Effects of 3 Canine Weight Loss Foods on Body Composition and Obesity Markers

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ABSTRACT

Two experimental canine weight loss foods were developed and compared to a commercially available high fiber weight loss food in a 2-month weight loss study. The 2 new weight loss foods were formulated to contain increased levels of amino acids and crude protein. In addition, the 2 new weight loss foods had reduced total dietary fiber and increased soluble fiber when compared to the commercially available high fiber weight loss food. All foods were effective in reducing body weights of dogs. The foods containing increased lysine:calorie and reduced fiber enabled dogs to maintain lean muscle mass during weight loss. Thus, increasing the lysine:calorie and decreasing fiber in weight loss foods ensures that dogs lose fat predominantly during weight loss. In addition, serum levels of leptin, triglycerides, cholesterol, potassium, magnesium, sodium, and total protein were reduced during weight loss in dogs fed all 3 foods.

INTRODUCTION

Traditionally, canine weight loss foods have been based on either high fiber or high crude protein and caloric restricted foods.[1-3] However, simply reducing the caloric content of a food with the addition of dietary fiber doesn't necessarily supply the proper amount of amino acids to maintain protein synthesis relative to protein turnover during weight loss. Inadequate protein or amino acid availability results in muscle loss, impaired immune system, and poor hair coat quality.[4] On the other hand, balancing foods based on total protein will provide an excess of some essential and non-essential amino acids and won't necessarily supply the appropriate balance of amino acids to maintain lean muscle during weight loss. As well, high crude protein foods may have negative effects on kidney health[5,6] due to processing of excess nitrogen.

Lysine is the first limiting amino acid required for protein deposition or maintenance of muscle mass.[7] The requirements of the other essential amino acids are typically expressed relative to dietary lysine concentration in swine formulations.[8] Supplying the proper concentrations of the essential amino acids relative to lysine (protein quality) rather than a total dietary protein amount (protein quantity) is required for muscle protein synthesis and will decrease the mobilization of amino acids from muscle tissue.[9-11] Because of the relationship between energy and protein on body composition, increasing the lysine:calorie ratio and thus the other essential amino acids relative to lysine rather than total protein in foods may provide an alternative means to maintain lean muscle mass in weight management foods without negative implications of excess protein on other health indices.

Dietary fiber provided either as insoluble or soluble fiber has effects on satiety, and it is a common practice to add it to reduce caloric content[12,13] and improve insulin sensitivity in weight management foods. In addition, fiber has also been used to potentially influence food intake hormone responses; however, much debate still exists on the impact of dietary fiber to improve satiety and affect blood parameters in obese companion animals.[2]

Thus, the objective of this study was to determine the effect of enhanced lysine: calorie ratio and increased soluble fiber (reduced total dietary fiber) compared to a commercially available high fiber food on weight loss and lean maintenance in dogs as determined by measures of body composition and blood biomarkers.

MATERIALS AND METHODS

Dogs and Treatments

Thirty dogs were utilized in the weight loss study. Dogs were randomly allotted based off of sex, age, body weight, and % fat composition. The dogs were cared for in accordance with Institutional Animal Care and Use Committee protocols. All dogs began the study with greater than 31% body fat (of total weight). Dogs were allotted to 1 of 3

Table. 1 Nutrient Composition of Foods Fed to Dogs in the Weight Loss Study.

