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EFFECTS OF PELLETING PROCESS ON FERTILIZING VALUES OF BROILER LITTER

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ABSTRACT

The effects of a pelleting process on broiler litter properties were investigated at the Siriwan Co. Ltd.'s network farms, Saraburi Province, Thailand. The pelleting process decreased among-set variability in dry matter, electrical conductivity, urea N, K, Na, S, Fe, Cu and Cd contents. On the othr hand, this process increased among-set variability in pH, total N, ammonium N, nitrate N and total P. N form contents including total N, ammonium N, nitrate N, organic N and urea N in the pelleted broiler litter that could be estimated accurately through the basis of dry matter content. Additionally, heavy metal (Cd, Ni, Pb and Cr) content was significantly higher in the pelleted form than in the fresh form which was consistent with a reduction in moisture content. The pelleted broiler litter was clearly preferable to the fresh broiler litter in terms of storage, handling, transport and field application. The results highlight a need to optimize the pelleting process with the objective of minimizing variability in pH, total N, ammonium N, nitrate N and total P.

Key words: Animal waste, fertilizer, prediction, recycle

INTRODUCTION

Broiler production is a prominent livestock industry in Thailand, generating tremendous waste or litter which includes a mixture of manure, bedding material, waste feed and feathers removed from broiler houses (Suppadit, 2000) that has significant potential effects on environmental quality (McCasky *et al*., 1989). If improperly managed, broiler litter can pollute the environment, primarily by contaminating surface and ground waters (Suppadit, 2003). However, the broiler litter has a high nutritional value and is used as an organic fertilizer, thus recycling nutrients such as nitrogen, phosphorus and potassium. These components (broiler litter) have traditionally been used as an amendment (Suppadit, 2005). But, utilizing fresh broiler litter directly in food crop production can lead to unacceptable residues associated with pathogens, parasites, fungi, heavy metals and noxious odor (Suppadit *et al*., 2002a). This has an adverse impact on the health of growers and consumers and on crop quality.

To overcome these problems, pelleting the broiler litter is proposed. Pelleting is a process that eliminates microorganisms and odor in broiler litter (Suppadit, 2004). Furthermore, pelleting can facilitate usage, storage, handling and transportation management (Suppadit *et al*., 2002b). To the best of our knowledge, there has been no study of the effects of pelleting on fertilizer in Thailand. The study sought to investigate the effects in pelleting method on the fertilizing values of broiler litter in terms of the basic physicochemical properties, nutrient contents and heavy metal contents.

MATERIALS AND METHODS

Preparation of Experimental Broiler Litter

Broiler litter was obtained from the Siriwan Co. Ltd.'s network broiler chicken (*Gallus gallus domesticus*) farms, Saraburi Province, Thailand, consisting of five 1,000 m^2 concrete-floored and closed houses with evaporative cooling system that measured 20.0 m wide x 50.0 m long with a stocking density of 17.5 birds/m^2. At the beginning stage of each 50-day production cycle, the floor was covered with 5.50 kg/m^2 of rice hull, the by-product of rice-growing that is widely used in chicken farms in Thailand. In fact, rice hull is high in silica, and as an important source of carbon in chicken litter used as fertilizer (Pongpiachan, 1999). It is a material with near-neutral pH, high C:N ratio, and relatively high Fe, Mn, Zn and Cr contents (Table 1). At the end of each production cycle, after removal of the birds, the broiler litter was removed with a loading shovel and piled under plastic cover, and the floor was washed, cleaned and disinfected. Then, fresh rice hull was introduced for the next cycle.

In this study, the sampling time of broiler litter was February 2008 to February 2009. After removal with the loading shovel, samples were immediately collected at the end of four production cycles, from all five houses. A composite sample was prepared , 200 g of each 20 samples were taken from each pile, at 75.0-100 cm deep. Twenty working samples (4.00 kg) were collected from 4 cycles of the 5 houses.

