Evaluation of the nutritive value of broiler and broiler parent stock litters after pelleting for ruminants

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Abstract

Samples of poultry litter were collected in January-February 2009; 30 each from broiler and from broiler parent stock houses in the different parts of Thailand. The bedding material was rice hull. Both types of litter were pelleted as feed ingredient and nutritive values were analyzed. Results revealed that total ash (TA), crude protein (CP) and acid detergent fiber (ADF) contents for pelleted broiler litter (PBL) were much lower than those for pelleted broiler parent stock litter (PBPSL) (P<0.05), while dry matter (DM) was not significant (P>0.05). The range of values in both groups was very large. Mean copper contents were very similar for both PBL and PBPSL samples (P>0.05). Estimations of metabolizable energy (ME) were predicted from rumen fluid-pepsin in vitro digestible organic matter content of the DM (ME-IV), and organic matter loss during 72h rumen incubation (ME-RI). ME-IV value for PBL and PBPSL was not significant (P>0.05), while the corresponding difference of ME-RI values was significant (P<0.05). The ranges within each of these means were large. ME contents were closely correlated with the sum of TA and ADF, the correlation coefficient for ME-IV was -0.870, and for ME-RI, -0.910. Useful estimations of ME of the litter samples could be made utilizing regression equations for either ME-IV or ME-RI, ME-RI being preferred for its slightly greater correlation coefficient, ME-RI (MJ/kg DM) = 12.7-0.0105 (TA + ADF) (g/kg DM).

Keywords: available energy, estimation, litter, pelleting, poultry.

1. Introduction

Broiler litter (BL) and broiler parent stock litter (BPSL) are major by-product of the poultry industry that has significant potential effects on environmental quality (McCaskey et al., 1989). If improperly managed, BL and BPSL can pollute the environment, primarily by contaminating surface and ground-waters (Suppadit, 2009a). However, BL and BPSL have an economic value associated with its nutrient and mineral components (Suppadit et al., 2008). Recycling BL and BPSL as a feed ingredient for ruminants could be beneficial for farmers and the poultry industry (Rankins et al., 1993; Rude et al., 1994; Suppadit, 2009b). Given its potential as a source of diet, it is worthwhile to study how the BL and BPSL can be processed and used as a nutrient source for ruminant production (Suppadit et al., 2008). On the other hand, utilizing fresh BL and BPSL directly in feed ingredient can lead to unacceptable residues associated with pathogens, parasites, fungi, heavy metals and bad odors. This has an adverse impact on the health of animal, farmers and consumers and on meat quality (Suppadit, 2000). To overcome these problems, pelleting the BL and BPSL is proposed. Pelleting is a process that eliminates microorganisms and odor in BL and BPSL (Suppadit, 2004). Furthermore, pelleting can facilitate usage, handling, storage and transportation management (Suppadit, 2002). Therefore, the objective of this research is to obtain further nutritional data from samples of BL and BPSL in Thailand. For the present study, 30 samples each of BL and BPSL were collected, and aspects of their nutritive value,
particularly the estimation of available energy after pelleting, as metabolizable energy (ME), were determined.

2. Materials and Methods

The samples of BL and BPSL were collected from the Siriwan Co. Ltd.'s network broiler chicken (Gallus gallus domesticus) farms in different parts of Thailand, 30 each from broiler and broiler parent stock houses. The two types of fowl were housed in conventional commercial buildings, closed house with evaporative cooling system. The bedding material was rice hull, the by-product of rice-growing that is widely used in nationwide chicken farms (Suppadit, 2009a). The two types of samples were taken in January-February, 2009. At the end of each production cycle, after removal of the poultry, the BL and BPSL were removed with a loading shovel and piled under plastic cover. All the litters were dried to the standard laboratory conditions (The Land Development Department, 2005). From each batch of litter 10 sub-samples of about 10.0 kg were taken and mixed thoroughly, and then were pelleted. The Siriwan Model Machine located at Siriwan Co. Ltd., Saraburi Province and invented by Suppadit (2009a) was used for pelleting. The whole sample pelleted from each batch was quartered and one quarter was ground through a 2 mm mesh sieve. Sixty samples from each batch were sent to the laboratories at the Chiang Mai Field Crops Research Center for analysis of its nutritive value. The estimation of available energy in pelleted broiler litter (PBL) and pelleted broiler parent stock litter (PBPSL) followed the procedures outlined by Deshck et al. (1998). Prediction of ME content was made from two techniques, the in vitro (IV) determination of digestible organic matter (OM) using rumen fluid and pepsin in two stages (Tilley and Terry, 1963), and the measurement of organic matter loss (OML) during a 72h incubation of samples in nylon bags in the rumen of sheep (Huntington and Givens, 1995). The IV digestible OM (IVOMD), as g/kg dry matter (DM), was converted to an ME content, using 18.5 MJ (McDonald et al., 1998) as the gross energy per kg digested OM, and the factor 0.800 commonly used to convert digestible energy to ME:

\[
\text{ME (MJ/kg DM)} = \text{digestible OM (g/kg DM) x 18.5 (MJ/kg digested OM) x 0.800}
\]

