Evaluation of meat meal, chicken meal, and corn gluten meal as dietary sources of protein in dry cat food

Masayuki Funaba, Yuko Oka, Shinji Kobayashi, Masahiro Kaneko, Hiromi Yamamoto, Kazuhiko Namikawa, Tsunenori Iriki, Yoshikazu Hatano, Matanobu Abe

Abstract

The nutritional value of meat meal (MM), chicken meal (CM), and corn gluten meal (CGM) as dietary sources of protein in dry food formulated for adult cats was evaluated. Twelve healthy adult cats (11 males and 1 female) were used. Dry diets containing MM, CM, or CGM as the main protein source were given for a 3-week period in a 3×3 Latin-square design. Digestion and balance experiments were conducted during the last 7 d of each period. In addition, freshly voided urine was taken to determine urinary pH and number of struvite crystals. As compared with the CM diet, dry-matter digestibility was higher and lower for the MM and CGM groups, respectively. Percentages of nitrogen (N) absorption and N retention to N intake were higher in the MM group, and N utilization was not different between the CM group and the CGM group. All cats excreted alkaline urine ($pH > 7$). Urinary pH, struvite activity product, and number of struvite crystals in urine were lower for the CGM group. There was no difference in retention of calcium and magnesium among the groups. From the point of view of digestibility and N utilization, MM is superior to CGM, and CM is better than or equivalent to CGM as a protein source of dry foods for adult cats. However, when CM is used as a dietary protein source, some manipulation of dietary base excess may be needed to control urinary acid-base balance, because CM contains higher calcium and phosphorus.

Résumé

La valeur nutritive de farine de viande (MM), de farine de poulet (CM) et de farine de gluten de maïs (CGM) comme source alimentaire de protéines dans une ration sèche formulée pour chats adultes a été évaluée chez douze chats adultes en santé (11 mâles et 1 femelle). Les rations sèches à base de MM, CM ou CGM comme source principale de protéines ont été données durant une période de 3 semaines selon un plan expérimental en carré latin de 3×3. Des expériences de digestion et de balance ont été menées durant les 7 derniers jours de chaque période. De plus, de l'urine fraîchement éliminée a été prélevée afin de déterminer le pH urinaire et le nombre de cristaux de struvite. Comparativement à la ration CM, la digestibilité de matière sèche était supérieure et inférieure, respectivement, pour les groupes MM et CGM. Les pourcentages d'absorption d'azote (N) et de rétention de N par rapport à l'ingestion de N étaient supérieurs dans le groupe MM, et l'utilisation de N n'était pas différente entre les groupes CM et SGM. Tous les chats excrétaient une urine alcaline ($pH < 7,0$). Le pH urinaire, l'activité des produits de struvite et le nombre de cristaux de struvite dans l'urine étaient inférieurs pour le groupe CGM. Il n'y avait pas de différence dans le taux de rétention de calcium et magnésium parmi les groupes. Du point de vue de la digestibilité et de l'utilisation de N, la ration MM est supérieure à la ration CGM, et la ration CM est meilleure ou équivalente à la ration CGM comme source de protéines dans une ration sèche pour chats adultes. Toutefois, lorsque CM est utilisé comme source de protéine alimentaire, certaines manipulations de l'excès de bases alimentaires pourraient s'avérer nécessaires afin de contrôler la balance acide-base urinaire, étant donné que CM a une teneur plus élevée en calcium et phosphore.

(Traduit par Docteur Serge Messier)

Introduction

Cats are carnivores with several metabolic characteristics. Cats require relatively high amounts of protein, specific amino acids, essential fatty acids, and vitamins that are abundant in animal tissues (1–3). Although, not only the quantity but also the quality of diet is known to affect nutritional status of cats, nutritional value of the individual food ingredient is not fully characterized.