The broiler litter taken at the end of each production cycle was processed based on Suppadit's method (2000). The Siriwan Model Machine located at Siriwan Co. Ltd., Thatoom Sub-district, Kaeng Khoi District, Saraburi Province, Thailand was used for pelleting process. Fresh litter was sent into a screw conveyer, moved into a receiving elevator, and sent into the pelleting chamber. The litter was fed between the die and rollers, and as the rollers turned, it was then forced into the holes to produce pellets. The movement of the rollers and die during the compression process generated heat over 90°C. The pelleting technology is to mold broiler litter into a pellet form that produced cylindrical pellets 6.00 mm in diameter and 1.50-2.00 cm in length. Twenty samples of pelleted form were taken from each house every ten minutes during the pelleting process. These samples were then pooled. Samples of fresh and pelleted form of broiler litter were analyzed in the laboratories of the Chiang Mai Field Crops Research Center.

Fertilizing Value Analyses

Subsamples of fresh and pelleted broiler litter were oven dried at 65-70°C for 24 hours, for moisture and dry matter determination. The remaining fresh broiler litter was air dried and passed through a 2.00-mm-mesh sieve to remove feather fragments. The remaining pelleted broiler litter was ground to a particle diameter of about 2.00 mm.

Physicochemical properties, nutrient contents and heavy metal contents of fresh and pelleted broiler litter were analyzed according to the procedures in The Land Development Department manual (2005). Electrical conductivity and pH were determined in a 1 (solid) : 10 (water extracts) using conductivity meter and pH meter, respectively (Peverill *et al*., 1999). Ash was determined by combustion in porcelain dish (Greweling and Peech, 1960); organic C by Walkley and Black method (Walkley and Black, 1947); total N and S by Dumas method (Jackson, 1967); ammonium (NH_4-N), nitrate (NO_3-N), organic N and urea N by AOAC standard methods (AOAC, 1970; 1980); total P by the molybdenum blue method (Chapman and Pratt, 1961); K, Ca, Mg, Na, Fe and Mn contents by atomic emission/absorption spectrophotometry method (Thomas *et al*., 1967); B by the azomethine-H method (Wolf, 1974); Cu, Zn, Cd, Ni, Pb and Cr by atomic absorption spectrophometry method (Tessier *et al*., 1979).

Statistical Analysis

The data were subjected to analysis of variance (normal data) or Kruskal-Wallis analysis and Mann-Whitney *U* tests (non-normal data) (Key, 2009). Linear regression analysis (Key, 2009) was used to investigate the possible utility of dry matter content as a predictor of nutrient contents. All analyses were performed with the statistics package SPSS 15.0 (Leech *et al*., 2007).

RESULTS AND DISCUSSION

Characteristics of the Fresh and Pelleted Broiler Litter

For the fresh broiler litter, total N content was high (6.00 % dry weight), and N:P:K ratio was 3.35:1.00:1.79 (Table 1). N levels in broiler litter were more likely to reflect feed characteristics (Lopez-Mosquera *et al*., 2008). During the processing in the Siriwan Co. Ltd.'s network farms, protein content in feed ranged 22.0% at the first stage (0-21 days), 20.0% at the second stage (22-42 days) and 18.0% at the end stage (> 42 days) of production cycle. Organic N was high (83.5%) that agreed with the earlier study of Suppadit (2005) who investigated fresh broiler litter from different 20 farms (80.0-85.0%) in Saraburi Province, Thailand. As a result of low C:N ratio (6.43), this organic N can be considered as readily mineralized (Alexander, 1991). Most of inorganic N was ammonium N (0.500 %), that agreed with Carballas (1996) research (0.300-1.00%). Although there were different in physiological, seasonal, environmental and management aspect factors that may affect broiler litter component. The results were similar to those obtained from the other previous studies of Ekinci *et al*. (2000) (dry matter, 69.4-80.5%), Gordillo and Cabrera (1997a) (electrical conductivity, 6.30-12.6 dS m^{-1}), Gordillo and Cabrera (1997b) (pH, 6.30-8.40), Stephenson *et al*. (1990) (ash, 8.80-54.4%), Wood and Hall (1991) (organic C, 29.3-38.8%), Nicholson *et al*. (1996) (C:N ratio, 6.40-11.8), Gordillo and Cabrera (1997b) (urea N, 0.200-1.10%), Brown *et al*. (1993) (total P, 0.600-3.90%), Brown *et al*. (1994) (K, 0.700-5.20%), Henry and White (1993) (Ca, 0.800-6.10%), Cummis *et al*. (1993) (Mg, 0.200-0.900%), Edwards *et al*. (1995) (Na, 0.700-1.50%), Nicholson *et al*. (1996) (S, 0.200-0.800%), Stephenson *et al*. (1990) (Fe, 529-2,982 mg/kg), Smith and Chambers (1993) (Mn, 125-667 mg/kg), Malone (1992) (Zn, 54.0-680 mg/kg), and Edwards *et al*. (1995) (Cd, 2.40-3.00 mg/kg).

