Study of ingredients and nutrient composition of commercially available treats for dogs

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Abstract

Forty-one dog treats were selected from the market with the aim of providing more insight into supplemental pet food composition. Thirty-two products (four biscuits, nine tender treats, two meat-based strips, five rawhides, eight chewable sticks, four dental care sticks) were analysed for proximate nutrient composition and quantification of minerals, hydroxyproline (Hyp), starch, glucose, fructose and sucrose. Labelled ingredients were often expressed as non-specific categories. A treat supplied a mean of 332.0±39.2kcal metabolisable energy (ME)/100g, and the most energy-dense product was a tender treat (475.0 kcal ME/100g). Small dogs receive the highest percentage of maintenance energy requirement when producers' feeding instructions are followed. Treat categories revealed variability in dry matter, crude protein, ash, Hyp and starch. Rawhides showed the highest Hyp content. Simple sugars were identified in most treats, and sucrose was the most prevalent. Results of the study suggest treat labelling should include more information on the ingredients used, and the varying nutrient and caloric density of treats should be considered. Specific attention should be given to the use of treats in dogs with specific ingredient sensitivities or nutrient considerations.

Introduction

Dog treats represent the fastest growing segment of the pet food industry today, and nearly every pet food brand produces many types of treats.1 The latest EU regulation[2] states that dog treats should be labelled as 'complementary feed', which is legally defined as 'compound feed which has a high content of certain substances but which, by reason of its composition, is sufficient for a daily ration only if used in combination with other feed'. European feed law also establishes rules and requirements for labelling to provide adequate information for consumers.[2]

Little is known about the nutritional value of treats and their impact on the dog's diet, health and wellness despite the popularity of such products. Previous studies performed on treats have assessed their microbiological quality with specific regard to the potential risk of bacteria[1] contamination for dogs and human beings rather than evaluating their chemical composition.[3–6] Moreover, treats are not intended to contribute significantly to the daily ration, but they may be given in quantities that impact total energy intake. Therefore, feeding instructions should provide clear recommendations on how not to overfeed dogs as suggested by FEDIAF Nutritional Guidelines for Complete and Complementary Pet Food for Cats and Dogs.[7] The literature[8 9] clearly demonstrated treats to be a risk factor for the development of excess body fat in dogs.

The aim of this study was to provide greater insight into the nutrient composition and ingredients used in the production of dog treats given the scarce information presently available in the literature. A secondary aim was to verify whether producer's daily intake recommendations on the label were in accordance with the common recommendation that treats should not exceed 10 per cent of maintenance energy requirement (MER).[10] Analyses were inclusive of quantification of minerals, starch, simple sugars and the amino acid hydroxyproline.

These analytes were selected to provide information about protein quality and the presence of potentially high amounts of minerals or simple sugars, which may be of importance in managing certain nutritionally responsive disease conditions.

Materials and methods

Sample recruitment and classification

Forty-one dog treats of different international pet food brands were collected from different stores (pet shops and supermarkets); the most popular and purchased ones, according to the shop assistants, were chosen. The selected samples were divided into six categories as follows: five biscuits, ten tender treats, three meatbased strips, five rawhides, twelve chewable sticks and six sticks for dental care. Biscuits included dry treats mainly made of cereals, similar to those manufactured for human consumption; tenders were small semimoist treats having meat and cereals as main ingredients; meat-based strips were rectangular pieces of dry meat; rawhides were bone-shaped treats made of bovine skin; chewable sticks were semimoist to dry sticks made of various ingredients; and dental care sticks were identified by a label that reported an oral health benefit.

Label reading

Labels of the selected samples were examined and the following data were recorded using commercially available software (Excel, Microsoft): product name, brand, number and type of ingredients and their label order, analytical composition (moisture, when stated; crude protein (CP); ether extract (EE); crude fibre (CF); ash), net weight and/or number of pieces per pack, recommended quantities of treats/day, and place of production. Nitrogen-free extract (NFE) was calculated from label information (100 per cent – moisture – crude protein – crude fat – crude fibre – ash).