Nutrient, 100% Dry Matter Basis	Food A	Food B	Food C
Crude protein, %	28.3	33.9	33.4
Crude fat, %	9.7	8.5	9.1
Crude fiber, %	20.9	10.3	11.6
Total dietary fiber, %	33.5	25.4	25.4
Soluble fiber, %	1.0	3.0	1.6
Metabolizable energy, kcal/kg	2940	3283	3241
Ash, %	5.1	6.3	6.2
Calcium, %	0.79	0.93	0.93
Phosphorous, %	0.61	0.80	0.79
Lysine, %	1.51	1.74	1.70
Methionine + cystine, %	0.83	1.65	1.67
Tryptophan, %	0.28	0.27	0.24
Threonine, %	1.07	1.24	1.22
Arginine, %	1.55	1.64	1.71
Isoleucine, %	1.02	1.19	1.09
Valine, %	1.23	1.39	1.29
Leucine, %	2.21	3.82	3.74
Histidine, %	0.60	0.69	0.67
Phenylalanine + tyrosine, %	1.81	2.91	2.92
Lysine: Mcal	5.14	5.30	5.25
Methionine+ cystine:lysine	0.55	0.95	0.98
Tryptophan:lysine	0.19	0.16	0.14
Threonine:lysine	0.71	0.71	0.72
Arginine:lysine	1.03	0.94	1.01
Isoleucine:lysine	0.68	0.68	0.64
Valine:lysine	0.81	0.80	0.76
Leucine:lysine	1.46	2.20	2.20
Histidine:lysine	0.40	0.40	0.39
Phenylalanine + tyrosine:lysine	1.20	1.67	1.72
Carnitine, ppm	300	300	300
Linolenic acid, %	0.32	0.96	0.29
Linoleic acid	3.04	2.03	2.90

Food A (Hill's® Canine Prescription Diet® r/d® Dry) Ingredients: corn meal, peanut hulls 28.2% (a source of fiber), chicken by-product meal, soybean meal, soybean mill run, chicken liver flavor, dried egg product, vegetable oil, taurine, L-carnitine, preserved with butylated hydroxytoluene (BHT), butylated hydroxyanisole (BHA), and ethoxyquin, minerals (salt, ferrous sulfate, zinc oxide, copper sulfate, manganous oxide, calcium iodate, sodium selenite), beta-carotene, vitamins (choline chloride, vitamin A supplement, vitamin D3 supplement, vitamin E supplement, L-ascorbyl-2-polyphosphate [a source of vitamin C], niacin, thiamine mononitrate, calcium pantothenate, pyridoxine hydrochloride, riboflavin, folic acid, biotin, vitamin B12 supplement).

Food B Ingredients: corn meal, corn gluten meal, poultry by-product meal, pea bran meal, soybean mill run, beet pulp, rice bran, flaxseed, pal enhancer, potassium citrate L-lysine, DL-methionine, iodized salt, L-carnitine, vitamin premix, choline chloride, vitamin E, preservative, taurine, mineral premix.

Food C Ingredients: corn meal, corn gluten meal, poultry by-product meal, pea bran meal, soybean mill run, rice bran, beet pulp, pal enhancer, soybean oil, potassium citrate, L-lysine, DL-methionine, iodized salt, L-carnitine, vitamin premix, choline chloride, vitamin E, preservative, taurine, mineral mix.

Table 2. Body Composition of Dogs Fed Weight Loss Foods.

Body Parameter Measured	Food A	Food B	Food C	Food A vs. Food B*	Food A vs. Food C*	Food B vs. Food C*
Weight Day 0, g	15866 ± 920	16645 ± 920	17686 ± 920	ND	ND	ND
Weight Day 30, g	14797 ± 881	15114 ± 881	16180 ± 881	ND	ND	ND
Weight Day 60, g	14598 ± 894	14539 ± 894	15552 ± 894	ND	ND	ND
Weight change Day 0 to 30, g	-1069 ± 262	-1531 ± 262	-1506 ± 262	ND	ND	ND
Weight change Day 0 to 60, g	-1268 ± 309	-2105 ± 309	-2134 ± 309	0.07	0.06	ND
Day 0 vs Day 30*	<0.01	<0.01	<0.01	—	—	—
Day 0 vs Day 60*	<0.01	<0.01	<0.01	—	—	—
Lean Day 0, g	9840 ± 563	10161 ± 563	10864 ± 563	ND	ND	ND
Lean Day 30, g	9266 ± 479	9775 ± 479	10389 ± 479	ND	ND	ND
Lean Day 60, g	8713 ± 491	10502 ± 491	11100 ± 491	0.02	<0.01	ND
Lean change Day 0 to 30, g	-573 ± 159	-386 ± 159	-475 ± 159	ND	ND	ND
Lean change Day 0 to 60, g	-1126 ± 152	341 ± 152	236 ± 152	<0.01	<0.01	ND
Day 0 vs Day 30*	<0.01	0.02	<0.01	—	—	—
Day 0 vs Day 60*	<0.01	0.03	ND	—	—	—
Fat Day 0, g	5602 ± 446	5997 ± 446	6321 ± 446	ND	ND	ND
Fat Day 30, g	5128 ± 503	4876 ± 503	5315 ± 503	ND	ND	ND
Fat Day 60, g	5491 ± 519	3571 ± 519	3976 ± 519	0.01	0.05	ND
Fat change Day 0 to 30, g	-474 ± 212	-1121 ± 212	-1006 ± 212	0.04	0.09	ND
Fat change Day 0 to 60, g	-111 ± 279	-2426 ± 279	-2345 ± 279	<0.01	<0.01	ND
Day 0 vs Day 30*	0.03	<0.01	<0.01	—	—	—
Day 0 vs Day 60*	ND	<0.01	<0.01	—	—	—