The nutritional value of fish meal (FM), meat meal (MM), and corn gluten meal (CGM) as the major protein source for healthy adult cats was previously examined (4,5). As a result, it was found that apparent digestibility and nitrogen (N) balance did not differ between FM and CGM (4). By contrast, the apparent digestibility, N, and mineral retention were higher in the MM diet than in the CGM diet, suggesting the superiority of MM over CGM and FM as an ingredient of dry cat foods (5). However, since the occurrence of bovine spongiform encephalopathy in Japan, the use of MM or meat and bone meal (MBM) as a pet food ingredient has been prohibited. Therefore, some other ingredients, which are safe and are nutritionally equivalent to MM or MBM, are required. In the study reported here, we examined the nutritional value of MM, CGM, and chicken meal (CM) as the main protein source of dry cat foods.

Laboratory of Nutrition, Azabu University School of Veterinary Medicine, 1-17-71 Fuchinobe, Sagamihara 229-8501, Japan (Funaba, Oka, Kobayashi, Namikawa, Iriki, Abe); Research and Development Center, Nosan Corporation, 5246 Takura, Tsukuba 300-2615, Japan (Kaneko, Yamamoto, Hatano).

Address all correspondence and reprint requests to Dr. Masayuki Funaba; telephone: 81 42 754 7111(276); fax: 81 42 754 7661; e-mail: funaba@azabu-u.ac.jp

Received June 18, 2004. Accepted March 29, 2005.

Table I. Dietary ingredients of 3 dry diets

Ingredients (g/kg of diet)[a]	Diet MM	CM	CGM
Meat meal (MM)	300	0	0
Chicken meal (CM)	0	355	0
Corn gluten meal (CGM)	0	0	346
Corn	519	519.5	486
Cellulose powder	15	15	15
Beef tallow	75	60	50
D,L-methionine	1	0.5	0
Vitamins and minerals[b]	20	20	20
$Ca(PO_4)_2$	35	0	48
$CaCO_3$	5	0	5
Flavor[c]	30	30	30

[a] Determined on an as-fed basis

[b] One kilogram of the vitamin and mineral mixture contained 2 250 000 IU of vitamin A, 35 g of vitamin E, 2.2 g of vitamin B_1, 2.3 g of vitamin B_2, 1.6 g of vitamin B_6, 8.5 mg of vitamin B_{12}, 20 g of nicotinic acid, 5 g of pantothenic acid, 22 mg of biotin, 185 g of choline, 10 g of inositol, 450 mg of folic acid, 39 g of sodium, 187 g of potassium, 230 g of chloride, 600 mg of manganese, 6.5 g of iron, 33 mg of cobalt, 420 mg of copper, 500 mg of iodine, and 500 mg of taurine

[c] Spray-dried fish extract

Table II. Composition of 3 dry diets

Component	Diet MM	CM	CGM
Metabolizable energy (kcal/100 g)	384	385	394
Crude protein (% of dry matter)	32.4	29.4	30.9
Acid ether extract (% of dry matter)	13.9	15.0	10.9
Crude fiber (% of dry matter)	0.8	0.8	0.8
Crude ash (% of dry matter)	9.0	9.2	8.7
Nitrogen-free extract (% of dry matter)	45.4	45.4	48.7
Sodium (% of dry matter)	0.54	0.33	0.40
Potassium (% of dry matter)	0.59	0.60	0.60
Calcium (% of dry matter)	1.99	2.31	2.08
Phosphorus (% of dry matter)	1.32	1.34	1.35
Magnesium (% of dry matter)	0.11	0.11	0.09
Chloride (% of dry matter)	0.75	0.55	0.59
Amino acids (% of dry matter)			
Arginine	1.77	1.59	1.01
Cystine	0.36	0.37	0.48
Histidine	0.47	0.56	0.62
Isoleucine	0.75	0.73	1.08
Leucine	1.85	1.87	5.15
Lysine	1.51	1.51	0.83
Methionine	0.74	0.73	0.74
Phenylalanine	0.94	0.98	1.98
Taurine	0.12	0.12	0.12
Threonine	0.81	0.93	0.99
Tryptophan	0.26	0.18	0.16
Tyrosine	0.78	0.65	1.66
Valine	1.13	0.93	1.34
Base excess (mmol/kg of dry matter)[a]	352	472	353

