SUITABILITY OF DRYIED POULTRY MANURE FOR USE AS ANIMAL FEED

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ABSTRACT

The aim of this study was to determine the optimum quality of poultry manure dried at various layer thickness and temperatures. The effects of the depth of manure layer (1, 2 and 3 cm) and dryer temperature (40, 50 and 60°C) on the drying time and the quality of the dried manure as a safe animal feed were investigated. The results indicate that the optimum depth and temperature to dry manure in a heated air dryer is 3 cm and 60 °C, respectively. Increasing the temperature and/or decreasing the depth of manure layer decrease the concentration of protein and amino acids in the dried manure. The temperature and depth of the manure layer did not affect the elemental composition of the dried manure. The presence and offensiveness of odour were reduced by 63.3% and 69.3%, respectively. The majority of the panel members described the odour of the dried manure as that of grain. The drying process reduced the number of bacteria, yeast and mould, and E. Coli by 65.62%-99.83%, 74.07%-99.63%, and 99.97% respectively. The Salmonallae were destroyed completely at temperatures above 50 °C.

Keywords: *poultry manure, solar, drying, temperature, depth, moisture, protein, odour, minerals, bacteria, yeast and mould, E. coli, Salmonallae.*

INTRODUCTION

The poultry industry is one of the largest and fastest growing food production sectors in the world with meat and egg production growing at an annual rate of 5% (Sims and Wolf, 1994). The 2016 Egyptian annual census data estimated the flock to be over 750 million birds with an estimated yearly output of 93,750 tonnes of manure (FAO, 2007). Storage and disposal of raw poultry manure has become an environmental problem because of the associated air, water and soil pollution (Benali and Kudra, 2006).

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Poultry manure begins to decompose immediately after excretion, giving off ammonia which can have adverse effects on the health and productivity of birds as well as the health of the farm workers (Pierson et al, 2005; and Amon et al., 2006). It can also serve as a breeding ground for pathogenic microorganisms, flies and other undesirable insects, a transmitting medium for diseases among birds and a source of odour caused by the activity of microorganisms in the manure (Berry and Miller, 2005; and Fares et al., 2005). Proper poultry manure management systems that will preserve the environment contribute to both animal and human health and return a profit on investment to the farmer need to be developed.

Drying can prevent environmental problems associated with storage and utilization of raw manure. Drying eliminates the stickiness of manure and minimizes the rate of deterioration from chemical and biological activities. Dried poultry manure can be used as a component of feed for ruminants (Lanyasunya et al. 2006; Hadjipanayiotou et al., 1993; El-Sayed, 1992; Islam and Hossain, 1990; Jakhmola et al., 1988; Daniet et al. 1983). Hadjipanayiotou et al. (1993) reported significant increase in goat milk production and reduced feeding costs when using diet supplemented with poultry manure.

The main aim of this study was to evaluate the suitability of dried manure as an animal feed. The specific objectives were to: (a) evaluate the drying behaviour of laying hen manure at temperatures in the range of 40-60°C and different depths of manure in the range of 1-3 cm. and (b) determine the changes in the properties of the manure due to the drying process as measured by its nutritional value, pathogens content and presence and offensiveness of odour.

MATERIALS AND METHODS

Drying Trays

Three sets of trays, each set consisting of three replicate trays of the same dimensions, were constructed using galvanized metal sheets and used for the drying of poultry manure in the laboratory. Each tray has a drying surface area of 100 cm^2. The depths of the trays were 1, 2, and 3 cm for the sets 1, 2 and 3, respectively. Figure 1 shows the dimensions of a drying tray.

Manure Collection and Preparation

Poultry manure was obtained from a commercial layer's house. The manure was collected under battery cages of a laying house accommodating approximately 50,000 hens. The manure was collected and placed in clean plastic bags and transported to the Bioengineering Laboratory. Some characteristics of the poultry manure used in this study are presented in Table 1.