For each sample, metabolisable energy (ME, expressed as kcal/100g) was calculated using the predictive equation for energy content based on the 'modified Atwater' factors of 3.5, 8.5 and 3.5 on as-fed basis for protein, fat and NFE, respectively.[7] A value of 10 per cent moisture was assumed if moisture was not stated in the label because regulations do not require a moisture declaration if the content is less than 14 per cent (according to European Regulation (EC) No 767/2009).[2] If more than one treat was contained in a package, two or three were weighed in order to obtain the mean weight of each sample. The mean weight of each treat (expressed as g) was then multiplied by the calculated ME/g value, and the mean caloric amount (kcal/piece) was obtained as the producers are not required to report it in the label according to the EU regulation (EC 767/2009).[2] Feeding recommendations (number of pieces/day), if provided on a label (as it is not mandatory in EU according to EC 767/2009),2 were converted into percentages of MER for a small, a medium and a large dog in order to investigate whether any treats exceeded 10 per cent. A 7-kg dog, a 15-kg dog and a 30-kg dog were chosen as reference bodyweight dogs, and their daily energy requirements were calculated according to the formula 95xkg Body Weight0.7511: 409 kcal, 724 kcal and 1218 kcal, respectively. The production site, if not explicitly reported, was obtained from the corporate code printed on the label.

Chemical analyses

Thirty-two of the 41 products (four biscuits, nine tender treats, two meat-based strips, five rawhides, eight chewable sticks and four dental sticks) were sent to the Chemical–NIRs–XRF Laboratory of the University of Padua for proximate analysis (dry matter, DM; CP; EE; CF; ash), and quantification of minerals (Calcium (Ca); Phosphorus (P); Sodium (Na); Potassium (K); Magnesium (Mg)), hydroxyproline (Hyp), starch and simple sugars (glucose; fructose; sucrose).

Proximate analysis and mineral quantification

The DM content was determined by oven-drying previously ground samples at 105°C for 24hours. CP content was determined according to the Kjeldahl method (EC 152/2009—annex III method C) and calculated using a nitrogen conversion factor of 6.25. EE analysis was performed according to method H, procedure B reported in annex III of the EC 152/2009, by Soxhlet extraction using petroleum ether. The CF was obtained by the Weende method according to the same regulation (EC 152/2009—annex III method I). Defatted samples were treated with boiling solutions of sulphuric acid and potassium hydroxide, and the residue was separated by filtration on sintered glass, washed, dried, weighed and heated in a furnace at 475°C–500°C. Weight loss after combustion was expressed as CF. The ash content was measured gravimetrically after combustion at 550°C until white, light grey or reddish ash was obtained, and subsequently cooled to environmental temperature (EC 152/2009—annex III method A). Mineral analyses (Ca; P; Na; K; Mg) were performed by the Inductively Coupled Plasma – Optical Emission Spectrometry (ICPOES) method (Spectro EOP, Ciros Vision) after microwave digestion (Association of Official Analytical Chemists 2000, 999.10).

Hyp quantification

Hyp determination in previously hydrolysed samples was performed by high-performance liquid chromatography (HPLC) technique following the previously published recommendations.12 13 A prior preparation was required to ensure the block of primary amine groups with o-phthalaldehyde and the derivatisation of the molecules with secondary amine groups, among which Hyp, with 9-fluorenylmethyloxycarbonyl chloride which developed highly fluorescent, stable compounds. Chromatographic analysis was performed using Shimadzu Series 10 Avp equipment with fluorimetric revelator based on the following operating conditions: SAX column 5µm, 150mm, inner diameter 4.6mm (Eurisco Diagnostica); mobile phase: mixture water/acetonitrile/buffer in the ratio of 45/50/5; injection volume: 10µL; room temperature; max work pressure 1800psi; mobile phase flow: 1.2mL/minute; fluorimeter RF10AXL, 260nm λ of emission and 330nm λ of excitement; and analytical time: 10minutes, Hyp reading at minute 5.4, and internal standard at minute 6.4. The volume (expressed as µL) of Hyp per litre of injected solution was multiplied by its own molecular weight (131.11g/mol) and by appropriate coefficients derived from the dilution ratio and the DM contained in the sample. The total content of Hyp was therefore expressed as milligram per 100g of sample. The Hyp content obtained by analysis permitted an indirect estimate of the treats' collagen content using the formula Hyp (%)x7.14.

