

# Characterization of Chicken Manure from Manjung Region

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**Abstract.** Poultry business is a growing industry in Manjung Region, associated with high loading of daily manure generation. The manure contains food source that attract flies to lay eggs, which create an endemic health and societal problem. Chicken manure however can be a potential resource for value-added products such as biogas and bio fertilizer. As a start, manure was characterized for its contents such as using CHNS, TGA, AAS, XRF and ICP-OES. Key highlights include protein content of 34.5% and 27% as well as total organics of 45% and 51% for fresh and composted manure respectively. Stored energy was determined as 6905 J/g for fresh manure and 8239 J/g for composted manure. These and other parameters determined are comparable to literature values on chicken manure from various countries. The availability of energy and protein in the manure provides an avenue to convert them into another form of energy such as biogas. As the food source is digested, the fly issue could potentially be alleviated.

## 1. Introduction

Manjung district, a south-western part of the state of Perak in Malaysia is known for its major tourist attraction of Pangkor Island. The district alone supplies about 10% of the national chicken produce. At typical steady-state chicken population of 14 million, Manjung's poultry generates approximately 1400 tons of chicken dropping daily for disposal. Currently, the biomass is sold raw at RM 3 per 20 kg for agricultural use, thus resulting in widespread flies' problem across the region. Two commonly employed farming practices are open and closed farming. Both systems are ridden with flies due to the large daily manure generation with the open system being significantly detrimental.

Generally, flies are attracted to decomposed organics such as food waste and manure to feed and lay eggs [1]. When the infested manure is used as fertilizer in agricultural land, under suitable humidity the eggs hatch into flies that created an endemic health and societal problem. One harvesting cycle of broilers (chickens bred for meat) takes about 40 days, which is also when the manure is collected to be sold as raw fertilizer. Apart from fertilizer, the manure is a potential biomass for biogas production [2-5].

Prior to any treatment, the fresh manure was characterized in terms of moisture content, carbon and nitrogen content as well as macro and micronutrients. Analysis techniques used include CHNS, atomic



absorption spectroscopy (AAS), inductive coupled plasma optical emission spectrometry (ICP-OES), and Bomb Calorimetry.

This paper discusses experimental findings on manure characterization from Manjung region in comparison to literature values obtained from various countries. The established values could serve as a baseline values for researchers to further enrich the nutritional content or to modify the parameters for specific premix formulations of biomass for biogas production.

## 2. Material and methods

### 2.1. Material

Fresh and composted chicken manure were obtained from Manjung's poultry closed farm. The fresh manure was collected after 40 days of a harvesting cycle while the composted manure was supplied by Dindings Poultry Sdn. Bhd.

### 2.2. Methods

#### 2.2.1. Determination of moisture content

Moisture content was analysed in triplicate using a HX-240 Moisture Analyser by Mettler Toledo.

#### 2.2.2. Determination of pH value

The pH value of chicken manure was determined in triplicate using a pH meter of Eutech pH 700 at weight ratio of 1:10 (manure: water) [6].

#### 2.2.3. Determination of carbon and nitrogen content

Carbon and nitrogen content were analysed using a Perkin Elmer 2400 series CHNS analyser on 1 mg manure sample.

#### 2.2.4. Determination of Protein, Macro and Micro Nutrients

Theoretical protein content was calculated by multiplying nitrogen content with 6.25 [7]. Microelements of  $K^+$ ,  $Na^+$ ,  $Ca^{2+}$ ,  $Mg^{2+}$  were determined using two methods- AAS and ICP-OES for comparison. For both analyses, 0.1g of manure sample was added into 1g of concentrated nitric acid ( $HNO_3$ ) and 5g of distilled water. The mixture was transferred into ETHOS One Microwave Digester at 170°C (500 W) for 50 minutes. Later, the sample was diluted to 1% (volume basis) concentration prior to analysis using AAS and ICP-OES.

#### 2.2.5. Thermogravimetric Analysis (TGA)

5 mg manure was weighed and transferred to microbalance of a TGA Q50 analyser. The system was purged with nitrogen prior to thermal treatment under gas mixture of air at a flow rate of 20 ml.min<sup>-1</sup>. The temperature range used was 25 - 900°C at a heating rate of 20°C.min<sup>-1</sup>. The sample then was held at 900°C for 1 hour. Thermal degradation data was extracted to plot the percentage of weight loss over temperature [8].

## 3. Result and discussion

### 3.1. Characterization of chicken manure

Table 1 summarizes the characterization results in comparison to literature findings. Fresh and composted manure were determined to have high protein and carbohydrate at 34.5% and 31% at the highest. These are food sources for flies that could explain the rampant regional flies problem. Fresh manure contains 34.5% protein and 21% carbohydrate as compared to composted manure at 27.13% and 31% respectively. Both values reflect the poultry practice of overfeeding the chicken in order to meet minimum body weight of 2 kg prior to harvesting in 40 days. The chickens therefore do not have sufficient time to digest the food which are predominantly starch from mixed grains. Protein and

carbohydrate content signify stored energy in the manure that could be potential for energy conversion into biogas.

