	18.86	2.81	1.01	1.40	2.90	1.91	1.61	1.83	2.17	3.89
Dog	Senior	39.71	16.73	3.01	0.97	1.35	2.84	2.03	1.58	1.71	1.12	2.74
Dog	Senior	21.88	11.46	1.27	0.47	0.75	1.44	0.96	0.80	1.03	0.98	1.75
Cat	ALS	34.77	22.10	2.39	0.82	1.07	2.21	1.36	1.31	1.41	1.70	3.08
Cat	ALS	35.21	15.73	2.48	0.91	1.27	2.67	1.55	1.36	1.70	1.99	3.54
Cat	ALS	47.92	22.37	3.28	1.17	1.86	3.36	2.26	1.86	2.38	2.54	4.53
Cat	ALS	36.80	18.21	2.65	0.89	1.28	2.57	1.79	1.53	1.66	1.81	3.26
Cat	ALS	43.41	22.46	2.98	1.02	1.58	2.96	1.98	1.68	2.02	2.20	3.91
Cat	ALS	39.27	21.62	2.64	0.84	1.24	2.53	1.71	1.47	1.62	1.78	3.19
Cat	ALS	39.92	20.82	2.81	0.94	1.44	2.73	1.91	1.51	1.86	2.02	3.55
Cat	ALS	45.21	17.00	3.35	1.12	1.65	3.03	2.29	1.60	2.03	2.39	4.21
Cat	ALS	37.09	12.96	2.84	1.00	1.58	3.05	1.97	1.66	2.08	2.24	4.07
Cat	ALS	32.41	10.90	2.22	0.94	1.29	3.34	1.26	1.30	1.74	2.08	3.75
Cat	Senior	34.49	17.19	2.42	0.87	1.30	2.45	1.49	1.28	1.67	1.84	3.27

[a] Nutrient content reported on a dry matter basis.
[b] Failed to meet the AAFCO nutrient profile for intended animal.
ALS = all life stages.

Table 4. Effect of species or life stage on the nutrient composition (%) of dry extruded dog and cat food.[a]

Nutrient composition (%)	Species				*P*-value	
	Dogs		Cats			
	ALS $n = 22$	Senior $n = 10$	ALS $n = 20$	Senior $n = 2$	Life stage	Species
Crude protein	32.4 ± 1.67	28.8 ± 5.28	36.4 ± 1.59	32.3 ± 2.36	0.229	0.243
Crude fat	16.6 ± 1.02	12.4 ± 3.22	17.1 ± 0.97	16.1 ± 1.44	0.183	0.278
Ash	8.87 ± 0.49	7.26 ± 1.56	7.90 ± 0.47	7.05 ± 0.70	0.195	0.525
Moisture	6.61 ± 0.48	8.48 ± 1.51	7.86 ± 0.46	6.80 ± 0.68	0.654	0.812
Alanine	1.77 ± 0.10	1.50 ± 0.30	2.02 ± 0.09	1.79 ± 0.14	0.179	0.148
Arginine	2.22 ± 0.13	1.92 ± 0.42	2.56 ± 0.13	2.23 ± 0.19	0.211	0.199
Aspartate	2.47 ± 0.15	2.33 ± 0.47	2.75 ± 0.14	2.28 ± 0.21	0.280	0.676
Glycine	2.76 ± 0.20	2.21 ± 0.64	3.23 ± 0.19	2.93 ± 0.29	0.268	0.128
Histidine	0.77 ± 0.04	0.71 ± 0.13	0.89 ± 0.04	0.80 ± 0.06	0.370	0.190
Isoleucine	1.09 ± 0.07	1.00 ± 0.22	1.32 ± 0.07	1.20 ± 0.10	0.430	0.108
Leucine	2.19 ± 0.13	1.97 ± 0.41	2.64 ± 0.12	2.26 ± 0.18	0.221	0.132
Lysine	1.47 ± 0.11	1.37 ± 0.33	1.68 ± 0.10	1.37 ± 0.15	0.312	0.594
Phenylalanine	1.58 ± 0.10	1.45 ± 0.31	1.92 ± 0.09	1.69 ± 0.14	0.335	0.119
Proline	1.92 ± 0.14	1.58 ± 0.43	2.05 ± 0.13	2.12 ± 0.19	0.584	0.197
Serine	1.41 ± 0.09	1.25 ± 0.27	1.64 ± 0.08	1.31 ± 0.12	0.142	0.373
Threonine	1.20 ± 0.07	1.09 ± 0.22	1.42 ± 0.07	1.18 ± 0.10	0.205	0.251
Tyrosine	1.22 ± 0.07	1.14 ± 0.23	1.51 ± 0.07	1.32 ± 0.10	0.310	0.091
Valine	1.48 ± 0.08	1.31 ± 0.27	1.72 ± 0.08	1.54 ± 0.12	0.282	0.150
Aromatic	3.56 ±0.21	3.30 ± 0.66	4.33 ± 0.20	3.81 ± 0.29	0.326	0.116