*Probability of greater F value, ND = No difference.

treatments (Table 1). Each food was kibbled and formulated in accordance with the Association of American Feed Control Officials[14] nutrient guide for dogs and balanced to meet adult maintenance requirements. All dogs underwent dual-energy x-ray absorptiometry (DXA; DXA-QDR-4500, Hologic, Inc., Waltham, Massachusetts) scans at 0, 30, and 60 days. Blood was pulled at 0 and 60 days. Serum was harvested and stored at -20°C in 1-mL aliquots. Additionally, dogs were offered enrichment toys, received routine grooming, and had daily opportunities for socialization with other dogs and people.

Serum Analysis

Serum was analyzed for chemistry screens and obesity markers. Chemistry screens were preformed at the Hill's Pet Nutrition Center (Topeka, Kansas). Insulin, insulin-like growth factor-1, ghrelin, and leptin were performed by MD Biosciences, Inc. (St. Paul, Minnesota).

Statistical Analysis

Data were analyzed using the General Linear Models procedure of SAS[15] to determine treatment means. The experimental unit was dog and differences were considered significant when $P < 0.05$ and trends were determined when $P < 0.10$.

RESULTS

The results of the study are presented in Tables 2-5. The changes in body condition throughout the study are presented in Table 2. Dogs fed Food A had significant weight loss (-1268 g; $P < 0.01$) and lean loss (-1126 g; $P < 0.01$) at Day 60 when compared to Day 0. Fat loss for dogs consuming Food A was not significant when comparing Day 60 to Day 0. Dogs fed Food B had significant weight loss (-2105 g; $P < 0.01$), fat loss (-2426 g; $P < 0.01$) and lean gain (341 g; $P = 0.03$) at Day 60 when compared with Day 0. Dogs fed Food C had significant weight loss (-2134; $P < 0.01$) and fat loss (-2345 g; $P < 0.01$). Dogs fed Food C maintained lean muscle mass. When comparing Food A to Food B, dogs consuming Food B had more lean mass ($P = 0.02$) and less fat ($P = 0.01$). When comparing Food A to Food C, dogs consuming Food C had more lean mass ($P < 0.01$) and less fat ($P = 0.05$). No differences were observed between Foods B and C for all body composition measures and time points.

Serum chemistry screens, electrolytes, and obesity markers are presented in Tables 3-5. Dogs fed Food A had a decrease in total protein ($P = 0.04$), total bilirubin ($P = 0.01$) alanine aminotransferase ($P = 0.02$), triglycerides ($P < 0.01$), phosphorus ($P < 0.01$), sodium ($P < 0.01$), potassium ($P < 0.01$), magnesium ($P < 0.01$), chloride ($P = 0.02$), and leptin ($P < 0.01$). Dogs fed Food B had a decrease in albumin ($P < 0.01$), total protein ($P < 0.01$), creatinine ($P < 0.01$), cholesterol ($P < 0.01$), calcium ($P = 0.03$), sodium ($P < 0.01$), sodium:potassium ($P = 0.05$), potassium ($P < 0.01$), magnesium ($P < 0.01$), and leptin ($P < 0.01$). Dogs fed Food C had a decrease in total protein ($P < 0.01$), creatinine ($P < 0.01$), cholesterol ($P < 0.01$), calcium ($P = 0.01$), sodium ($P < 0.01$), sodium:potassium ($P = 0.06$), potassium ($P < 0.01$), magnesium ($P < 0.01$), leptin ($P < 0.01$), insulin ($P = 0.03$), and IGF-1 ($P = 0.06$), and an increase in blood urea nitrogen:creatinine ($P = 0.03$) and albumin:globulin ($P < 0.01$).