Starch and sugar quantification

The starch content of each sample was quantified by HPLC technique using Shimadzu SLC10 Avp equipment with refractometric detector Refractive Index Detector 10A and software class VP 7 based on the following operating conditions: refractometer equipped with thermostatted cell at 40°C; H_2SO_4 0.0025 n; 0.6 mL/minute flow; analytical time: 10 minutes; injection volume: 20 µL; and Bio-Rad column HPX-87H-300×7.8 mm thermostatted at 90°C. Each sample (100 mg per glass tube) was finely milled with a 0.5 mm grid and had the following added: 3.9 mL of acetate buffer 0.1 M, pH 4.2 and α-amylase. The glass tubes were then placed in a water bath at 80°C for 15 minutes. After allowing cooling at room temperature, 1 mL of enzymatic solution (amyloglucosidase 5 g/L, Sigma A-7255 from Rhizopus mould) was added. The samples were then incubated in a stove at 40°C for 24 hours, centrifuged at 3500 g/ minute for 10 minutes and filtered with a 0.45-µm disposable filter. The refractometer determined the amount of glucose resulting from starch hydrolysis and from the glucose already contained in the sample, corrected according to the following formula:

% Starch as is = X ˜ 0.9 ˜ 10/weighted value ˜ 100

where X=glucose determined by HPLC or possibly corrected by the glucose contained in the sample before analysis; 0.9=glucose molecular weight (MW)/ glucose MW+H_2O ratio; and 10=sample dilution. The quantification of simple sugars (glucose, fructose and sucrose) was carried out according to Charles[14] by HPLC technique using a Shimadzu SCL10 Avp system with refractometric detector RID 10A and software class VP 7 based on the following operating conditions: refractometer equipped with thermostatted cell at 40°C; H_2O; 0.6 mL/minute flow; analytical time: 20 minutes; injection volume: 20 µL; and Bio-Rad column HPX-87C-300×7.8 mm thermostatted at 90°C. Every sample was extracted with aqueous solution, centrifuged and filtered with a 0.45-µm disposable filter. The refractometer determined the total amount of glucose, fructose and sucrose in the sample, expressed as mg/mL, according to the following formula:

Simple sugar(g/100 g of the sample) =(extracted sample(mg/mL)) extraction volume/sample weight(g) ˜ 100/1000

The amount of glucose obtained with this analysis was subtracted from the amount of starch to reduce the over-rated error of the starch due to the presence of free sugar in the sample. Sucrose was not hydrolysed; therefore, the amounts of free glucose and fructose were not overestimated.

Results

Information collected from labels

Ten treats (24 per cent) were composed of one to three ingredients; 20 (49 per cent) were composed of four to six ingredients, and 11 (27 per cent) were composed of seven to nine ingredients. The composition of the treats was indicated on the label by a list of specific ingredients and in most cases by category of ingredients (eg, 'meat and animal derivatives', 'cereals'). The most widely represented ingredient categories were 'meat and animal derivatives' (n=35), 'vegetable by-products' or 'vegetable protein extracts' (n=32), 'cereals' (n=29), 'minerals' (n=27), 'oils and fats' (n=22) and 'sugars' (n=17). Minor ingredients included 'glycerol'/'glycerin' or 'sorbitol' (n=12), which are used as sweeteners and emulsifiers, 'yeasts' (n=5), 'milk and milk derivatives' (n=5), 'fish and fish by-products' (n=4), 'seeds' (n=4), 'aromatic plants' (n=4), 'eggs and egg derivatives' (n=2) and 'additives' (n=1). 'Meat and animal derivatives' was the first ingredient in 21 products and 'cereals' in 18. The second leading ingredient categories listed were 'vegetable by-products' or 'vegetable proteins extracts' (n=14), 'meat and animal derivatives' (n=9) and 'cereals' (n=8). The third ingredient was most commonly 'vegetable by-products' (n=8), 'sugars' (n=7), 'minerals' (n=6) and 'vegetable protein extracts' (n=3). Biscuits and dental sticks had 'cereals' mentioned as the first ingredient of the list, while tenders, meat strips, rawhides and chewable sticks had 'meat and animal derivatives' as the first.