[a] Nutrient content reported on an as is basis. Values are least square means ± standard error.
Aromatic = histidine + phenylalanine + tyrosine; ALS — All life stages.
Significant difference was considered at $P \leq 0.05$ and a trend when $0.05 < P \leq 0.10$).

any false or misleading representation that related to or may reasonably be regarded as relating to that product" (11). Based on the results of this study, 2 of the 27 diets carrying an AAFCO adequacy claim, violated the *Act* by having lower threonine concentrations than recommended by the AAFCO. During heat processing threonine becomes heat labile and losses are observed with increasing time and heat (12). It is possible that pet food manufacturers are failing to conduct nutrient analyses after extrusion to account for losses accrued during processing, resulting in the overestimation of end-product nutrient density. For the 2 diets below the recommended AAFCO level for threonine, the lowest represented 93% of the AAFCO level, and both were above the NRC recommended allowances (0.81 for growing puppies). However, the NRC recommendations for threonine are estimated in highly digestible diets underestimating total threonine requirements. It is therefore necessary for commercial diets to comply with the AAFCO recommendations that account for potential losses or reductions in digestibility in processed pet foods. More than 70% of dietary threonine is used first pass in the gastrointestinal tract for mucin synthesis (13), and undersupply may reduce mucin synthesis exposing the intestinal lining to colonization by pathogenic bacteria (14). There are mathematical methods that can be used to estimate protein quality (total intake, balance, and digestibility), such as the protein digestibility corrected amino acid score that is used to make claims on packaged foods for humans. These models would be useful in the pet food industry to allow for the quantification of digestibility and to determine the content of available nutrients in pet foods.

There was no life stage effect on any of the measured nutrients when life stage nutrients were compared among formulations. This is inconsistent with current literature as nutrient requirements for cats and dogs in all life stages (i.e., growth and maintenance) are higher than those for maintenance only (2). Therefore, diets that are formulated for adult and senior animals are oversupplying individual nutrients. When formulas intended for dogs or cats were compared, there were no significant differences among formulations of the nutrients analyzed, despite the different nutritional requirements of dogs and cats (2). Similarities in the nutrient composition of dog and cat specific formulations can be partially attributed to recent trends in the pet food industry. Retail trends such as meat-rich and high-protein formulations for dogs have had a dramatic effect on the nutrient composition of pet food formulations (15). The AAFCO (4) recommends CP requirements for dogs in maintenance at 18% on a dry matter basis presuming that the diet contains a caloric density of 4000 kcal/kg, yet there are products in the current North American market, not included in this study, that report as much as 69.3% protein on a DM basis. Although an oversupply of protein is important for maintenance of lean body mass in aging animals (3), it is not appropriate for dogs and cats at all life stages. Apart from the continued debate that high dietary protein consumption is believed to play a role in the etiology of renal disease (16,17), undigested protein is simply fermented and excreted in feces producing odor compounds (18). Furthermore, AA absorbed above requirements are catabolized and used as an energy source, increasing nitrogen excretion in urine without further benefit to the animal. Excessive nitrogen excretion negatively impacts the environment due to the increased acidification and eutrophication of soil. Overall, the high protein trend in pet food, especially in adult dog food, results in potentially negative consequences for

dogs and the environment, and compromises the sustainability of protein ingredients (19–22) used in the pet food industry. Inaccurate quantification of fat, ash, and moisture will result in an incorrect prediction of energy content and an increased risk of urinary stone formation (10,23).

In conclusion, the present findings suggest that a large portion of Canadian pet food product selected herein fail to meet the GA and claims made for their products. Because of these inadequacies, pet food manufacturers are failing to meet the requirements of the *Consumer Packaging and Labelling Act.* The pet foods analyzed in this study had similar nutrient profiles labelled as intended for different species and/or life stages. The latter is of importance as oversupply of nutrients above nutrient requirements may negatively impact the health status of dogs and may increase the price of food. Pet food companies need to ensure that they are accurately tracking the nutrient content of incoming ingredients and outgoing final products to ensure that the consumer receives accurate product information. CVJ

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