DISCUSSION

Obesity has become one of the primary diseases in companion animals with approximately 30% of the canine population thought to be obese or overweight.[16-19] Often times, obesity leads to other complications including diabetes,[20] arthritis,[21,22] and hypertension.[23] Ideally, dogs should lose weight and body fat while maintaining or increasing the absolute percentage of lean muscle mass during weight loss. In the current study, feeding dogs foods enhanced with amino acids (increased lysine:calorie ratio), soluble fiber, and reduced total fiber was compared to a reduced calorie, high fiber food for their ability to induce weight loss and maintain muscle mass.

All dogs in the study lost significant weight at Day 60 compared to Day 0. However, dogs fed Food B or Food C tended to lose greater weight compared to Food A. In addition, dogs fed Food B or Food C maintained greater lean muscle mass and had a greater change in fat loss compared to dogs fed Food A. Increasing the lysine:calorie ratio and amino acid content of the food along with reducing the total dietary fiber provided a greater concentration of amino acids required for protein deposition and increased muscle preservation. Reeder et al[24] observed a linear relationship to increasing

Table 3. Blood Chemistry Screens of Dogs Fed Weight Loss Foods.

Analyte	Day	Food A	Food B	Food C	Food A vs. Food B*	Food A vs. Food C*	Food B vs. Food C*
Albumin: globulin	0	1.63 ± 0.06	1.55 ± 0.06	1.59 ± 0.06	ND	ND	ND
	60	1.65 ± 0.07	1.63 ± 0.07	1.76 ± 0.07	ND	ND	ND
	0 vs 60*	ND	ND	<0.01	—	—	—
Albumin, g/dL	0	3.88 ± 0.08	4.04 ± 0.08	4.04 ± 0.08	ND	ND	ND
	60	3.75 ± 0.07	3.84 ± 0.07	3.99 ± 0.08	ND	0.03	ND
	0 vs 60*	0.07	<0.01	ND	—	—	—
Alkaline phosphatase, U/L	0	112 ± 196	100 ± 196	419 ± 196	ND	ND	ND
	60	115 ± 86	67 ± 86	222 ± 86	ND	ND	ND
	0 vs 60*	ND	ND	0.09	—	—	—
Alanine aminotransferase, U/L	0	54 ± 12	59 ± 12	56 ± 12	ND	ND	ND
	60	35 ± 11	62 ± 11	64 ± 11	0.09	0.08	ND
	0 vs 60*	0.02	ND	ND	—	—	—
Blood urea nitrogen:creatinine	0	22.3 ± 1.7	18.9 ± 1.7	18.3 ± 1.7	ND	ND	ND
	60	21.0 ± 1.2	21.0 ± 1.2	22.6 ± 1.2	ND	ND	ND
	0 vs 60*	ND	ND	0.03	—	—	—
Blood urea nitrogen, mg/dL	0	13.1 ± 1.2	11.8 ± 1.2	11.6 ± 1.3	ND	ND	ND
	60	12.4 ± 0.7	12.0 ± 0.7	12.6 ± 0.7	ND	ND	ND
	0 vs 60*	ND	ND	ND	—	—	—
Creatinine, mg/dL	0	0.58 ± 0.03	0.63 ± 0.03	0.64 ± 0.03	ND	ND	ND
	60	0.60 ± 0.03	0.57 ± 0.03	0.58 ± 0.03	ND	ND	ND
	0 vs 60*	ND	<0.01	<0.01	—	—	—
Total bilirubin, mg/dL	0	0.77 ± 0.24	0.44 ± 0.24	0.36 ± 0.24	ND	ND	ND
	60	0.13 ± 0.02	0.15 ± 0.02	0.17 ± 0.02	ND	0.09	ND
	0 vs 60*	0.01	ND	ND	—	—	—
Total protein, g/dL	0	6.30 ± 0.10	6.67 ± 0.10	6.61 ± 0.10	0.01	0.04	ND
	60	6.07 ± 0.10	6.24 ± 0.10	6.29 ± 0.10	ND	ND	ND
	0 vs 60*	0.04	<0.01	<0.01	—	—	—