In terms of C and N content, it is not expected for composted manure to have higher C and less N. In fact, the opposite trends typically prevail in various work [9]. Low C/N ratio (less than 20) signifies nitrogen volatilization in the form of ammonia and odours which is enhanced by high temperature and basic pH [10]. The pH recorded for composted chicken manure is 7.79 as compared to 6.10 for fresh chicken manure. This shows that composted manure is aged significantly to reach the classic pH of matured compost at about neutral. However, at C/N value of 7.19, the ratio is far less than normally recorded for matured compost in the range of 25 to 30. Compost with such C/N ratio signifies balance degradation process between carbon and nitrogen sources [11]. These results show that the composted manure has not reached maturation stage and could still attract flies based on its protein and carbohydrate leftovers. In general, the C and N content determined in this work differ greatly to the literature references, attributed to the chicken diet and farming practices worldwide. This is evidence by equally large variations between the literature values as well. This trend continues for macro and microelements in the manure as can be seen for  $K^+$ ,  $Na^+$ ,  $Ca^{2+}$  and  $Mg^{2+}$ .

**Table 1.** Elemental analysis of the chicken manure

Parameters	Experimental		Literature Review			
	Fresh Chicken Manure	Composted Chicken Manure	[12]	[13]	[14]	[15]
Total C	21.12%	31.20%	-	44.70 %	407.4 g/kg	22.70%
Total N	5.52%	4.34%	-	24.30 %	55.7 g/kg	2.40%
C/N Ratio	3.83	7.19	-	1.84	7.31	9.5
Moisture	39.73%	28.26%	-	-	-	-
Protein	34.5%	27.13%	-	-	-	-
$K^+$	537.03 ppm <sup>a</sup>	574.25 ppm <sup>a</sup>	588.9 ppm	0.70 <sup>c</sup> %	14469 ppm	-
$Na^+$	92.35 ppm <sup>a</sup>	486.59 ppm <sup>a</sup>	193.2 ppm	-	-	375.8 ppm <sup>b</sup>
$Ca^{2+}$	1633 ppm <sup>b</sup>	811 ppm <sup>b</sup>	1958 ppm <sup>a</sup>	5.60 <sup>c</sup> %	1480 ppm	1503 ppm <sup>b</sup>
$Mg^{2+}$	101.8 ppm <sup>b</sup>	206 ppm <sup>b</sup>	75.6 ppm <sup>a</sup>	0.30 <sup>c</sup> %	192 ppm	436.7 ppm <sup>b</sup>
pH	6.10	7.79	7.29	-	7.7	6.94
Energy Content (J/g)	6905 <sup>d</sup>	8239 <sup>d</sup>	-	-	-	-

<sup>a</sup> AAS analysis

<sup>b</sup> ICP-OES

<sup>c</sup> XRD

<sup>d</sup> Bomb calorimeter

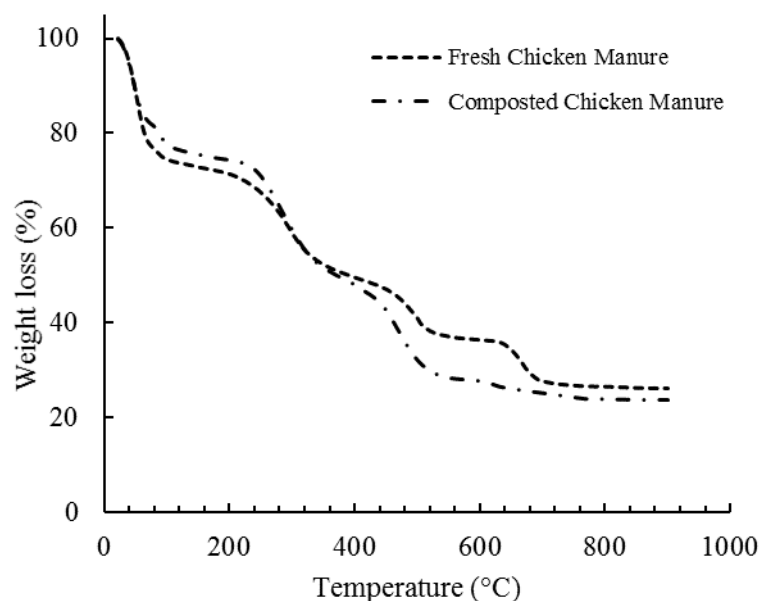
The elemental concentration increased after composting process except for  $Ca^{2+}$ . The values are comparable to literature findings suggesting that the natural chicken digestive system able to render the food into a uniform quality of manure. The only difference is on the protein (N) and carbohydrate (C) leftovers that are heavily dependent on the feeding practice. Cations are essential supplements that impact soil chemical properties which eventually affect plant development [7]. Fresh manure has lower  $Na^+$  content while composted manure has a low concentration of  $Mg^{2+}$  relative to other elements, similar trend is represented in the literatures. Sodium ( $Na^+$ ) is a micronutrient for plant while the rest of the cations are macronutrients. Based on low  $Na^+$  alone, fresh manure could be a better

plant's growth promoter as the element is only required in small amount, but other qualities should also be considered when choosing a suitable fertilizer.