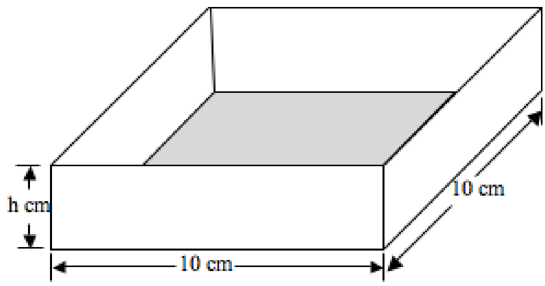

Figure 1: The dimensions of the drying tray (h=1, 2, or 3cm)

Table 1: Characteristics of poultry manure used in study

Item	Measured value*
Moisture content	78.4 %
Density	960 kg/m^3
Total solids	215520 mg/L
Volatile solids	139770 mg/L
Ash	75750 mg/L
Total Chemical Oxygen Demand	328500 mg/L
Soluble Chemical Oxygen Demand	130000 mg/L
Total Kjedahl Nitrogen	18960 mg/L
Ammonium Nitrogen	9470 mg/L
Calcium	19760 mg/L
Phosphorous	5590 mg/L
Potassium	4140 mg/L
pH	8.40

*** dry basis**

Experimental Procedure

The effects of three drying temperatures (40, 50 and 60°C) and three manure depths (1, 2 and 3 cm) on the manure drying time and manure characteristics were investigated. The three sets of trays were weighted with a weighing scale (METTLER Balance model PM4600, Fisher

Scientific, Montreal, Quebec, Canada). The trays were then filled to their respective depths with the manure and weighed. They were then placed in a forced draft oven (Isotemp Oven Model 655F, Fisher Scientific, Montreal, Quebec, Canada) adjusted to the required temperature. The drying rate was monitored by determining the change in weight at 2 h time intervals until there was no change in weight. The oven temperature was then readjusted to the next level and the same experimental procedure was followed. Three replications for each temperature-manure depth combination were carried out.

Experimental Analysis

The properties of the manure were determined before and after drying. The pH, density, total solids, chemical oxygen demand, total Kjeldahl nitrogen, ammonia nitrogen and microbiological analyses were performed according to the procedures described in APHA (1998). The moisture content was determined using the oven method according to the procedure described in ASAE (1991). The elemental analyses (P, K, Ca) were performed according to the procedures described in the AOAC (1975). The total protein was determined using the Tecator Kjeltec Auto Analyzer (Model-1026, Fisher Scientific, Montreal, Quebec, Canada). The amino acids were determined using the HFB-IBA (Heptafluorobutyric isobutyl esters of amino acids) Amino Acid derivatization Kit (Alltech Associates, Inc. Cat. No.18094) and the amino acids profile was determined using the gas chromatograph (Model-HP5890 Series II, Hewlett, Palo Alto, CA). The organoleptic test developed by Ghaly (1982) for measurement of odour from animal waste was used to measure the presence and offensiveness of odour in the dried poultry manure using the evaluation sheet in Figure 2.

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Odour evaluation data sheet

Name: ______________________

Date: ______________________

A. Rate the samples to the presence of odor and the odor as to offensiveness according to the following scale using samples “0” as having 0 rating and samples “10” as having 10 rating.

Presence		Offensiveness	
No odour	0	No offensive odour	0
Very faint	1-2	Very faint offensive odour	1-2
Faint	3-4	Faint offensive odour	3-4
Definite	5-7	Definite offensive odour	5-7
Strong	8-9	Strong offensive odour	8-9
Very strong	10	Very strong offensive odour	10

B. Describe the odor of each sample by giving an appropriate descriptive term. Possible terms that might be used are given in the list below or you may use a term of your choice which you feel properly describes the odor.