The caloric density of each category of treat (kcal ME/100g) calculated from the label is reported in Table 1. The most calorically dense treats were biscuits, whereas the least calorically dense were dental sticks. A treat supplied 303.5±46.8kcal ME/100g on average.

When caloric density was expressed as kcal/treat, rawhides were the heaviest and the most energy-dense products, followed by chewable sticks and dental sticks (Table 1). The feeding instructions were reported in the label of 21 products, none of which was a rawhide (so one piece per day was assumed). If the feeding instructions were followed, biscuits and rawhides provide the highest percentage of MER for small-sized and medium-sized dogs, while biscuits and chewable sticks provide the highest percentage for big-sized dogs (Table 2). On average, biscuits accounted for 16 per cent of MER for dogs of any size; rawhides exceeded 25 per cent MER for small-sized dogs and 18 per cent MER for medium-sized dogs; chewable sticks surpassed 10 per cent MER for all size dogs, reaching 16.9 per cent MER in small-sized dogs; the feeding instructions of dental sticks remained below 10 per cent MER for every dog size.

The most common origin country of the selected treats was Germany (35 per cent of the samples), followed by China (18 per cent), Hungary (13 per cent), UK (10 per cent), Italy (8 per cent), Holland (5 per cent), Thailand (5 per cent), France (3 per cent) and Spain (3 per cent).

Chemical analysis of 32 treats

The results of the chemical analyses divided by treat category are shown in Table 3. In agreement with the labels reading in the previous section, the proximate analysis revealed that biscuits are the most caloric treat type with 351.3±16.5kcal ME/100g. All categories showed DM of greater than 80 per cent, with biscuits showing the highest and meat strips the lowest mean value. Tenders also showed the most variable DM content, with the lowest and highest values recorded among all treats. Rawhides had the highest CP value, while tenders had the highest fat content. Selected treats were generally low in fibre, ranging from 0.2 to 13.9g/1000 kcal. Rawhides showed the lowest ash level, whereas the remaining categories ranged from 17 to 25g/1000 kcal on average, with a tender product reaching up to 42.5g/1000 kcal. Although high variability among treat categories was detected also in Ca, P, K, Mg and Na, no significant differences were apparent.

The treat category with the highest Hyp content was rawhide; chewable sticks showed a high mean level (6.9±9.9g/1000 kcal), while the other categories recorded an average Hyp content lower than 2.5g/1000 kcal.

Hyp/CP ratio calculation showed that Hyp accounted for 19.1 per cent of the protein content of rawhides on average, 4.6 per cent of chewable sticks, 3.2 per cent of dental sticks, 2.1 per cent of meat strips, 1.7 per cent of tenders and 1.0 per cent of biscuits. Estimated collagen, expressed as average per treat category, was distributed as follows: 83.4 per centDM in rawhides, 20.0 per centDM in chewable sticks, 6.1 per centDM in meat strips, 4.1 per centDM in tenders, 2.0per cent DM in dental sticks and 1.3 per centDM in biscuits. Starch was one of the nutrients with the highest variability: dental sticks and biscuits showed the highest content, while rawhides had no starch. A wide variability in sucrose content was observed among treat categories, and the maximum concentrations detected were 35.9g/1000 kcal in a biscuit and 51.7g/1000 kcal in a tender treat.