[a] Base excess was calculated as 2[Ca] + 2[Mg] + [Na] + [K] − 2[P] − 2[methionine] − [Cl] (8)

Materials and methods

Cats

Twelve healthy, mixed-breed adult cats (11 sexually intact males and 1 sexually intact female), weighing between 3.0 and 5.5 kg (mean body weight [BW], 4.0 kg) were used in the study. The cats were considered clinically normal on the basis of results of physical examinations (hemograms, serum biochemical profiles, and urinalyses). All the cats were housed separately in metabolic cages in a temperature-controlled room (mean ± *s*, 24°C ± 2°C) with artificial light provided from 6 AM to 6 PM daily. Cats were cared for according to the principles outlined in the Institute for Laboratory Animal Research Guide for the Care and Use of Laboratory Animals (6).

Diet

Three dry diets were prepared with a twin-screw extruder. Dietary ingredients, dietary composition determined by chemical analyses, and base excess calculated from chemical composition were recorded for 3 diets (Tables I and II). Each diet contained $>$ 48% corn, and MM, CM, or CGM as the major protein source; crude protein from MM, CM, and CGM accounted for 80% of the total crude protein in each diet. Calcium (Ca) and phosphorus (P) contents were identical among the 3 diets; this was accomplished by the addition of Ca and P salts as appropriate. The diets contained crude protein, acid-ether extract, Ca, P, and magnesium (Mg) concentrations at or above the minimum amounts recommended by the Association of American Feed Control Officials (AAFCO) for maintenance (7). Dietary base excess calculated as 2[Ca] + 2[Mg] + [Na] + [K] − 2[P] − 2[methionine] − [Cl] (8) was slightly higher for the CM diet. A positive relationship between dietary base excess and urinary pH has been described (8,9).

Procedure

Digestion and balance experiments were conducted in a 3 × 3 Latin-square design. Cats were randomly assigned to 1 of the 3 diets for a period of 3 wk; there were 5 d between one period and the next. For the last 7 d of each dietary period, feces and urine were collected daily at 4 PM. The AAFCO recommends a precollection or adaptation period of 5 d followed by a 5-day period for collection of feces, when digestibility of dog and cat foods is determined. However, it was suggested in another study (10) that cats require a longer adaptation period than dogs. To measure availability of nutrients, feeding for 3 wk is recommended in cats (11).

Diets and water were available ad libitum throughout the study. Fresh food was provided daily at 4 PM. Intake of food and water was recorded each day, and BW was measured weekly. Urine was collected in a bottle containing 10 mL of 10% (vol:vol) sulfuric acid to prevent loss of ammonia and to prevent electrolytes from forming crystals, except when freshly voided urine was collected. In addition, we collected the first urine voided after 5 AM on each of the last 7 d of each dietary period and immediately used it to measure urinary pH and the number of crystals.

Table III. Mean (± s) values of daily food and water intakes, urine volume, dry-matter digestibility and fecal moisture content in 12 cats fed a dry diet containing meat meal (MM), chicken meal (CM), or corn gluten meal (CGM)

Variable	MM	CM	CGM
Food intake (g/kg of BW/d)	13.1 ± 1.3	14.6 ± 1.2	14.1 ± 1.5
Water intake (mL/kg of BW/d)	22.4 ± 1.9	24.2 ± 1.6	24.6 ± 1.4
Urine volume (mL/kg of BW/d)	12.2 ± 1.2	12.4 ± 0.9	11.2 ± 0.8
Dry-matter digestibility (%)	83.3 ± 0.5[a]	80.2 ± 0.8[b]	77.7 ± 1.0[c]
Fecal moisture content (%)	54.7 ± 1.4[a,b]	52.4 ± 1.7[b]	56.3 ± 2.4[a]