During the decomposition of organic matter, nitrogen usually experiences two different stages of mineralization and immobilization. The latter results in nitrogen decomposition into plant accessible forms such as  $\text{NH}_4^+$  and  $\text{NO}_3^-$  (via nitrification). Immobilization of nitrogen occurs when the accessible nitrogen species are taken up by microorganisms, preventing them from being accessible by plants. The extent of nitrogen immobilization is related to the bio-chemical composition of the manure. C/N ratio for composted chicken manure is significantly higher than fresh chicken manure. High C/N ratio in compost will promote nitrogen immobilization. The immobilized nitrogen will be available to plants after the microorganisms die and the nitrogen is released [16]. The results obtained in this study suggest that chicken manure can be a decent source of organic carbon which is essential in enhancing soil quality while the N plays a critical part in plant development [12]. However, without an analysis of common fertilizer quality benchmark of N, P and K content; both fresh and composted manure examined cannot be deemed suitable as an all-rounder fertilizer. Nevertheless, there are generous amount of literature to support the claim especially on chicken manure role to promote plant's growth [12].

### 3.2. Thermogravimetric analysis

TGA profiles of fresh and composted chicken manure are shown in Figure 1. The mass loss curves of chicken manure over temperature were summarized into Table 2. The percentage weight was calculated at temperature intervals from 160°C to 900°C, corresponding to percentage loss of water, surface organics, bound organics and low volatility organics [17].



**Figure 1.** TGA curve for Fresh and Composted chicken manure

**Table 2.** Summary of TGA for fresh and composted chicken manure

Types of chicken manure	TGA composition				Total Organics	Ash
	0-160 (°C)	160-400 (°C)	400-600 (°C)	600-900 (°C)		
	A	B	C	D		
Fresh Chicken Manure (%)	27.37	22.97	13.12	10.24	45.11	26.20
Composted Chicken Manure (%)	24.60	27.20	20.36	4.00	50.70	23.74

<sup>A</sup> Water;<sup>B</sup> Surface organics;<sup>C</sup> Hydroxyl water and intercalated organics;<sup>D</sup> Low volatility organics/compounds

From room temperature to 160°C, the weight loss of 24–28% indicates the moisture content of the manure where fresh manure has about 3% higher moisture than its composted version. The weight loss from 160°C to 400°C is mainly from thermal degradation of cellulose, hemicelluloses, protein, starch and microbial cell walls [18]. Composted manure has higher concentration of total organics and lower ash content compared to the fresh manure. The reason being that as the water mass is reduced, the other components are concentrated.

At 400°C to 600°C, about 13% of mass is further reduced for fresh manure, indicating the content of bound organics that are trapped within the sample lattice and heat-resistant organics such as lignin. Lignin is a recalcitrant biopolymer that resists degradation. Lignin degradation is suggested to occur between 300°C and 500°C [8]. Composted chicken manure did not exhibit this degradation curve between 400–600 °C, possibly due to thermal or chemical treatment used during the composting process to speed up the compost generation. The former could be ruled out as the sample contained moisture and surface organics.

The last region which is 600–900°C, the weight loss rate became steady and close to zero. The weight that loss between 600°C to 900°C corresponds to low volatility organics. These are particulate matters of compounds derived from the atmospheric transformation of organic species [19]. Residual mass of 23–27% after 900°C represents the ash and fixed carbon content. Composted manure contains less ash due to pre-treatment process employed such as screening and drying. Whereas fresh manure contains grits or sand particles from food source.

#### 4. Conclusion

Fresh and composted manure samples contain high amount protein and carbohydrates which are a food source that attract flies. At 27% protein and 31% carbohydrate, the compost is far from maturation as also evidences by C/N ratio of 7.19. The elemental analysis revealed that both fresh and composted manure could be potential as fertilizer however more analysis in terms on N, P and K values should be conducted. Variation in characterization values between experiment and literature is mainly due to different broiler diets in various countries. Besides being sold at RM 3 per 20 kg, the manure has high potential for biogas generation via anaerobic digestion and biofertilizer production by aerobic composting. Future work will examine the effectiveness of both treatment processes to convert the stored energy into biogas and the compost should alleviate the flies problem. This adds values to what has traditionally been considered as waste.

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