The estimation of ME content from rumen incubation (RI) was based on the relationship between dry matter loss (DML) during the 72h RI, and the ME content, determined in vivo, of a fibrous feed. The original equations (ADAS, 1987):

\[
\text{ME (MJ/kg DM)} = 0.249 + 0.0109 \text{DML (g/kg DM)}
\]

The estimation was obtained using straw of wheat and oats. This equation was modified to accommodate the possible problem posed by the large and variable ash contents of the litter, by comparison with a low and narrow range, around 60.0 g/kg DM (Deshck et al., 1998), of wheat and oat straw. DML was replaced by OML in the equation, by increasing the factor 0.0109, times 0.06, reflecting the total ash (TA) content of straw, giving (Deshck et al., 1998):

\[
\text{ME (MJ/kg DM)} = 0.249 + 0.0116 \text{OML (g/kg DM)}
\]

Dried BL and BPSL samples were analyzed for DM content (method 930.15), TA, CP, ADF, and Cu of samples of PBL and PBPSL, are shown in Table 1. The range of all values for both PBL and PBPSL samples were very large. The DM contents were all high, and there were no significant difference (P>0.05) between PBL and PBPSL. PBL and PBPSL removed from the poultry houses during the winter and at the time of collection are described as air-dried. The moisture content of the fresh BL and fresh BPSL decreased after pelleting.

### Table 1. Chemical composition of BL and BPSL after pelleting (on a dry matter basis, g/kg).

<table>
<thead>
<tr>
<th>Components</th>
<th>PBL (N=30)</th>
<th>PBPBL (N=30)</th>
<th>t</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>S.E.</td>
<td>Range</td>
<td>Mean</td>
</tr>
<tr>
<td>DM (g/kg)</td>
<td>852</td>
<td>13.8</td>
<td>790-912</td>
<td>844</td>
</tr>
<tr>
<td>TA (g/kg DM)</td>
<td>198</td>
<td>10.4</td>
<td>121-295</td>
<td>209</td>
</tr>
<tr>
<td>CP (g/kg DM)</td>
<td>290</td>
<td>8.32</td>
<td>198-363</td>
<td>328</td>
</tr>
<tr>
<td>ADF (g/kg DM)</td>
<td>250</td>
<td>7.20</td>
<td>195-298</td>
<td>288</td>
</tr>
<tr>
<td>Cu (mg/kg DM)</td>
<td>50.9</td>
<td>5.88</td>
<td>32.7-80.0</td>
<td>50.4</td>
</tr>
</tbody>
</table>

3. Results and Discussion

Comparison of the mean DM contents and concentrations of TA, CP, ADF, and Cu of samples of PBL and PBPSL, are shown in Table 1. The range of all values for both PBL and PBPSL samples were very large. The DM contents were all high, and there were no significant difference (P>0.05) between PBL and PBPSL. PBL and PBPSL removed from the poultry houses during the winter and at the time of collection are described as air-dried. The moisture content of the fresh BL and fresh BPSL decreased after pelleting.
Mean TA was slightly higher for PBPSL than PBL samples and the difference was statistically significant (P<0.05). TA contents of PBL and PBPSL were high; this may have been caused by the soil that contaminated the bedding materials (rice hull) or by transportation. Some farmers used a soil truck to move the rice hulls, and from the limestone that was used as the source of calcium (Ca) in poultry diet. A large quantity of limestone is needed in the diets of broiler parent stocks for shell formation; the Ca requirement for broiler parent stocks is 40.0 g/kg DM, and 10.0 g/kg DM for broiler (NRC, 1994). Part of the limestone ingested by broiler parent stocks would almost certainly escape, undissolved, from the upper tract, and pass out in the droppings (Deshck et al., 1998), contributing to the greater TA content of PBPSL than PBL.

Mean CP values for PBL and PBPSL were 280 and 328 g/kg DM, respectively, and the corresponding values for ADF were 250 and 288 g/kg DM. Differences between PBL and PBPSL values were significant (P<0.05) for CP and ADF. These differences for CP and ADF between PBL and PBPSL samples are reflected properties of the differences in TA. The ranges of values for CP and ADF were large for both PBL and PBPSL samples, but not as large as for TA. These samples of PBL and PBPSL would have contributed usefully to the protein requirements of a large proportion of ruminants (Suppadit, 2009b), most of the samples contained more than 280 g CP/kg DM. Also, the nitrogen of poultry litter is present largely as uric acid that is more stable than urea (Deshck et al., 1998), which is converted to ammonia relatively slowly after excretion, allowing a greater proportion to be converted to microbial protein, than from urea (McDonald et al., 1988; Gomez et al., 1995; Boyles and Golden, 2000; Jackson et al., 2006).