BW — Body weight

[a,b,c] Mean values which do not have a common letter in their superscripts differ at a significance level of $P < 0.05$

Table IV. Mean (± s) values of nitrogen (N) balance in 12 cats fed a dry diet containing meat meal (MM), chicken meal (CM), or corn gluten meal (CGM)

Variable	MM	CM	CGM
N (g/kg of BW/d)			
Intake	0.64 ± 0.06	0.65 ± 0.05	0.66 ± 0.07
Feces	0.06 ± 0.01[b]	0.09 ± 0.01[a]	0.09 ± 0.01[a]
Urine	0.47 ± 0.06	0.48 ± 0.04	0.48 ± 0.04
Absorbed	0.57 ± 0.06	0.56 ± 0.05	0.57 ± 0.06
Retained	0.10 ± 0.02	0.08 ± 0.03	0.08 ± 0.05
Percentage of N intake			
Feces	10.0 ± 4.0[b]	14.0 ± 3.9[a]	14.1 ± 6.2[a]
Urine	73.6 ± 0.5	74.7 ± 0.5	75.6 ± 0.8
Absorbed	90.0 ± 4.0[a]	86.0 ± 3.9[b]	85.9 ± 6.2[b]
Retained	16.4 ± 3.9[a]	11.3 ± 4.0[a,b]	10.3 ± 6.4[b]
Percentage of N absorbed			
That was retained	18.3 ± 4.4	13.1 ± 4.6	11.8 ± 7.3

BW — Body weight

[a,b,c] Mean values which do not have a common letter in their superscripts differ at a significance level of $P < 0.05$

Analysis of samples

The amino acid concentrations of each diet were determined by use of an amino acid analyzer (MLC-203; Atto, Tokyo, Japan). Samples were treated with performic acid for 16 h, and were then hydrolyzed with 20% (wt:vol) hydrochloric acid for 16 h at 135°C. Feces excreted during the sampling period were pooled for each cat. Aliquots of pooled feces were dried at 135°C for 2 h (12) or oven dried at 70°C for 5 d prior to chemical analysis. Daily excretion of nutrients into feces was calculated from nutrient contents in air-dried feces and dry-matter contents of pooled feces and air-dried feces.

Urine samples collected during the sampling period were also pooled for each cat and stored at −20°C till analysis. Urinary N, nitrogenous compounds, and minerals were analyzed as described elsewhere (4,13). The struvite activity product (SAP; $[Mg^{2+} \times NH_4^{+} \times PO_4^{3-}]$) was calculated; Mg was assumed to be in ionic form in urine, and NH_4^+ and PO_4^{3-} concentrations in the urine were estimated from the urinary pH and determined urinary concentrations of total ammonia and P (13). For convenience, SAP is expressed as pSAP, the negative logarithm of SAP (13–16). In contrast to SAP, pSAP is negatively related to struvite crystal formation (14). Urinary pH was measured using glass electrodes (HM-30S; Toa, Tokyo, Japan) immediately after urine was voided. The number of struvite crystals in the urine was counted using light microscopy.

Data analysis

Data were analyzed by analysis of vairance (ANOVA) (17) using a computer-based statistical program (SAS, Release 8.2; SAS Institute, Cary, North Carolina, USA). The model included diet, cat, and period. Results were considered significant at values of $P < 0.05$.