However, total N (6.00%), nitrate N (0.290%), organic N (5.01%) and Cr (13.0 mg/kg) contents were relatively higher than the earlier studies of Beegle (1997) (total N, 2.60-5.30%), Gordillo and Cabrera (1997a) (nitrate N, 0.00500-0.100%), Fulhage and Pfost (1993) (organic N, 0.300-3.30), Edwards *et al*. (1995) (Cr, 8.50-9.00 mg/kg), while the content of B (20.2 mg/kg), Pb 0.450 (mg/kg) and especially Cu (70.8 mg/kg) and Ni (0.400 mg/kg) were relatively lower than those from the earlier studies of Cummis *et al*. (1993) (B, 23.0-125 mg/kg), Henry and White (1993) (Pb, 14.6-55.0 mg/kg), Brown *et al*. (1994) (Cu, 100-1,003 mg/kg), Edwards *et al*. (1995) (Ni, 7.60-181 mg/kg). The Cr content was a result of the Cr content in rice hull bedding. The higher the Cr content in rice hull bedding, the higher the Cr content in fresh broiler litter. Whereas, the content of B, Pb, Cu and Ni was low as a result of feed composition, particularly as regards Cu salts, antibiotics and coccidiostatics (Sims and Wolf, 1994; Lopez-Mosquera *et al*., 2008).

The pelleted broiler litter showed the primary characteristics of organic fertilizer under specification of the Land Development Department manual (2005) (dry matter, > 65%; organic C, > 17.4%; C:N ratio, 3.00-15.0; organic N, > 2.00%; total P, > 0.440%; K, > 0.830%; Cu, < 450 mg/kg; Zn, < 1,100 mg/kg) (Table 1). The pelleted broiler litter had high content of N (5.20% dry weight, 80.8% as organic N), P (1.70%) and K (3.08%) contents as well as N:P:K ratio that was 3.06:1.00:1.81. As in the fresh broiler litter, most of inorganic N was ammonium N (0.500%). A low C:N ratio (7.04) was harmonious to the high N content, and again the organic N (4.20%) can thus be considered readily mineralizable. All of these components showed that the pelleted broiler litter had high value as fertilizer that it met all requirements as an organic fertilizer even if some components were denatured by the heat during the pelleting process (90°C). Heat and pressure from the pelleting process occurred only for a short period (~5-10 second) (Suppadit and Panomsri, 2009). Meanwhile, the low moisture content (85.8% dry matter) of pelleted broiler litter greatly reduced noxious odor. Heavy metal content (Cd, 3.30 mg/kg; Ni, 0.500 mg/kg; Pb, 0.500 mg/kg; Cr, 13.8 mg/kg) in all cases of pelleted broiler litter were much lower than the allowable maximum values for organic fertilizer (Cd, < 3.50 mg/kg; Ni, < 120 mg/kg; Pb, < 150 mg/kg; Cr, < 270 mg/kg) (The Land Development Department, 2005). These results showed that pelleted broiler litter was acceptable for fertilizer use.

Variability among the Production Cycles

As far as the factors are concerned, there were a rise in variability and stock-related factors (age, variety, stocking density) as well as factors relating to feeding, litter and losses of nutrients, especially N (Lopez-Mosquera *et al*., 2008). According to the utilization of pelleted broiler litter as a fertilizer, variability among the four consecutive production cycles of properties in fresh and pelleted form of broiler litter were investigated (Table 2). The results of this analysis indicated that indicators did not show significant among-cycle variability in either fresh or pelleted form that were ash content, organic C, total N, Ca, Mg, Mn, B, Zn, Ni, Pb and Cr. One indicator, C:N ratio, showed significant variability in both products. Indicators that showed significant variability in fresh form but not in pelleted form were dry matter, electrical conductivity, urea N, K, Na, S, Fe, Cu and Cd. Whilst, indicators that showed significant variability only pelleted broiler litter were pH, total N, ammonium N, nitrate N and total P. As noted, the pelleting process decreased variability in nine indicators, however, it increased variability in five indicators (pH, total N, ammonium N, nitrate N and total P). The reasons perhaps caused from variability in the temperature reached during the pelleting process, that may be important to control this factor carefully. Pressing and pelleting temperature could probably be important for nitrogen, since NH_3 volatilization increases exponentially with temperature (Wood and Hall, 1991; Lopez-Mosquera *et al*., 2008; Suppadit *et al*., 2008).

