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Original Article

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

Tawadchai Suppadit*

The Graduate School of Social and Environmental Development,
National Institute of Development Administration, Bang Kapi, Bangkok, 10240 Thailand.

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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,

* Corresponding author.
Email address: stawadchai@yahoo.com

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*., 1988) as the gross energy per kg digested OM, and the factor 0.800 commonly used to convert digestible energy to ME:

ME (MJ/kg DM) = 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):

ME (MJ/kg DM) = 0.249 + 0.0109 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):

ME (MJ/kg DM) = 0.249 + 0.0116 OML (g/kg DM)

Dried BL and BPSL samples were analyzed for DM content (method 930.15), TA (method 924.05) and crude protein (CP, Kjeldahl N x 6.25, method 984.13) according to the procedures of AOAC (1990). Acid detergent fiber (ADF) was determined according to the method of Van Soest *et al*. (1991) using Ankom Fiber Analyzer (Ankom Technology Corporation, Macedon, NY, USA). Copper (Cu) was determined according to the method of The Land Development Department (2005) using Atomic Absorption Spectrophotometer (Lambda EZ210, Perkin Elmer, CA, USA). The results obtained were analyzed by the group *t*-test (SAS, 1996) to examine differences between the PBL and PBPSL.

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.

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

Components	PBL ($N=30$)			PBPSL ($N=30$)			t	P
	Mean	S.E.	Range	Mean	S.E.	Range		
DM (g/kg)	852	13.8	790-912	844	12.8	767-905	6.05	>0.05
TA (g/kg DM)	198	10.4	121-295	209	9.80	102-310	5.60	<0.05
CP (g/kg DM)	280	8.32	198-363	328	12.4	211-402	3.74	<0.05
ADF (g/kg DM)	250	7.20	195-298	288	10.1	190-397	3.43	<0.05
Cu (mg/kg DM)	50.9	5.88	32.7-80.0	50.4	5.32	31.5-79.8	0.400	>0.05

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 dropping (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, 1975), especially in young sheep because of this species high susceptibility to Cu poisoning (Nicholson *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.

Components	PBL ($N=30$)			PBPSL ($N=30$)			t	P
	Mean	S.E.	Range	Mean	S.E.	Range		
IV-DOM (g/kg DM)	525	24.0	312-601	572	22.5	345-648	1.25	>0.05
ME from IV digestibility of OM (MJ/kg DM)[1]	7.82	0.530	4.90-8.52	8.52	0.510	5.33-9.20	1.40	>0.05
ME from OML in rumen (MJ/kg DM)[2]	7.58	0.420	4.96-8.48	8.26	0.330	5.30-9.11	2.98	<0.05

[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)

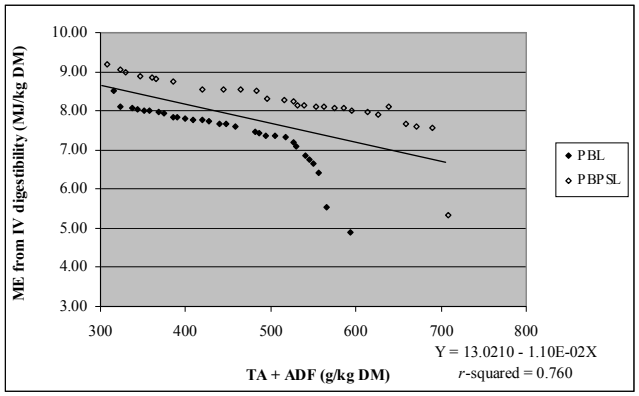

Figure 1. The relationship between estimated ME of PBL and PBPSL from IV digestibility, and TA + ADF.

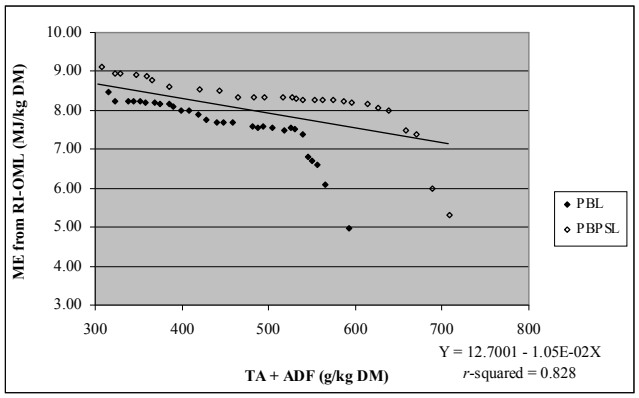

Figure 2. The relationship between estimated ME of PBL and PBPSL from RI-OML, and TA + ADF.

$$\text{ME-IV (MJ/kg DM)} = 13.0 - 0.0110\,(\text{TA} + \text{ADF})\ (\text{g/kg DM})$$

$$\text{ME-RI (MJ/kg DM)} = 12.7 - 0.0105\,(\text{TA} + \text{ADF})\ (\text{g/kg DM})$$

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.