Results

All cats appeared to be healthy and manifested no clinical abnormalities throughout the study. Changes in BW during each period were minimal. Daily intake of food and water, urine volume, dry-matter digestibility, and fecal moisture content were determined for each diet (Table III). Dietary protein sources did not affect daily intake of food and water, nor urine volume. Dry-matter digestibility

Table V. Mean ($\pm s_{\bar{x}}$) values of urinary nitrogen (N) excretion of nitrogenous compounds relative to the total N in 12 cats fed a dry diet containing meat meal (MM), chicken meal (CM), or corn gluten meal (CGM)

Nitrogenous compounds (%)	MM	CM	CGM
Urea	91.9 ± 1.4	93.5 ± 1.6	93.8 ± 1.7
Ammonia	3.4 ± 0.7[b]	4.4 ± 0.6[a]	5.0 ± 0.5[a]
Creatinine	3.7 ± 0.2[a]	2.9 ± 0.2[b]	2.4 ± 0.2[c]
Creatine	0.15 ± 0.04	0.07 ± 0.02	0.09 ± 0.03
Total	99.1 ± 1.7[d]	100.9 ± 1.7[d]	101.3 ± 1.7[d]

BW — Body weight

[a,b,c] Mean values which do not have a common letter in their superscripts differ at a significance level of $P < 0.05$

[d] Total does not equal 100% because of rounding of values

Table VI. Mean ($\pm s_{\bar{x}}$) values of urinary pH, urinary concentrations of struvite constituents, negative logarithm of struvite activity product (pSAP), and urinary struvite crystals in 12 cats fed a dry diet containing meat meal (MM), chicken meal (CM), or corn gluten meal (CGM)

Variable	MM	CM	CGM
pH	7.99 ± 0.12[a]	7.58 ± 0.11[b]	7.08 ± 0.08[c]
Magnesium (mM)	4.50 ± 0.46[b]	6.85 ± 0.82[a]	4.70 ± 0.45[b]
Ammonium ion (mM)	86.3 ± 13.2[c]	117.1 ± 12.0[b]	147.8 ± 14.4[a]
Total phosphorous (mM)	36.1 ± 4.3[b]	40.9 ± 5.1[b]	54.6 ± 5.3[a]
Phosphoric acid ion ($\times 10^{-3}$ mM)	3.15 ± 5.92[a]	1.14 ± 1.27[b]	0.50 ± 0.45[b]
pSAP	9.27 ± 0.09[b]	9.20 ± 0.09[b]	9.61 ± 0.15[a]
Struvite crystals (No./μL of urine)	374.3 ± 42.1[a]	403.2 ± 70.3[a]	114.4 ± 34.4[b]

BW — Body weight

[a,b,c] Mean values which do not have a common letter in their superscripts differ at a significance level of $P < 0.05$

was significantly higher in the MM group than in the CGM group, which was consistent with the previous study (5). Dry-matter digestibility of the CM group was intermediate; it was significantly higher than that of the CGM group but lower than that of the MM group. Fecal moisture content in the CM group was significantly lower than that in the CGM group.

The N balance was determined for the 3 diet groups (Table IV). Consistent with daily food intake, daily N intake was comparable among the groups. Fecal N excretion was lower in the MM group than in the other 2 groups, resulting in the highest percentage of N absorption to N intake in the MM group. Dietary protein sources affected neither urinary N excretion nor percentage of urinary N to N intake. As a result, percentage of N retention to N intake in the MM group was higher than that in the CGM group, although it was not significantly higher than that of the CM group.

Urinary N excretion of nitrogenous compounds expressed as a percentage of total urinary N was calculated (Table V). More than 90% of the total urinary N was excreted in the form of urea. The percentage of urinary ammonia N was higher in the CM group and the CGM group than in the MM group. In contrast, the percentage of creatinine N was highest in the MM group, and intermediate in the CM group.

Urinary pH, urinary concentration of struvite constituents, pSAP, and number of urinary struvite crystals were determined in cats fed a diet containing MM, CM, or CGM (Table VI). All cats excreted alkaline urine ($pH > 7$); urinary pH of the MM group and the CGM group were highest and lowest, respectively. Urinary concentration of Mg was highest in the CM group, whereas urinary concentration of NH_4^+ was highest in the CGM group. The calculated PO_4^{3-} concentrations were lowest in the CGM group; PO_4^{3-} concentrations of the MM group and the CM group were 6.3-times and 2.3-times higher than those of the CGM group, respectively. As a result, pSAP value of the MM group and the CM group was significantly lower than that of the CGM group. Consistent with the notion that pSAP is negatively related to the formation of struvite crystals (14,18), the number of urinary struvite crystals of the MM group and the CM group was higher than that of the CGM group.