Mean Cu contents of PBL and PBPSL samples were similar, 50.9 and 50.4 mg/kg DM, respectively and were not significantly different (P>0.05). The Cu contents of litter samples were determined to relate them to the possible hazard from Cu toxicity in ruminants (Webb and Fontenot, 1995; Jackson et al., 1996). The excess Cu can accumulate in the liver of litter-fed ruminant and result in potential fatal toxicity, symptoms of which include jaundice and extremely dark blood (Suppadit, 2009b). The Cu content of litter that may lead to Cu toxicity depends upon the proportion included in the diet and the Cu contents of other ingredients of the diet, but contents greater than about 75.0 mg/kg DM should be regarded as possibly hazardous, at least for young sheep (Deshck et al., 1998). A few of the samples of this study contained more than this, the highest being 80.0 mg/kg DM.

Estimations of available ME studied from IVOMD determinations and from OML in RI are shown in Table 2. Mean IVOMD contents for PBL (525 g/kg DM) and PBPSL (572 g/kg DM) values were not significantly different (P>0.05) from each other, nor were the ME values obtained from them (P>0.05), 7.82 and 8.52 MJ/kg DM, respectively. The corresponding values from in situ RI were both slightly lower, 7.58 and 8.26 MJ/kg DM, which was significantly different (P<0.05). The ranges of ME values for PBL and PBPSL samples for both methods of estimation were large, the highest being about twice the lowest. The ME values obtained in this study followed the procedures of Deshck et al. (1998) and made use of a regression equation of data from straw. The results were regarded as informative useful estimations, rather than accurate values of ME, with a reasonably good degree of confidence. ME values from IV digestibility were, for most samples, slightly higher than those from RI. This difference may represent a small contribution of ME from post-ruminal digestion (Deshck et al., 1998), that would not be included in the value from RI.

The overall relationship between the two types of ME estimation, and between the TA and ADF values for each ME estimation are shown in Figure 1 and Figure 2. When ME values were very low, the IV estimation was lower than that from RI, over most of the range, but for most of the samples, the reverse was true; at the high end of the range, 8.52-9.20 MJ/kg DM, the difference was 0.680 MJ/kg DM, that resembled with the study in BL and layer litter of Deshck et al. (1998). The sum of TA and ADF for PBL and PBPSL samples was negatively related with ME estimations. The regression equations were:

Table 2. Estimation of ME and digestibility values of BL and BPSL after pelleting.

<table>
<thead>
<tr>
<th>Components</th>
<th>PBL (N=30)</th>
<th></th>
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<th></th>
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<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>S.E.</td>
<td>Range</td>
<td>Mean</td>
<td>S.E.</td>
<td>Range</td>
<td>t</td>
<td>P</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IV-DOM (g/kg DM)</td>
<td>525</td>
<td>24.0</td>
<td>312-601</td>
<td>572</td>
<td>22.5</td>
<td>345-648</td>
<td>1.25</td>
<td>&gt;0.05</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ME from IV digestibility of OM</td>
<td></td>
<td></td>
<td></td>
<td>(MJ/kg DM)</td>
<td>7.82</td>
<td>0.530</td>
<td>4.90-8.52</td>
<td>8.52</td>
<td>0.510</td>
<td>5.33-9.20</td>
<td>1.40</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(MJ/kg DM)</td>
<td>7.58</td>
<td>0.420</td>
<td>4.96-8.48</td>
<td>8.26</td>
<td>0.330</td>
<td>5.30-9.11</td>
<td>2.98</td>
</tr>
</tbody>
</table>

1 ME from IV digestibility of OM (MJ/kg DM) = digestible OM (g/kg DM) x 18.5 (MJ/kg digested OM) x 0.800 (McDonald et al., 1988)
2 ME from OML in rumen (MJ/kg DM) = 0.249 + 0.0116 OML (g/kg DM) (Deshck et al., 1998)
The correlation coefficients were high, especially that for ME-RI, where $r = -0.910$, and variance accounted for, $r^2 = 0.828$; for ME-IV the corresponding values were -0.870 and 0.760. The negative relation found between the sum of TA and ADF, and ME is not unexpected, TA having a zero energy value, and ADF consisting of substances very resistant to rumen degradation and digestion (Deshck et al., 1998). However, the closeness of the relationship is high, and useful estimations of ME could be made from a determination of TA and of ADF.

The large range of values for each of the analyses was carried out. Similar ranges for TA and CP contents for poultry litter were found, that agreed with the study of Flachowsky and Hennig (1990) using straw and Suppadit et al. (2002) using rice hull as the bedding materials. They reported that estimation of ME made from RI, also showed a wide range of values. It was also noted that for the two potentially most valuable items, ME and CP, there were samples that combined relatively high ME values, as well as of CP. For the present study, PBL contained 7.58 MJ ME/kg DM and 280 g CP/kg DM, and PBPSL contained 8.26 MJ ME/kg DM and 328 g CP/kg DM.

### 4. Conclusion

Based on this experiment it could be concluded that prior to utilizing PBL and PBPSL as a ruminant feed ingredient, analysis in the laboratory should be carried out, especially TA, ADF and CP, their use for estimations of available energy, as ME from TA and ADF, and of CP. If possible, Cu content should also be determined in order to prevent Cu toxicity in young ruminant.

### Acknowledgements

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