Lysine Content in Canine Diets Can Be Severely Heat Damaged

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EXPANDED ABSTRACT

The protein quality of a food is the product of its amino acid content and the nutritional availability of these amino acids. Heat processing has been shown to have a negative impact on the nutritional value of the amino acids in animal feeds (1,2). In foods that are heat processed or stored for long periods of time, the free ε-amino group of lysine can react with the carbonyl group of other compounds such as reducing sugars. The complex that is formed (Maillard complex) may be partially absorbed but cannot be utilized by the animal (3). Moreover, a proportion of the complexes formed can revert back to lysine during conventional amino acid analysis, which does not occur in the digestive tract of the animal. This results in an overestimation of the amount of lysine that is available to the animal if it is determined using conventional methods. A method in which the lysine content with a free ε-amino group is measured [such as the O-methylisourea (OMIU)-reactive lysine assay] provides a superior estimate of the lysine available to the animal (4).

The production of commercial pet foods can involve heat treatments including sterilization, extrusion, cooking, and baking. During these heat treatments and the subsequent storage of the food, Maillard complexes may form, thereby reducing the availability of lysine for the animal. In addition, most pet food manufacturers use by-products of the meat, fish, and milling industries as primary ingredients, which, because of the processing required in their manufacture, can include lysine with a blocked ε-amino group. Although some pet foods are formulated using large proportions of non-heat-treated ingredients such as meat, lamb, rice, and corn, the manufacture of pet foods still promotes a reaction between the ε-amino group of lysine and other compounds. Although pet foods are extensively heat treated, little research has been conducted into the effects of the various heat processes on the nutritional value of pet foods.

The objectives of this study were to determine the total and reactive lysine content of commercial dog foods and to determine whether a relation exists between lysine availability and product price.

MATERIALS AND METHODS

Fourteen extruded canine growth and 19 maintenance diets were obtained from commercial outlets in Chile (n = 28) and the United States (n = 5). A total of 42% of these diets were manufactured in Chile, 27% were manufactured in the United States, 24% in Argentina, and 6% in Canada. The diets were ground over a 2-mm screen and analyzed for dry matter (DM, by oven drying at 105°C), nitrogen (Kjeldahl method), total and OMIU-reactive lysine, according to the procedure described by Moughan and Rutherfurd (4). All analyses were conducted in duplicate. The bound lysine content was calculated as the difference between the total and OMIU-reactive lysine content.

The prices of the foods were obtained from local commercial outlets and were converted to US dollars to allow comparison. Comparisons between the results obtained for crude protein, total lysine content, reactive lysine content, and percentage of bound lysine between the maintenance and growing diets were conducted using Student’s t tests with the program SAS (version 8e, SAS Institute). Correlations were determined between the prices of the foods and their OMIU-reactive lysine content and prices of the food versus the ratio of OMIU-reactive to total lysine content, using the correlation procedure of SAS (Pearson and Spearman coefficients, SAS Institute). A probability value of <5% was considered significant.
LYSINE DAMAGE IN CANINE DIETS

TABLE 1
Mean, SEM, minimum (min), and maximum (max) price, crude protein, total lysine, reactive lysine content, and reactive/total lysine ratio in commercial canine maintenance and growth diets

<table>
<thead>
<tr>
<th></th>
<th>Maintenance diets, n = 19</th>
<th>Growth diets, n = 14</th>
<th>Probability²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SEM</td>
<td>Min</td>
</tr>
<tr>
<td>Price, $/kg</td>
<td>1.85</td>
<td>1.02</td>
<td>0.74</td>
</tr>
<tr>
<td>Crude protein, g/kg DM</td>
<td>244.0</td>
<td>31.4</td>
<td>196.0</td>
</tr>
<tr>
<td>Total lysine, g/kg DM</td>
<td>10.4</td>
<td>2.6</td>
<td>7.2</td>
</tr>
<tr>
<td>Reactive lysine, g/kg DM</td>
<td>8.6</td>
<td>1.8</td>
<td>4.9</td>
</tr>
<tr>
<td>Reactive/total lysine</td>
<td>0.85</td>
<td>0.16</td>
<td>0.44</td>
</tr>
</tbody>
</table>

1 DM, dry matter
² NS, not significant, $P > 0.05$; *$P < 0.05$; **$P < 0.001$.

RESULTS

The mean total lysine content of the maintenance diets was 10.4 g/kg DM, and the mean OMIU-reactive lysine content was 8.6 g/kg DM (Table 1). The mean total lysine content of the growth diets was 13.6 g/kg DM, and the mean OMIU-reactive lysine content was 10.3 g/kg DM (Table 1). The mean crude protein ($P < 0.001$) and the total and reactive lysine contents of the growth diets per unit of dry matter were higher ($P < 0.05$) than those in the maintenance diets. The mean proportions of bound lysine (1− [OMIU-reactive/total lysine ratio]) were 25 and 15% for the growth and maintenance diets, respectively, with no difference ($P > 0.05$) between the 2 types of diet.