Low glucose and fructose concentrations were found in most treats, and no significant differences among treat types emerged. Rawhides contained no measurable sugars.

Discussion

Literature addressing the nutrient composition of common treats is lacking. Most studies conducted on these products assessed whether any bacterial contamination poses risks to consumers and possibly to pet owners.[3–6] For example, Freeman and others[5] collected 26 bully stick treats for dogs, but beyond microbiological testing, only five were submitted to proximate analysis. Therefore, our study is the first that reports and compares the nutrient composition of different categories of treats. The findings demonstrated that dog treats varied widely in chemical composition among the categories considered and even among products in the same category.

Information on the label is an important benchmark in feeding practices for both owners and veterinarians.

This study revealed that 76 per cent of the selected treats contained from four to nine ingredients, and that ingredients were not precisely described on the label. It is significant that the ingredient categories listed most often in treats were ‘meat and meat derivatives’, ‘vegetable by-products’ and ‘cereals’, none of which permitted the identification of the precise animal or plant species in question. Categories of ingredients are allowed to be listed on complementary pet food rather than single and specific ingredients, according to the European Regulation (EC) No 767/2009 – Article 17 (2) I,[2] and this lack of clarity confirms that the use of these products should be strictly avoided with dogs undergoing an elimination diet whenever adverse food reactions may be suspected.[15]

Interestingly, many treats are composed of ingredients not usually seen in maintenance pet food, such as ‘milk and milk derivatives’, and ‘sugars’ and sweeteners such as glycerol, glycerin and sorbitol, which were listed in the labels of many products (almost half of products mentioned ‘sugars’ on the label’s ingredient list). It is well-known that dogs appreciate sweet taste,[16] so sugars may have been added by producers to increase treat palatability (although glycerol, glycerin and sorbitol are also used as emulsifiers or humectants). ‘Milk and milk derivatives’ was listed in the labels of five of the selected treats, and this should be taken into consideration when feeding treats to dogs with known intolerance to these foods and their derivatives. The ingredients on the label must be listed in descending order by weight, inclusive of water weight, as per Regulation (EC) No 767/2009 Article 17[2]; in the treats selected in this study, it is clearly evident that the ingredients at the top of the list are ‘meat and meat derivatives’ and ‘cereals’.

The energy value of treats was previously investigated in two studies.[5 17] The former study included only three products; however, among those, a rawhide with a reported digestible energy of 334.4 kcal/100g is unfortunately incomparable with the mean ME value we calculated using ‘modified Atwater’ factors for our five rawhides (309.5 kcal/100g). Freeman’s study calculated the ME content to a mean value of 301 kcal/100g using ‘modified Atwater’ factors in five bully sticks, a type of product which was not included in our study because it is unavailable in the Italian market. According to the World Small Animal Veterinary Association (WSAVA) nutritional assessment guidelines,[10] daily treat intake should not exceed 10 per cent of the dog's energy requirement in order to avoid dietary imbalances.

The MER estimation calculated in the present study for a small-sized, medium-sized and large-sized dog revealed that producers should reconsider the feeding instructions (number of treats/day) they provide on labels, especially for small dogs. This result agrees with the finding of Freeman and others,[5] who demonstrated that an average-sized 6' bully stick provides 30 per cent of the daily calorie requirements for a 4.5-kg dog. Unlike in EU countries, American pet food manufacturers are required to report the caloric density of all types of treats in the label,[18] except for rawhides which are not included in this category. Because the use of treats has been considered a risk factor for obesity in dogs,[8 9] the energy content per piece of treat should be added to packaging labels in order to help veterinarians recommend the proper daily intake for each individual.