Effects of pelleting process

There was a difference in mean components between fresh and pelleted broiler litter (Table 3). The pelleting process decreased moisture content by over 44.1%, from an average of 25.4% (74.6% dry matter) in fresh broiler litter to an average of 14.2% (85.8% dry matter) in pelleted broiler litter. The moisture content was associated with volume reduction. The pelleting method was convenient for storing, handling, transporting and field application. However, fresh broiler litter typically offers risk to the environment, including N emission to the atmosphere and leaching to groundwater (Sims and Wolf, 1994; Lopez-Mosquera *et al*., 2008; Suppadit, 2009). The pelleting process likewise led to a significant reduction in organic C and especially total N content, although C:N ratio was not significantly affected. On the average, pelleted broiler litter showed less in organic C (5.18 %) and total N (13.3 %) than those in fresh broiler litter. These reductions probably reflect the high temperature (90°C) in which the fresh broiler litter was subjected. Lopez-Mosquera *et al*. (2008) also detected a significant reduction of fresh broiler litter in organic C after heating to 60-80°C, which was lower than that used in this study. As far as total N is concerned, it is well known that losses increase with increasing pelleting temperature, largely as a result of NH_3 volatilization (Gale *et al*., 1991; Wood and Hall, 1991; Lopez-Mosquera *et al*., 2008; Suppadit *et al*., 2008). However, differences between the fresh and pelleted form of broiler litter were not detected for ammonium N, nitrate N, or urea N. The pH level remained basic but was less significant in pelleted broiler litter (pH, 7.60) than fresh broiler litter (pH, 8.20). It is known that the oxidation of the organic matter is an acidifying method (McBride, 1994). The decrease in pH was possibly due to the release of H^+ that are associated with organic anions during pelleting process (Lopez-Mosquera *et al*., 2008). The alkalinity of the pelleted broiler litter made it suitable especially for neutral or acid soil areas (Suppadit, 2009).

Table 1. Fertilizing values of fresh and pelleted broiler litter.