*Probability of greater F value, ND = No difference.

total essential amino acids in dogs fed caloric-restricted foods on nitrogen absorption and retention. The concept of lysine:calorie ratio has been used in the swine industry to maximize lean growth with the requirement of essential amino acids expressed relative to lysine, the first limiting amino acid.[25,26] Similarly, Baker and Czarnecki-Maulden[8] have established amino acid requirements of dogs for maintenance and expressed them relative to lysine. Previously, high protein foods have been used to prevent lean muscle loss during weight loss[3,9,10]; however, the crude protein levels required to achieve this effect may have harmful effects on kidney health.[27-29] This study suggests that increasing the lysine:calorie ratio and thus, amino acid concentration of the food helped maintain or increase lean muscle mass while enhancing fat mobilization for energy in obese dogs.

Increasing the insoluble or soluble fiber content of the food may impact satiety, gastrointestinal health, and help control

Table 4. Blood Electrolytes of Dogs Fed Weight Loss Foods.

Analyte	Day	Food A	Food B	Food C	Food A vs. Food B*	Food A vs. Food C*	Food B vs. Food C*
Calcium, mg/dL	0	10.9 ± 0.1	10.9 ± 0.1	11.2 ± 0.1	ND	ND	ND
	60	10.9 ± 0.1	10.7 ± 0.1	10.8 ± 0.1	0.06	ND	ND
	0 vs 60*	ND	0.03	0.01	—	—	—
Chloride, mmol/L	0	115 ± 2	114 ± 2	113 ± 2	ND	ND	ND
	60	110 ± 1	111 ± 1	111 ± 1	ND	ND	ND
	0 vs 60	0.02	ND	ND	—	—	—
Potassium, mmol/L	0	4.9 ± 0.1	4.4 ± 0.1	4.7 ± 0.1	0.03	ND	0.07
	60	4.4 ± 0.1	4.1 ± 0.1	4.2 ± 0.1	0.02	ND	ND
	0 vs 60*	<0.01	<0.01	<0.01	—	—	—
Magnesium, mg/dL	0	3.0 ± 0.2	3.3 ± 0.2	3.3 ± 0.2	ND	ND	ND
	60	2.1 ± 0.1	2.2 ± 0.1	2.2 ± 0.1	ND	ND	ND
	0 vs 60*	<0.01	<0.01	<0.01	—	—	—
Sodium, mmol/L	0	162 ± 2	162 ± 2	160 ± 2	ND	ND	ND
	60	147 ± 1	146 ± 1	147 ± 1	ND	ND	ND
	0 vs 60*	<0.01	<0.01	<0.01	—	—	—
Sodium: potassium	0	33.6 ± 0.9	37.0 ± 0.9	34.0 ± 0.9	0.02	ND	0.03
	60	33.3 ± 0.8	35.8 ± 0.8	35.0 ± 0.8	0.04	ND	ND
	0 vs 60*	ND	0.05	ND	—	—	—
Phosphorous, mg/dL	0	4.3 ± 0.2	3.9 ± 0.2	3.9 ± 0.2	ND	ND	ND
	60	3.1 ± 0.2	3.8 ± 0.2	3.8 ± 0.2	<0.01	<0.01	ND
	0 vs 60*	<0.01	ND	ND	—	—	—

*Probability of greater F value, ND = No difference.

weight[30]; however, these responses were not measured in this study. Even so, Butterwick and Hawthorne[2] reviewed the relationship of insoluble and soluble fiber and found no effect of either fiber on satiety in dogs. Kimmel et al[31] found that insoluble fiber aided in glycemic control in dogs with naturally occurring diabetes. In the current study, dogs fed Foods B and C had a significant reduction in serum cholesterol. All dogs undergoing weight loss had a reduction in serum leptin compared to the start of the study. Leptin correlates highly with percent body fat[32] and is involved in energy intake signaling to the brain. Jeusette et al[33] observed higher plasma leptin levels in obese animals and a reduction in leptin with weight loss. Contrary to the present study, Diez et al[3] found no effect of either high crude protein or high crude fiber food on blood parameters. Jewell et al[34] found that dogs fed a high fiber food had reduced caloric intake and body fat independent of conjugated linoleic acid supplementation. Although total dietary fiber may have limited efficacy to control satiety, the current data suggest that soluble fiber may aid in reducing cholesterol reabsorption from the intestinal tract and suppress hormones that stimulate the hunger response.