Mould, musty
Fish
Stagnant water
Sulphide, rotten eggs
Petroleum
Earth
Yeast
Ammonia
Grain, animal feed
Sour, fermented
Rotten cabbage, mercaptans
Other (Please specify)

RATING

Sample	Presence Rating	Offensiveness Rating	Odour Description
1			
2			
3			

Thank you for your time

Figure 2**:** Odour evaluation sheet (Ghaly, 1984)

RESULTS AND DISCUSSION

Drying Effectiveness

The data on the drying time, moisture and drying effectiveness at various manure depths and drying temperatures are presented in Table 2. The parameter "drying effectiveness" is defined in this study as the time needed to drive off 1 g of moisture from the manure. The results indicated that the 1 cm deep manure layer dried fastest at the three drying temperatures, followed by 2 cm deep manure layer and 3 cm deep manure layer. The thinner the manure layer, the lower the amount of moisture it contained and consequently a shorter time duration was required to drive off the moisture. The time required to dry the 2 cm deep manure layer was more than the time required to dry the 1 cm deep layer by about 106% at 40°C, 100% at 50°C and 87% at 60°C. The time required to dry the 3 cm deep manure layer was more than the time required to dry the 2 cm deep manure layer by 22% at 40°C, 12% at 50°C and 7% at 60°C. This showed that the difference in drying time between the shallower and deeper manure layers decreased as the temperature increased.

Total Protein and Amino Acids

Ruffin and McCaskey (1990) reported that most poultry manure contains about 25% crude protein on a DM basis, about half of which derives from uric acid, which can be efficiently used by rumen microbes for protein production. Generally, nutrients in manure will vary from farm to farm depending on the quality of the ration offered to the birds, their age, amount of feed wasted, the amount of water spillage and more importantly, the type and amount of bedding used (Lanyasunya et al., 2006).

The total protein content and amino acids profile determined in this study for raw and dried manure are shown in Table 3. The raw manure used in this study contained 43.3% DM basis crude protein. Lanyasunya et al. (2006) reported crude protein content of 15.4% DM basis for raw poultry manure/litter. Trevino et al. (2002) reported crude protein content of 31.6% DM basis for raw poultry manure/litter. The protein value reported in this study is higher than those reported by others due to the freshness and proper storage of the manure used in the study. Lanyasunya et al. (2006) stated that poultry manure may lose more than 75% of its nutritional value through volatilization, leaching and rotting as a result of poor manure handling.

Manure air-drying is used to increase the manure shelf life. However, Jakhmola et al., (1988) reported that drying of manure results in loss of nitrogen. This problem was not encountered in this study as the total protein concentration in dried manure was slightly and insignificantly lower than that in raw manure. Neither the temperature nor the depth of the manure layer appeared to have any significant effect on the final protein concentration.

The amino acids profile consisted of 12 amino acids: alanine, glutamic, threonine, arginine, phenylalamine, valine, methionine, histidine, serine, leucine, lysine and cystine. Generally, the drying process reduced the concentration of all amino acids in poultry manure. Increasing the ambient temperature and/or decreasing the manure depth decreased the concentration of amino acids in the dried manure. The highest values of amino acids were observed at the lowest drying temperature and the highest manure depth while the lowest values of amino acids were observed at the highest drying temperature and the lowest manure depth.

Table 2**:** Drying time and drying effectiveness of poultry manure at various temperatures and depths

Drying Temperature (°C)	Manure Depth (cm)	Drying Time (h)	Weight(g)		Moisture (g)	Drying Effectiveness (h/g)
			Initial	Final		
40	1	55	125.95	27.15	98.80	0.56
	2	106	224.70	48.43	176.27	0.60
	3	120	312.72	67.41	245.31	0.50
50	1	44	129.16	27.84	101.32	0.43
	2	84	226.21	48.71	177.50	0.47
	3	90	314.28	67.74	246.54	0.37
60	1	28	127.18	27.41	99.77	0.28
	2	52	227.86	49.11	178.75	0.29
	3	60	322.57	69.52	253.05	0.24