Treats must be carefully considered in feeding regimens of dogs afflicted with chronic heart failure (CHF) and chronic kidney disease (CKD) due to their potential high mineral content.[16] However, conflicting literature is available on the importance of mineral modifications for some nutrients like sodium and no studies have addressed the impact of treats. The minerals to be kept under closest control in the disorders above are P and Na. Given that the recommended P and Na concentrations for foods used in managing CKD and CHF in dogs range from 0.2 to 0.5 per cent DM and 0.3 per cent DM (estimated 500–1250mg/1000 kcal and 750mg/1000 kcal for a diet containing 4000 kcal/kg DM) or less at late stage of the diseases, respectively,16 only rawhides respected the P recommendations for P intake, whereas meat strips, chewable sticks and dental sticks failed to fulfil those for Na. An online questionnaire used in a study by Freeman and others[19] to determine the dietary patterns and intake of nutrients of concern in dogs with cardiac disease showed that even when owners fed dogs low Na dog food, they may be adding large amounts of Na to the diet (25 per cent of total daily intake, on average) via treats and foods used to administer pills. Therefore, veterinarians should consider treats in the feeding regimens of CKD and CHF patients and evaluate whether the products owners feed are suitable for their dogs. Rawhides, whose only ingredient is dried bovine skin, were the treats richest in Hyp, and recent findings suggest that the consumption of Hyp-containing protein sources should be discouraged for dogs prone to calcium-oxalate urolith formation.[20] A study by Dijcker and others[21] showed Hyp to be related to the synthesis of endogenous oxalate, a potential substrate in the formation of calcium-oxalate uroliths in dogs and cats. A recent study[20] involving cats demonstrated that collagen tissue-rich diets (collagen is the protein source in which Hyp is most concentrated) significantly increased urinary oxalate excretion proportionally to Hyp intake. No recommended levels of dietary Hyp have been proposed thus far, but this study suggests that the use of products such as rawhides should be minimised in calcium-oxalate preventive regimen diets.

Starch was predictably the main nutrient in dental sticks and biscuits because both categories had 'cereals' as the first ingredient in the list. Interestingly, some products showed very high levels of sucrose (maximum 51.7g/1000 kcal in one product), which was more than 5 per centDM in half of the selected treats. As reported above, dogs like sweet taste,16 so producers may add sugars as palatability enhancers or as humectants in semimoist products. In dogs fed diets containing high concentrations of lactose and sucrose (>10 per centand 30 per centDM, respectively), higher water content was observed in small and large intestine chyme and in faeces as well.[11] However, as treats generally comprise a small portion of a pet's diet, even those treats with sugars higher on the ingredient list would be unlikely to cause clinically significant changes in faecal quality.

The small number of treats that were analysed per each category is one limitation of this study. This is the first investigation that aimed to categorise dog treats and to determine their nutrient profile, and future studies should sample a greater number of products to provide more precise data. Also, these results may not be representative of all products worldwide given the wide number of dog treats available on the market of many countries to state that. More research is needed to augment the availability of data about complementary pet food.

In conclusion, the treat categories considered in this study showed wide variability in chemical composition. Dog treats are usually made of numerous ingredients, which are often undefined because their specific name is replaced by the name of the category to which the feed materials belong; in many cases sugars are mentioned among the ingredients listed. Treat labelling should be more explicit and provide more detailed information on ingredients. Given that treats have been identified as a risk factor in making dogs overweight, product energy values should also be specified in order to help veterinarians prescribe proper amounts for dogs, especially those of small size. Treats contain varying amounts of minerals, and because more specific information is not available on the label, caution should be adopted when feeding treats to individuals requiring mineral restrictions in their diet. Rawhides contain a high concentration of Hyp and for this reason should be avoided in dogs predisposed to calcium-oxalate urolith formation. Further studies are deemed necessary in order to compare treats of similar categories selected from different markets with the results provided here.