The correlation coefficients relating price of the dog foods to their reactive lysine content or proportion of bound lysine were −0.12 and 0.34, respectively. None of these correlations were significant. A scatter plot of the percentage of the total lysine that was found to be bound versus the price/kg of the dog food is presented in Figure 1.

DISCUSSION

To our knowledge, this is the first study reporting the proportion of bound lysine in extruded canine diets that is not expected to be nutritionally available to the dog. Thermal processing of high-protein materials generally reduces lysine availability, with the total effect depending on the temperature levels and the time of exposure to the heat. Although extrusion will enhance the nutritional value of cereal grains (5), it is likely to reduce the lysine availability, similar to that observed by Rutherfurd et al.(6) and Rutherfurd and Moughan (7). Rodhouse et al. (8), however, studied the effect of extrusion of soybean meal on lysine availability (FDNB method) in chickens and found no effect on lysine digestibility (ileal and fecal).

A significant amount of total lysine present in the dog foods, as measured using conventional amino acid analysis, was bound with the percentage of the total lysine that was bound (and thus would be unavailable to the dog) showing a very high variation, ranging from −5 to 56% in the maintenance diets and from 2 to 53% in the growth diets. To meet the minimum lysine requirements of adult and growing dogs, a food must contain a minimum available lysine content of 0.48 and 0.59%, respectively, for diets containing 3,500 kcal ME/kg [calculated from values published in AAFCO (9), taking into consideration the correction for bioavailability]. All of the maintenance diets and all except one of the growth diets did contain sufficient available lysine to satisfy the nutritional requirements of their target dogs.

In all cases, the prices of the growth diets were greater than the prices for the maintenance diets, which is to be expected because of the higher concentration of protein present in these diets. Ingredients with a relatively high protein content (particularly ingredients from animal sources) tend to have higher prices than ingredients incorporated for their energy content (e.g., cereal grains). Canine diets are normally composed of 25–40% animal by-products [dry matter basis (10)]. An alternative to animal proteins is the use of soybeans, which are considered to be a good source of vegetable protein. Soybeans are generally incorporated into canine foods as soybean meal, which has a relatively low price (11). Soybean meal is manufactured using extrusion, to inactivate its antinutritional factors, but this process will also decrease the digestibility of the amino acids in this ingredient (11) and would be expected to result in a decrease in the amount of reactive lysine present. The sources of protein used in the formulation of canine diets will affect the final price of the food, especially in the case of growth diets, which contain greater concentrations of protein in comparison to maintenance diets to satisfy the higher requirements for amino acids in growing dogs.

It was expected that diets formulated using ingredients that had been processed before their incorporation would contain more bound lysine than diets elaborated with primary ingredients.

FIGURE 1 Scatter plot of the percentage of total lysine with a bound ε-amino group versus the price in commercial canine maintenance and growth diets.
such as meat, without prior processing. This difference in protein source was expected to be reflected in the commercial prices of the canine diets, with the diets containing by-products as the main protein sources having a lower price than those that contain primary ingredients without prior processing. Because there was no relation between the proportion of the lysine that was bound and the price for the canine diets evaluated, this suggests that the main process causing the lysine to become bound is the heat processing of the food (extrusion or pelleting). There was a very notable variation between dog foods of different brands in the proportion of the total lysine that was bound, with a range between 0 and 56% of the total lysine being bound and thus nutritionally unavailable to the dog. This suggests that the production systems, including conditions for extrusion or pelleting, differ between manufacturers, and it is important to determine the conditions necessary to minimize the nutritional “loss” of essential amino acids such as lysine during processing.

Damage to lysine in canine diets, most likely by factors such as the use of ingredients containing damaged lysine (e.g., corn, wheat), extrusion, and/or storage, appears to be significant and varies greatly between brands. Although the total lysine content may be sufficient to meet lysine requirements for growth and maintenance, a large proportion of the lysine in the diets appears to have been damaged and can be expected to be unavailable to dogs.

LITERATURE CITED