Table 3**:** Effect of drying on protein and amino acids concentration in manure

Drying Temp. (°C)	Manure Depth (cm)	Total Protein (%DB)	Amino Acids (%DB)											
			Ala	Glu	Thu	Arg	Phe	Val	Met	His	Ser	Leu	Lys	Cys
40	1	40.6	1.27	1.32	0.30	0.25	0.43	0.47	0.22	0.22	0.40	0.90	0.34	0.05
	2	42.2	1.39	1.39	0.34	0.34	0.47	0.50	0.25	0.25	0.45	0.98	0.40	0.06
	3	42.4	1.46	1.42	0.36	0.36	0.49	0.52	0.26	0.27	0.47	1.03	0.43	0.06
50	1	39.4	1.25	1.31	0.27	0.23	0.41	0.46	0.20	0.20	0.39	0.87	0.32	0.03
	2	41.5	1.36	1.37	0.31	0.32	0.46	0.49	0.23	0.23	0.42	0.96	0.38	0.04
	3	41.6	1.44	1.39	0.33	0.33	0.48	0.50	0.25	0.26	0.43	0.99	0.41	0.05
60	1	39.4	1.18	1.09	0.21	0.18	0.37	0.44	0.15	0.13	0.35	0.80	0.27	0.02
	2	40.0	1.30	1.23	0.27	0.22	0.42	0.46	0.19	0.19	0.39	0.87	0.32	0.04
	3	40.2	1.36	1.26	0.31	0.27	0.44	0.47	0.21	0.22	0.41	0.91	0.35	0.04
Raw Manure		43.3	1.52	1.47	0.39	0.39	0.52	0.54	0.29	0.31	0.50	1.11	0.47	0.07

Ala-Alanine, Glu-Glutamic, Th-Threonine, Arg- Arginine, Phe-Phenylalamine, Vla- Valine, Met- Methionine, His- Histidine, Ser-Serine, Leu- Leucine, Lys- Lysine, Csy- Cysteine

Elemental Analyses

Paul et al., (1993) reported that poultry manure contains a wide array of minerals such as phosphorous (0.56 - 3.92%), potassium (0.73 - 5.17) and calcium (0.81 - 6.13). Others elements such as magnesium (Mg), sulphur (S), manganese (Mn), copper (Cu), zinc (Zn), chlorine (Cl), boron (B), iron (Fe), and molybdenum (Mo) may also be present in the poultry manure. Most of these elemental nutrients originate from the feed, supplements, medications, and water consumed by the birds. The concentration of nitrogen, calcium, phosphorous and potassium in the dried poultry manure are shown in Table 4. Very small changes in the concentration of Ca, P and K occurred during the drying process. However, about 50% of the nitrogen was lost during the drying process. Both temperature and manure depth did not have any significant effect on the elemental composition in the dried manure.

Odor

At the start of a new experiment, the odor given off near the oven during the drying process was noticeable. However, when the drying process progressed, the presence and offensiveness of the odor decreased with the time and the final product (dried manure) did not have any offensive odor. The results of the organoleptic test showed that both the presence and offensiveness of the dried poultry manure odor were reduced by 65.3% and 69.3%, respectively (as compared to that of the fresh poultry manure). The odor present in the dried manure was not offensive. 33.3% of the panel members described the odor as that of grain, 20% described it as a mold musty odor, 13.3% described it as that of ammonia, 13.3 described it as sour or fermented odor, 6.7% described it as fish odor, 6.7% described it as yeast odor ad 6.7% described it as sulfide or rotten eggs odor). Mondinia et al. (1996) reported that active drying is one of the main techniques employed to prevent losses of NH_3 and development of undesirable odor from poultry manure.

Microbial Analysis

A major obstacle to the feeding of poultry manure as a protein supplement for ruminants is pathogenic organisms (Lanyasunya et al., 2006). However, this problem may be minimized by proper manure handling. Raw poultry manure contains many potentially harmful pathogens, such as Salmonella and E. coli. Fortunately, these potentially harmful bacteria can be killed with mild heat (60 ºC).

The microbial count in manure attained in this study is presented in Table 5. Generally, a high number of bacteria (477×10^7 cells/g manure) were found in the raw manure. The drying process reduced the number of bacteria by 65.62%-99.83% (from 477×10^7 to 2.1×10^7 - 75×10^7 cells/g manure). The initial number of yeast and mold cells in raw manure was 2700 cells/g manure. The drying process reduced the number of yeast and mold cells by 74.07% - 99.63% (to <10 cells/ g manure). The initial number of *E. coli* cells in the raw manure was 21,986,666 cells/g manure. The drying process reduced the number of *E. coli* by 99.97% (to <10 cells/g manure). *Salmonellae* were detected in the dried manure samples collected after the drying process of the 3 cm manure layer at 40°C. The results indicated that the higher the drying temperature cycle and the thinner the manure layer, the smaller the number of microbes present in the dried manure which make it more suitable for animal feeding. Hadjipanayiotou et al. (1993) didn't encounter any health problems with ruminants fed on diet mixed with 33% poultry manure.