Indicators	Fresh broiler litter			Pelleted broiler litter (Mean ± S.D.; *n* = 20)
	Previous studies	**References**	**In this study (Mean ± S.D.; *n* = 20)**	
Dry matter (% d.w.)	69.4-80.5	Ekinci *et al*. (2000)	74.6 ± 4.90	85.8 ± 4.20
Electrical conductivity (dS m^{-1})	6.30-12.6	Gordillo and Cabrera (1997a)	10.0 ± 2.50	11.0 ± 2.00
pH (H_2O)	6.30-8.40	Gordillo and Cabrera (1997b)	8.20 ± 0.500	7.60 ± 0.600
Ash (% d.w.)	8.80-54.4	Stephenson *et al*. (1990)	20.2 ± 0.200	21.1 ± 0.500
Organic C (% d.w.)	29.3-38.8	Wood and Hall (1991)	38.6 ± 1.20	36.6 ± 1.60
Total N (% d.w.)	2.60-5.30	Beegle (1997)	6.00 ± 0.500	5.20 ± 0.800
C:N ratio	6.40-11.8	Nicholson *et al*. (1996)	6.43 ± 0.600	7.04 ± 0.600
Ammonium N (% d.w.)	0.300-1.00	Carballas (1996)	0.500 ± 0.0600	0.500 ± 0.0800
Nitrate N (% d.w.)	0.00500-0.100	Gordillo and Cabrera (1997a)	0.290 ± 0.0300	0.300 ± 0.0500
Organic N (% d.w.)	0.300-3.30	Fulhage and Pfost (1993)	5.01 ± 0.400	4.20 ± 0.900
Urea N (% d.w.)	0.200-1.10	Gordillo and Cabrera (1997b)	0.200 ± 0.0300	0.200 ± 0.0200
Total P (% d.w.)	0.600-3.90	Brown *et al*. (1993)	1.79 ± 0.400	1.70 ± 0.300
K (% d.w.)	0.700-5.20	Brown *et al*. (1994)	3.20 ± 0.600	3.08 ± 0.400
Ca (% d.w.)	0.800-6.10	Henry and White (1993)	3.76 ± 0.700	3.50 ± 0.500
Mg (% d.w.)	0.200-0.900	Cummis *et al*. (1993)	0.660 ± 0.100	0.600 ± 0.100
Na (% d.w.)	0.700-1.50	Edwards *et al*. (1995)	1.50 ± 0.500	1.10 ± 0.200
S (% d.w.)	0.200-0.800	Nicholson *et al*. (1996)	0.600 ± 0.0500	0.700 ± 0.0300
Fe (mg/kg)	529-2,982	Stephenson *et al*. (1990)	740 ± 185	794 ± 148
Mn (mg/kg)	125-667	Smith and Chambers (1993)	348 ± 40.0	185 ± 20.2
B (mg/kg)	23.0-125	Cummis *et al*. (1993)	20.2 ± 2.28	13.8 ± 2.30
Cu (mg/kg)	100-1,003	Brown *et al*. (1994)	70.8 ± 10.5	64.2 ± 5.50
Zn (mg/kg)	54.0-680	Malone (1992)	263 ± 20.0	261 ± 18.8
Cd (mg/kg)	2.40-3.00	Edwards *et al*. (1995)	2.90 ± 0.400	3.30 ± 0.300
Ni (mg/kg)	7.60-181	Edwards *et al*. (1995)	0.400 ± 0.0200	0.500 ± 0.0400
Pb (mg/kg)	14.6-55.0	Henry and White (1993)	0.450 ± 0.0300	0.500 ± 0.0300
Cr (mg/kg)	8.50-9.00	Edwards *et al*. (1995)	13.0 ± 2.60	13.8 ± 2.20

Characteristics of the rice hull used as bedding material on the Siriwan Co. Ltd.'s network farm: Dry matter, 92.1 %; pH, 6.58; Total C, 36.5% d.w.; Total N, 0.510% d.w.; C:N ratio, 71.2; P, 0.00180% d.w.; K, 0.285% d.w.; Ca, 0.158% d.w.; Mg, 0.100% d.w.; Na, 0.256% d.w.; S, 0.0680% d.w.; Fe, 105 mg/kg; Mn, 422 mg/kg; Co, 2.79 mg/kg; Cu, 2.58 mg/kg; Zn, 22.7 mg/kg; Cd, <0.190 mg/kg; Ni, <0.100 mg/kg; Pb, <0.100 mg/kg; Cr, 10.6 mg/kg.

In this study, heating at 90°C led to significant reductions in Fe, Mn, B and Cu contents of fresh broiler litter, that agreed with the study of Lopez-Mosquera *et al*. (2008), which showed that B, Mn, Cu, Cr and Cd contents of broiler litter were affected by pelleting temperatures of up to 90°C. Heavy metals (Cd, Ni, Pb, Cr) in this study increased which is related to a decrease in moisture content in broiler litter that agreed with the previous study of Suppadit *et al*. (2008). This could be result of the contamination of the apparatus used in the pelleting process according to the previous study of Lopez-Mosquera *et al*. (2008).

Table 2. Temporal variability among the four production cycles in the fresh and the pelleted broiler litter.