Mineral balance was determined in cats fed a diet containing MM, CM, or CGM (Table VII). Dietary Ca and P contents were planned to be equal among diets; however, the determined mineral contents were slightly different, although all diets met or exceeded the amount recommended by AAFCO (7) (Table II). As a result, intake of Ca and Mg was significantly different among the groups. Results were thus expressed not only on BW basis, but also as a percentage of intake. The major excretion route of Ca and Mg was via feces (> 90%). Dietary protein sources did not affect Ca and Mg retention, although Mg retention exhibited negative values in all of the cats. The percentage of fecal P to P intake in the CM group was significantly higher than that of the other 2 groups, whereas the percentage of urinary P to P intake was higher in the CGM group. As a result,

Table VII. Mean (± $s_{\bar{x}}$) values of mineral balance in 12 cats fed a dry diet containing meat meal (MM), chicken meal (CM), or corn gluten meal (CGM)

	Calcium balance			Phosphorus balance			Magnesium balance		
Variable	MM	CM	CGM	MM	CM	CGM	MM	CM	CGM
Intake (mg/kg of BW/d)	263.9 ± 27.4[b]	340.8 ± 27.9[a]	293.8 ± 30.4[b]	164.1 ± 17.0	185.9 ± 15.2	180.1 ± 18.6	13.6 ± 1.5[b]	15.9 ± 1.3[a]	12.9 ± 1.3[b]
Feces (mg/kg of BW/d)	265.8 ± 34.8	335.0 ± 34.1	304.1 ± 34.7	96.0 ± 9.5[c]	131.4 ± 13.0[a]	108.2 ± 10.4[b]	12.4 ± 1.5	15.0 ± 1.7	12.2 ± 1.3
Urine (mg/kg of BW/d)	0.08 ± 0.01[b]	0.26 ± 0.09[a]	0.12 ± 0.03[a]	19.6 ± 2.0[b]	20.2 ± 1.7[b]	25.0 ± 2.3[a]	1.4 ± 0.3[b]	2.1 ± 0.3[a]	1.4 ± 0.2[b]
Retained (mg/kg of BW/d)	−2.0 ± 14.5	5.5 ± 19.2	−10.5 ± 19.8	48.5 ± 7.9	34.4 ± 8.3	46.9 ± 10.2	−0.3 ± 0.4	−1.3 ± 1.4	−0.6 ± 0.5
Feces (% of intake)	98.8 ± 5.1	99.5 ± 6.4	103.5 ± 5.4	59.3 ± 2.7[b]	70.7 ± 4.1[a]	61.2 ± 3.1[b]	90.9 ± 3.2	90.1 ± 7.9	95.3 ± 4.6
Urine (% of intake)	0.03 ± 0.01	0.08 ± 0.03	0.05 ± 0.01	12.1 ± 0.8[b]	11.3 ± 1.1[b]	14.5 ± 1.4[a]	10.2 ± 1.0[b]	13.3 ± 1.5[a]	10.8 ± 1.6[b]
Retained (% of intake)	1.2 ± 5.1	0.4 ± 6.4	−3.5 ± 5.4	28.6 ± 2.3[a]	18.0 ± 3.7[b]	24.4 ± 3.5[a,b]	−1.1 ± 3.2	−8.4 ± 8.9	−6.1 ± 4.2

BW — Body weight

[a,b,c] Mean values which do not have a common letter in their superscripts differ at a significance level of $P < 0.05$

P retention was higher in the MM group, although differences between the MM group and the CGM group were not statistically significant.