Finally, blood chemistry, electrolyte, and obesity markers were reduced with weight loss. Dietz et al[35] and Yamka et al[36] also observed similar reductions in obesity-related markers with weight loss. Although these markers were not outside of normal ranges, they still provide an indication of the correction in metabolism that is occurring. In the

Table 5. Obesity Markers of Dogs Fed Weight Loss Foods.

Analyte	Day	Food A	Food B	Food C	Food A vs. Food B*	Food A vs. Food C*	Food B vs. Food C*
Cholesterol, mg/dL	0	208 ± 16	217 ± 16	244 ± 16	ND	ND	ND
	60	184 ± 16	144 ± 16	162 ± 16	ND	ND	ND
	0 vs 60*	ND	<0.01	<0.01	—	—	—
Triglycerides, mg/dL	0	152 ± 34	98 ± 34	106 ± 34	ND	ND	ND
	60	58 ± 9	59 ± 9	76 ± 9	ND	ND	ND
	0 vs 60*	<0.01	ND	ND	—	—	—
Glucose, mg/dL	0	84 ± 4	82 ± 4	81 ± 4	ND	ND	ND
	60	81 ± 3	82 ± 3	84 ± 3	ND	ND	ND
	0 vs 60*	ND	ND	ND	—	—	—
IGF-1, ng/mL	0	111 ± 9	140 ± 9	159 ± 9	0.02	<0.01	ND
	60	130 ± 14	119 ± 14	129 ± 14	ND	ND	ND
	0 vs 60*	ND	ND	0.06	—	—	—
Insulin, IU/mL	0	12.3 ± 2.9	13.6 ± 2.9	17.7 ± 2.9	ND	ND	ND
	60	11.7 ± 2.0	11.1 ± 2.0	10.8 ± 2.1	ND	ND	ND
	0 vs 60*	ND	ND	0.03	—	—	—
Leptin, ng/mL	0	8.58 ± 1.07	5.78 ± 1.07	6.91 ± 1.07	0.07	ND	ND
	60	3.42 ± 0.73	2.27 ± 0.73	2.54 ± 0.73	ND	ND	ND
	0 vs 60*	<0.01	<0.01	<0.01	—	—	—
Ghrelin, ng/mL	0	2.41± 0.31	2.04 ± 0.31	2.12 ± 0.31	ND	ND	ND
	60	2.50 ± 0.36	2.02 ± 0.36	2.26 ± 0.36	ND	ND	ND
	0 vs 60*	ND	ND	ND	—	—	—

*Probability of greater F value, ND = No difference.

current study, cholesterol decreased with use of Foods B and C, however, did not change in dogs fed Food A. Furthermore, dogs fed Foods B or C had reduced ($P < 0.01$) creatinine. This may indicate that providing the proper ratios of amino acids has reduced nitrogen processing (even though crude protein levels were increased). Triglycerides decreased in all 3 foods suggesting a correction in fat metabolism and lipoprotein processing through weight loss.[37] Serum IGF-1 was also numerically reduced in dogs fed Foods B and C, while dogs fed Food A numerically increased. IGF-1 responds to level of nutrition and has been shown to be elevated in obese dogs.[36,38] It appears that a large majority of the imbalances found in obese dogs can be corrected with weight loss and providing proper amino acid balance while reducing total dietary fiber can further improve these markers of general metabolism.

CONCLUSION

Feeding dogs a weight loss food enriched in amino acids and soluble fiber with reduced total dietary fiber resulted in increased fat loss and a greater lean muscle mass compared to a high fiber food. These results suggest that enhancing the amino acid profile (lysine:calorie ratio) and soluble fiber content while reducing total dietary fiber of a weight loss food can increase weight loss, fat loss, and lean muscle mass in obese dogs.

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