Varieties	**Indicators**	**F or X^2 value, fresh broiler litter**	**F or X^2 value, pelleted broiler litter**
No significant variability in either product	Ash	$F = 0.200^{n.s.}$	$X^2 = 7.90^{n.s.}$
	Organic C	$X^2 = 7.10^{n.s.}$	$X^2 = 9.00^{n.s.}$
	Total N	$F = 3.80^{n.s.}$	$F = 5.50^{n.s.}$
	Ca	$F = 5.20^{n.s.}$	$F = 2.10^{n.s.}$
	Mg	$F = 5.40^{n.s.}$	$F = 5.10^{n.s.}$
	Mn	$F = 4.40^{n.s.}$	$F = 3.90^{n.s.}$
	B	$F = 0.900^{n.s.}$	$F = 2.80^{n.s.}$
	Zn	$F = 4.80^{n.s.}$	$F = 3.20^{n.s.}$
	Ni	$F = 6.20^{n.s.}$	$F = 4.70^{n.s.}$
	Pb	$F = 1.20^{n.s.}$	$F = 1.40^{n.s.}$
	Cr	$F = 6.30^{n.s.}$	$F = 8.90^{n.s.}$
Significant variability in both products	C:N ratio	$F = 6.80$*	$F = 10.2$*
Significant variability in the fresh but not the pelleted broiler litter	Dry matter	$F = 198$*	$F = 10.0^{n.s.}$
	Electrical conductivity	$F = 121$*	$F = 4.10^{n.s.}$
	Urea N	$F = 92.1$*	$F = 7.80^{n.s.}$
	K	$F = 6.90$*	$F = 3.60^{n.s.}$
	Na	$F = 28.9$*	$F = 1.10^{n.s.}$
	S	$F = 80.9$*	$F = 5.70^{n.s.}$
	Fe	$F = 7.80$*	$F = 0.800^{n.s.}$
	Cu	$F = 8.50$*	$F = 2.10^{n.s.}$
	Cd	$F = 8.90$*	$F = 2.30^{n.s.}$
Significant variability in the pelleted but not the fresh broiler litter	pH	$X^2 = 10.1^{n.s.}$	$F = 804$*
	Total N	$F = 5.20^{n.s.}$	$F = 7.70$*
	Ammonium N	$X^2 = 6.50^{n.s.}$	$F = 20.3$*
	Nitrate N	$X^2 = 9.00^{n.s.}$	$F = 25.4$*
	Total P	$X^2 = 4.40^{n.s.}$	$F = 7.40$*

* = Significant variability (P<0.05)
$^{n.s.}$ = Non significant difference (P>0.05)

Table 3. Differences in properties between the fresh and the pelleted broiler litter.

Varieties	Indicators	*F* or *U* value (difference between broiler litter comparisons)	Pelleted vs. fresh (difference between means)
No temporal variability	Ash (% d.w.)	$F = 1.70^{n.s.}$	+ 0.900
	Organic C (% d.w.)	$U = 26.5$*	- 2.00
	Total N (% d.w.)	$F = 14.0$*	- 0.800
	Ca (% d.w.)	$F = 0.300^{n.s.}$	- 0.260
	Mg (% d.w.)	$F = 2.20^{n.s.}$	- 0.0600
	Fe (mg/kg)	$F = 20.8$*	- 54.0
	Mn (mg/kg)	$U = 6.20$*	- 163
	B (mg/kg)	$F = 30.0$*	- 6.40
	Zn (mg/kg)	$F = 0.300^{n.s.}$	- 2.00
Temporal variability	Dry matter (% d.w.)	$F_{min} = 780$* (3 cycles)	+ 11.2
	Electrical conductivity (dS m^{-1})	$F_{max} = 12.2^{n.s.}$	+ 1.00
	pH	$F_{min} = 998$* (3 cycles)	- 0.600
	C:N ratio	$F_{max} = 15.1^{n.s.}$	+ 0.610
	Ammonium N (% d.w.)	$F_{max} = 4.20^{n.s.}$	0
	Nitrate N (% d.w.)	$F_{max} = 5.30^{n.s.}$	+ 0.0100
	Organic N (% d.w.)	$F_{max} = 12.9^{n.s.}$	- 0.810
	Urea N (% d.w.)	$F_{max} = 6.00^{n.s.}$	0
	Total P (% d.w.)	$F_{max} = 1.60^{n.s.}$	- 0.0900
	K (% d.w.)	$F_{max} = 15.8^{n.s.}$	- 0.120
	Na (% d.w.)	$F_{max} = 7.00^{n.s.}$	- 0.400
	S (% d.w.)	$F_{min} = 65.8$* (4 cycles)	+ 0.100
	Cu (mg/kg)	$F_{min} = 18.8$* (3 cycles)	- 6.60
	Cd (mg/kg)	$F_{min} = 156$* (3 cycles)	+ 0.400
	Ni (mg/kg)	$F_{min} = 16.5$* (2 cycles)	+ 0.100
	Pb (mg/kg)	$F_{min} = 12.8$* (2 cycles)	+ 0.0500
	Cr (mg/kg)	$F_{min} = 30.0$* (2 cycles)	+ 0.800