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TABLE 1: Mean value, sd, and minimum and maximum of metabolisable energy (ME, kcal/100g), treat weight (g) and treat caloric density (kcal/treat) per category of treats

	ME* (kcal/100g) from label			**Weight/treat (g)**			**Caloric density (kcal/treat)**		
	Mean±sd	Min	Max	Mean±sd	Min	Max	Mean±sd	Min	Max
Biscuits	329.2±13.0	307.4	339.9	6.5±3.5	2.9	11.8	21.7±11.6	10.2	37.6
Tenders	312.2±70.6	252.5	484.3	3.5±3.9	0.7	12.0	10.9±12.6	1.9	37.3
Meat strips	284.4±19.2	262.8	299.1	10.0±0.6	9.2	11.0	28.6±1.5	27.4	30.3
Rawhides	309.5±20.6	296.3	340.1	45.0±16.0	27.4	68.5	132.5±44.4	83.7	161.8
Chewable sticks	294.0±25.9	251.0	337.1	33.3±63.8	5.8	214.2	97.7±191.3	20.9	640.8
Dental sticks	267.7±17.6	246.5	293.9	20.4±9.7	7.5	30.8	55.4±27.1	20.0	82.5

*Calculated using the FEDIAF formula: kcal ME/100g =% crude protein x 3.5+% crude fat x 8.5+% NFE x 3.5. NFE, nitrogen-free extract.

TABLE 2: Mean value and sd of the percentage of the daily metabolisable energy requirement (MER)* of a small-sized/medium-sized/big-sized dog supplied by the different categories of treats, according to the feeding indications reported on the label.

	% MER 7-kg dog (409 kcal/day)	% MER 15-kg dog (724 kcal/day)	% MER 30-kg dog (1218 kcal/day)
	Mean±sd	Mean±sd	Mean±sd
Biscuits	16.4±12.6	16.9±12.1	16.8±11.7
Tenders	10.1±3.8	10.0±3.5	9.7±3.2
Meat strips	10.5±4.1	10.0±2.5	9.6±0.6
Rawhides	25.5±7.2	18.3±5.1	10.9±3.0
Chewable sticks	12.2±1.7	12.4±2.9	16.9±14.6
Dental sticks	7.8±3.4	7.9±4.1	4.7±2.5

*MERs were calculated according to the following formula: 95xkg Body Weight$^{0.75}$.[11]

TABLE 3: ME, DM and nutrient composition (mean±sd, min, max) obtained from the proximate analysis of treats divided into categories

	Biscuits	Tenders	Meat strips	Rawhides	Chewable sticks	Dental sticks
	Mean±sd (min–max)	Mean±sd (min–max)	Mean±sd (min–max)	Mean±sd (min–max)	Mean±sd (min–max)	Mean±sd (min–max)
ME* (Kcal/100g)	351.3±16.5 (331.6–372.0)	337.6±65.2 (281.9–475.0)	302.8±5.8 (298.6–306.9)	349.0±13.0 (328.4–363.9)	327.4±22.3 (299.0–353.5)	302.9±6.6 (297.1–311.1)
DM (%)	89.9±1.3 (88.6–91.6)	82.5±7.1 (70.6–95.8)	80.2±3.3 (77.9–82.6)	87.9±1.1 (86.2–89.0)	82.9±3.7 (79.1–86.8)	84.7±2.3 (81.2–86.0)
CP (g/1000 kcal)	47.0±12.0 (36.7–62.4)	78.0±31.3 (19.2–118.7)	99.8±14.2 (89.8–109.9)	171.9±67.5 (78.0–244.6)	108.9±54.1 (22.0–204.2)	29.4±15.6 (10.8–48.9)
EE (g/1000 kcal)	27.0±9.5 (15.8–35.9)	29.2±16.0 (5.3–54.9)	24.8±9.8 (17.9–31.8)	10.7±9.9 (1.2–23.7)	19.7±15.4 (4.8–53.9)	11.5±3.7 (6.5–14.6)
CF (g/1000 kcal)	6.7±3.1 (3.4–10.1)	3.7±2.1 (0.2–6.8)	8.6±3.5 (6.1–11.1)	5.8±5.7 (0.7–13.9)	3.6±1.6 (1.8–6.3)	3.1±2.9 (0.6–7.3)
Ash (g/1000 kcal)	17.1±3.5 (13.7–21.2)	20.7±11.9 (6.2–42.5)	25.0±10.8 (17.4–32.6)	5.7±4.8 (1.9–13.4)	17.9±10.4 (5.5–34.1)	25.5±4.3 (21.2–31.2)