Discussion

Not only the quantity but also the quality of protein in diets is important for maintaining the health of cats, because the quality affects the utilization of nutrients including protein. Our previous study revealed that cats fed a dry diet containing MM exhibited higher digestibility and utilization of nutrients than those fed a diet containing CGM, suggesting the superiority of MM as a protein source for dry cat food (5). However, inclusion of MM in cat food has been prohibited since the occurrence of bovine spongiform encephalopathy in Japan in 2001. Hence, protein sources that are safe and nutritionally equivalent to MM are required for the production of commercial dry cat food. In the present study, the nutritional value of CM was compared with that of MM and CGM using adult cats. The results showed that dry-matter digestibility and N utilization of CM are intermediate, as compared with those of MM and CGM. These results suggest that CM is superior to CGM and may be an appropriate substitute for MM, as a protein source of dry food for adult cats.

However, when CM is used as the protein source of dry cat food, attention needs to be paid to its higher mineral contents, especially Ca and P. In this study it was planned to equalize the Ca and P content of the diets by adding $Ca(PO_4)_2$ and $CaCO_3$ to MM and CGM diets. The Ca and P contents of both diets were higher than those used in the previous study (5), resulting in a higher value of dietary base excess, namely 352 mmol/kg for the MM diet, 472 mmol/kg for the CM diet, and 353 mmol/kg for the CGM diet, in this study versus 121 mmol/kg for the MM diet and 85 mmol/kg for the CGM diet in the previous study (5). Previous studies have shown a positive relationship between dietary base excess and urinary pH (8,9,19). In fact, urinary pH measured in this study (7.08 to 7.99) was substantially higher than that in the previous study (6.11 to 6.14) (5). In addition, consistent with struvite crystallization with increasing urinary pH (14,18), the number of struvite crystals present in the urine was also higher in this study (114 to 403 per μL) than in the previous study (2 > per μL) (5). Consequently, additional manipulation of dietary base excess may be needed when CM is used as the main protein source of dry cat food, because of its higher contents of Ca and P.

In this study, urinary pH was lowest in the CGM group, although dietary base excess was comparable among the 3 diets. The CGM contains higher concentrations of sulfur-containing amino acids that produce acidic urine when fed to cats (20). Although dietary methionine contents were adjusted by additional supplementation of D,L-methionine, dietary cystine contents were higher in the CGM diet (Table II). Considering that cystine contents in the diet were not taken into consideration for the calculation of dietary base excess, the higher cystine content may cause lower urinary pH when the CGM diet is fed. In fact, urinary pH decreased in cats fed a diet supplemented with L-cystine (unpublished observation).

In the previous study, retention of Ca and P was higher in cats fed a diet containing MM than in those fed a diet containing CGM, suggesting an increase in Ca and P requirements when CGM is used as the protein source (5). In the present study using diets containing higher Ca and P, the retention of Ca and P did not differ between the MM group and the CGM group. Potential increases in mineral requirements in the CGM diet may be met by higher supply of Ca and P in the present study. Mineral retention in cats fed the CM diet was not different from that in cats fed the MM diet or the CGM diet, although the percentage of P retention to P intake was lower in the CM group. These results suggest that when CM is used as a protein source, Ca, P, and Mg are properly utilized.

The arginine content in the CGM diet was only slightly below AAFCO recommended minimum levels for maintenance (7) (97% of the minimum level). Since arginine is important in urea cycle to covert toxic ammonia to urea, additional arginine would be required when CGM is used as a single protein source for diet.

The present study characterized CM as a protein source for dry cat food. The CM is readily digested as compared with CGM, although MM is more digestible than CM. In addition, the percentage of N retention to N intake was intermediate between the MM group and the CGM group. These results suggest that the use of CM rather than CGM is preferable in preparing dry cat food. However, because CM contains more Ca and P than other common ingredients, additional manipulation of dietary base excess is needed to control body acid-base balance. In addition, nutritional values of CM may vary depending on lot and manufacturer. Further studies are needed to characterize the nutritional value of CM better.

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