For indicators not showing temporal variability (see Table 2), the two broiler litters products were compared by considering the samples obtained from the four different cycles simply as replicates (n = 20); for indicators showing temporal variability, comparisons were performed cycle by cycle (n = 5 in each case), and an overall significant difference between the fresh and pelleted broiler litter was defined to be present when significant differences were detected in two or more of the four cycles; for these latter indicators, the value shown is the maximum F value for non significant comparisons, or the minimum F value for significant comparisons, with the number of individual significant values in bracket.

* = Significant variability (P<0.05);

$^{n.s.}$ = Non significant difference (P>0.05)

Fertilizing Value Prediction

The results of linear regression on fertilizing values, in both fresh and pelleted broiler litter are shown in Table 4. To be harmonious to the previous study of Nicholson *et al*. (1996) which suggested that dry matter content of broiler litter is a good predictor of total N, P, K, Mg and S contents expressed through fresh broiler litter weight. The content of dry matter in pelleted broiler litter in this study was only a good predictor for various nitrogen contents, but not for other indicators. This suggests that simple determination of dry matter content could be effective for estimating total N content (ammonium N, nitrate N, organic N, urea N) in pelleted broiler litter. This may be particular value as a basis for rapid quality-control tests during the pelleting process.

Table 4. The results of linear regressions with dry matter as candidate predictor variable and chemical properties as dependent variables.

Broiler litter	**Regression equation [*n* = 20 (5 houses x 4 cycles)]**	r^2	***F* value**	***p* value**
Fresh	Total N = -6.70×10^{-3} DM + 6.50	0	0.0200	0.850
Pelleted	Total N = $-0.219 \times$ DM + 23.9	0.710	17.8	0.00100
Fresh	Organic N = -3.14×10^{-2} DM + 7.35	0.0300	0.250	0.540
Pelleted	Organic N = $-0.188 \times$ DM + 20.3	0.700	14.6	0.00200
Fresh	Ammonium N = 1.14×10^{-2} DM - 0.350	0.220	2.80	0.130
Pelleted	Ammonium N = -1.38×10^{-2} DM + 1.68	0.790	16.4	0.00200
Fresh	Urea N = 5.36×10^{-3} DM - 0.200	0.450	8.10	0.0560
Pelleted	Urea N = -9.32×10^{-3} DM + 1.00	0.760	20.3	0.00100
Fresh	Nitrate N = 3.62×10^{-3} DM + 0.0200	0.210	2.77	0.110
Pelleted	Nitrate N = -10.5×10^{-3} DM + 1.20	0.730	21.8	0.00300
Fresh	Total P = -3.23×10^{-2} DM + 4.20	0.165	2.23	0.125
Pelleted	Total P = -1.30×10^{-2} DM + 2.82	0.0500	0.430	0.620
Fresh	K = 6.30×10^{-2} DM - 1.50	0.230	3.67	0.100
Pelleted	K = -8.06×10^{-2} DM + 10.0	0.310	4.11	0.0700
Fresh	Mg = 1.29×10^{-2} DM - 0.300	0.300	5.30	0.0540
Pelleted	Mg = -9.32×10^{-3} DM + 1.40	0.120	1.30	0.344
Fresh	S = -3.75×10^{-3} DM + 0.88	0.220	3.33	0.0860
Pelleted	S = 3.50×10^{-3} DM + 0.40	0.210	2.65	0.150

CONCLUSIONS

The pelleted broiler litter meets all qualifications as an organic fertilizer on account of high fertilizer value. Some components may be slightly denatured due to the heat and pressure from the pelleting process that occurred only for a short period (~5-10 second). Pelleted broiler litter has more appropriate characteristic in fertilizing values than fresh broiler litter. Total N, ammonium N, nitrate N, organic N and urea N can be estimated from dry matter content. From a practical point of view, the pelleting process is convenient for storing, handling, transporting and field application of the broiler litter.

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