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References

ADAS. 1987. The nylon bag technique to predict the nutritive value of Cereal straw. ADAS Feed Evaluation Unit, Technical Bulletin 87/3, Stratford-Upon-Avon CV37 9RQ, UK., pp. 4-5.

AOAC. 1990. Official methods of analysis. 15th edition. Association of Official Analytical Chemists, Arlington, Virginia, USA., pp. 1230.

Boyles, S. and Golden, P. 2000. Feeding broiler litter to beef cattle. OSU Extension, Coshocton County Agriculture & Natural Resource, Oklahoma State University, Oklahoma, USA., pp. 10-30.

Deshck, A., Abo-Shehada, M., Allonby, E., Givens, D.I. and Hill, R. 1998. Assessment of the nutritive value for ruminants of poultry litter. Animal Feed Science and Technology. 73, 29-35.

Flachowsky, G. and Hennig, A. 1990. Composition and digestibility of untreated and chemically treated animal excreta for ruminants - a review. Biological Waste. 31, 17-36.

Gomez, C., Sugronez, R. and Vera, V.A. 1995. Recycling chicken litter for ruminant feed II. Nutritional experiments. Advance Alignment Major Animal. 35, 3-7.

Huntington, J.A. and Givens, D.I. 1995. The in situ technique for studying the rumen degradation of feeds: a review of the procedure. Nutrition Abstract Reviews (Series B). 65, 63-93.

Jackson, D.J., Rude, B.J., Karanja, K.K. and Whitley, N.C. 2006. Utilization of poultry litter pellets in meat goat diets. Small Ruminant Research. 66, 278-281.

McCaskey, T.A., Stephenson, A.H. and Ruffin, B.G. 1989. Good management necessary to cash in broiler litter

resource. Agricultural Research. 36, 14.

McDonald, P., Edwards, R.A. and Greenhalgh, J.F.D. 1988. Animal nutrition. 4th edition. Longman Group UK, Harlow, UK., pp. 219-220.

Nicholson, F.A., Chambers, B.J. and Smith, K.A. 1996. Nutrient composition of poultry manures in England and Wales. Bioresource Technology. 58, 279-284.

NRC. 1994. Nutrient requirement of poultry. 9th rev., edition. National Academy Press, Washington, DC, USA., pp. 176.

Rankins, D.L., Eason, J.T., McCaskey, T.A., Stephenson, A.H. and Floyd, J.G. 1993. Nutritional and toxicological evaluation of three deep-stacking methods for the processing of broiler litter as a foodstuff for beef cattle. Animal Production. 56, 321-326.

Rude, B.J., Rankins, D.L. and Dozier, W.A. 1994. Nitrogen and energy metabolism and serum constituents in lambs given broiler poultry litter processed by three deep-stacking methods. Animal Production. 58, 95-101.

SAS. 1996. SAS user's guide: statistics. SAS Institute, CARY, NC, USA., pp. 42-90.

Suppadit, T. 2000. Poultry waste pelleting: Villager technology. Livestock Production Journal. 18, 51-54.

Suppadit, T. 2002. The recycle of broiler litter as a feed ingredient for cattle to reduce environmental pollution I. Impact of broiler litter on environmental states and community health. Thai Environmental Consultant Journal. 6, 12-17.

Suppadit, T. 2004. Capitalizing on chicken litter. Feed & Livestock. 1, 24-25.

Suppadit, T. 2009a. Broiler litter pelleting using Siriwan model machine. Journal of Agricultural Technology. (accepted)

Suppadit, T. 2009b. Environmental health management in livestock sector. 2nd edition. Tippanate Printing Press, Bangkok, Thailand. pp. 340-448.

Suppadit, T., Kitikoon, V., Key, J.P., Chaicumpa, W., Pongpiachan, P. and Jaturasitha, S. 2002. Utilization of broiler litter as a source of crude protein for cattle I. The nutritional effect of different feed modification. Thai Journal of Agricultural Science. 35, 427-436.

Suppadit, T., Parukatpichai, K. and Talakhun, N. 2008. Dietary quality and safety in the reuse of broiler litter as a feed ingredient through fermentation and pelleting. Journal of Applied Animal Research. 33, 109-112.

The Land Development Department. 2005. Plant, fertilizer, water and soil analysis manual. Ministry of Agriculture and Cooperatives, Bangkok, Thailand., pp. 2-12.

Tilley, J.M.A. and Terry, R.A. 1963. A two-stage technique for the in vitro digestion of forage crops. Journal of the British Grassland Society. 18, 104-111.

Van Soest, P.J., Robertson, J.B. and Lewis, B.A. 1991. Methods for dietary fiber, neutral detergent fiber, and nonstarch polysaccharides in relation to animal nutrition. Journal of Dairy Science. 74, 3583-3597.

Webb, K.E. and Fontenot, J.P. 1975. Medicinal drug residues in broiler litter and tissues from cattle fed litter. Journal of Animal Science. 41, 1212-1217.