Table 4: Essential elements in raw and dried poultry manure

Drying Temperature (°*C)*	Manure Depth (cm)	Elements (% DB)			
		Nitrogen	Calcium	Phosphorous	Potassium
40	1	4.92	9.15	2.46	1.91
	2	4.63	9.16	2.45	1.90
	3	4.48	9.16	2.46	1.91
50	1	4.45	9.15	2.45	1.90
	2	4.35	9.14	2.45	1.89
	3	4.23	9.14	2.46	1.90
60	1	4.16	9.14	2.45	1.89
	2	3.99	9.13	2.44	1.90
	3	3.92	9.13	2.45	1.89
Raw Manure		8.8	9.17	2.48	1.92

Table 5: Average microbial count in raw and dried poultry manure

Drying Temperature (°C)	Drying Depth (cm)	Bacteria (10^4 cells/g)	Yeast/Mould (cells/g)	*E. Coli* (10^4 cells/g)	*Salmonellae* (preserve)
40	1	55000	250	10	PP
	2	69000	370	20	PP
	3	75000	430	30	PP
50	1	2100	170	<10	ND
	2	2900	210	10	ND
	3	4100	310	20	ND
60	1	440	<10	<10	ND
	2	530	<10	<10	ND
	3	620	<10	<10	ND
Raw Manure		477000	2700	2290	PP

PP= partially present, ND= not detected

CONCLUSIONS

The results indicate that the optimum depth and temperature to dry manure in the air dryer is 3 cm and 60°C, respectively. Increasing the temperature and/or decreasing the manure depth decreases the concentration of protein and amino acids in the dried manure. The temperature and manure depth did not affect the elemental composition of the dried manure. The presence and offensiveness of odour were reduced by 63.3% and 69.3% respectively. The drying process reduced the number of bacteria, yeast and mould, and *E. Coli* by 65.62%-99.83%, 74.07%-99.63%, and 99.97% respectively. The *Salmonallae* were destroyed completely at temperatures above 50°C.

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الملخص العربى

قابلية سماد الدواجن الجاف لاستخدامه كعلف حيواني

د.نسرين سمير محمود*

كان الهدف من هذه الدراسة هو تحديد الجودة المثلى لسماد الدواجن المجففة بسمك طبقة ودرجات حرارة مختلفة. تم دراسة تأثير عمق طبقة السماد (١، ٢ و ٣ سم) ودرجة حرارة المجفف (٤٠ و ٥٠ و ٦٠ درجة مئوية) على وقت التجفيف ونوعية السماد المجفف كعلف حيواني آمن. وتشير النتائج إلى أن العمق ودرجة الحرارة المثلى لتجفيف السماد في مجفف الهواء الساخن هو ٣ سم و ٦٠ درجة مئوية، على التوالي. زيادة درجة الحرارة و / أو خفض عمق طبقة السماد يقلل من تركيز البروتين والأحماض الأمينية في السماد المجفف. ولم تؤثر درجة حرارة وعمق طبقة الروث على التركيب الأولي للسماد الجاف. تم تقليل وجود ورائحة الرائحة بنسبة ٦٣.٣٪ و ٦٩.٣٪ على التوالي. ووصفت غالبية أعضاء الفريق رائحة السماد المجفف بأنه من الحبوب. خفضت عملية التجفيف عدد البكتيريا والخميرة والعفن، و E. كولي بنسبة ٦٥.٦٢٪ -٩٩.٨٣٪، ٧٤.٠٧٪ -٩٩.٦٣٪، و ٩٩.٩٧٪ على التوالي. تم تدمير السلمونالي تماما في درجات حرارة فوق ٥٠ درجة مئوية.

***مدرس الهندسة الزراعية - كلية الزراعة - جامعة القاهرة.**