Calcium (g/1000 kcal)	2.8±1.2 (1.1–3.5)	3.6±3.5 (0.2–11.2)	3.0±0.6 (2.6–3.4)	1.3±1.5 (0.1–3.9)	3.6±3.4 (0.2–9.9)	4.5±1.5 (3.0–6.6)
Phosphorus (g/1000 kcal)	2.3±0.9 (1.1–3–1)	2.9±2.4 (0.3–8.4)	2.9±0.6 (2.5–3.3)	0.2±0.3 (0.0–0.8)	1.9±1.6 (0.1–4.4)	2.2±1.5 (0.6–3.9)
Sodium (g/1000 kcal)	0.7±0.6 (0.3–1.5)	0.5±0.5 (0.0–1.4)	1.9±2.3 (0.3 – 3–6)	0.6±0.4 (0.3–1.2)	1.1±1.4 (0.3–4.5)	0.8±0.8 (0.2–2.0)
Potassium (g/1000 kcal)	2.6±1.8 (0.5–5.0)	2.0±1.3 (0.0–3.6)	2.5±0.8 (2.0–3.0)	3.4±1.6 (1.8–5.7)	4.1±2.6 (1.2–8.2)	3.3±1.3 (1.6–4.9)
Magnesium (g/1000 kcal)	0.4±0.1 (0.2–0.5)	0.3±0.3 (0.1–0.9)	0.4±0.0 (0.4–0.4)	0.2±0.2 (0.0–0.5)	0.2±0.0 (0.1–0.2)	0.3±0.1 (0.1–0.4)
Hyp (g/1000 kcal)	0.5±0.2 (0.3–0.8)	1.5±1.2 (0.0–3.3)	2.3±2.5 (0.5–4.0)	29.5±5.2 (20.4–33.0)	6.9±9.9 (0.1–26.3)	0.8±0.4 (0.4–1.1)
Starch (g/1000 kcal)	107.9±32.5 (63.6–135.6)	56.1±39.8 (0.0–137.4)	38.8±24.0 (21.8–55.8)	0.0±0.0 (0.0–0.0)	55.0±61.7 (0.0–186.3)	155.6±33.9 (112.1–194.7)
Glucose (g/1000 kcal)	0.8±1.0 (0.2–2.3)	2.3±2.8 (0.0–8.1)	0.7±0.5 (0.3–1.0)	0.0±0.0 (0.0–0.0)	0.3±0.4 (0.0–1.0)	0.1±0.2 (0.0–0.4)

Fructose (g/1000 kcal)	0.6±0.4 (0.2–1.0)	1.2±2.1 (0.1–6.6)	0.6±0.2 (0.4–0.7)	0.0±0.0 (0.0–0.0)	0.5±0.6 (0.0–1.7)	0.2±0.2 (0.0–0.5)
Sucrose (g/1000 kcal)	13.3±15.3 (2.9–35.9)	11.8±17.4 (0.4–51.7)	13.9±16.1 (2.5–25.3)	0.0±0.0 (0.0–0.0)	3.0±4.9 (0.0–14.5)	0.9±1.1 (0.0–2.0)

Percentage energy digestibility=91.2–(1.43xpercentage crude fibre in dry matter).

*Calculated using the National Research Council formula:

GE, (5.7xg protein)+(9.4xg fat)+[4.1x(g NFE+g fibre)].

DE, (GExpercentage energy digestibility/100).

ME, DE –(1.04xg protein).

CF, crude fibre; CP, crude protein; DE, digestible energy; DM, dry matter; EE, ether extract; GE, gross energy; Hyp, hydroxyproline; ME, metabolisable energy; NFE, nitrogen-free extract.