



Effect of Activated Carbon from Coconut Shells on Ammonia Concentration in Laying Hen Manure

Dampak Karbon Aktif Tempurung Kelapa terhadap Konsentrasi Amonia pada Feses Ayam Ras Petelur

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ABSTRACT

This research aimed to determine the response of activated carbon from coconut shells to releasing ammonia in the manure of laying hens. Thirty-six 70-week-old Isa Brown strain laying hens were utilized for each treatment in this investigation. The manure was collected in the morning. A total of 50 grams of laying hen manure were gathered. Activated carbon is then sprinkled over the collected manure. Activated carbon-sprinkled manure is kept for seven days. Activated carbon application was split into four treatments. The coconut shells-activated carbon (K) treatments were applied at doses of 0%, 10%, 20%, and 30%. The measurements include shrinkage, pH, ammonia levels, and a manure smell test. The results of this study indicate that adding different amounts of activated carbon made from coconut shells to laying hens' manure can increase shrinkage, lower pH and ammonia levels, and mask the smell of the manure—especially when using 20% Coconut Shells-Activated Carbon (K2). Based on these findings, applying 20% activated carbon derived from coconut shells is recommended for optimal manure management.

ABSTRAK

Penelitian ini bertujuan untuk mengetahui respon arang aktif dari tempurung kelapa terhadap pelepasan amonia pada feses ayam ras petelur. Sebanyak 36 ekor ayam ras petelur galur Isa Brown berumur 70 minggu digunakan untuk setiap perlakuan dalam penelitian ini. Koleksi feses dilakukan pada pagi hari. Sebanyak 50 gram feses ayam ras petelur dikumpulkan. Karbon aktif kemudian ditaburkan di atas feses yang terkumpul. Feses ayam yang telah ditaburi arang aktif disimpan selama tujuh hari. Aplikasi arang aktif dibagi menjadi empat perlakuan. Perlakuan karbon aktif (K) tempurung kelapa diberikan dengan dosis 0%, 10%, 20%, dan 30%. Pengukuran meliputi penyusutan feses, pH, kadar amonia, dan uji bau feses. Hasil penelitian ini menunjukkan bahwa penambahan arang aktif tempurung kelapa dalam jumlah yang berbeda ke dalam kotoran ayam petelur dapat meningkatkan penyusutan, menurunkan

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pH dan kadar amonia, serta mengurangi bau kotoran—terutama jika menggunakan Karbon Aktif (K2) Tempurung Kelapa 20%. Penerapan karbon aktif tempurung kelapa dengan konsentrasi 20% merupakan perlakuan terbaik yang direkomendasikan.

1. Introduction

The ammonia stench that contaminates the area surrounding the farm is one of the issues in the poultry farming sector. The primary source of ammonia odor is livestock manure, with a minor contribution from households and industry (Wyer et al., 2022). Ammonia (NH_3) is a gas produced by bacteria that break down nitrogenous waste products in excreta, including uric acid, unabsorbed protein, amino acids, and other non-protein nitrogen (NPN) molecules (Lema et al., 2022).

According to Hidayat et al. (2021), a high ammonia content is one of the reasons why poultry farms have strong odors. While chicken excrement can break down into other harmful gases such as carbon dioxide (CO_2), hydrogen sulfide (H_2S), and methane (CH_4), ammonia (NH_3) is the most concerning due to its severe health risks. With a nitrogen content of 1.57% and an average daily manure production of 0.025 kg/bird, laying hens are one of the environment's biggest sources of ammonia gas (Latshaw & Zhao, 2011; Utami et al., 2020). Later on, this leftover nitrogen will produce ammonia (Dari et al., 2019). The Ministry of Agriculture's Directorate General of Animal Husbandry and Animal Health reported that there were 379.27 million laying hens in the country in 2022 (Direktorat Jenderal Peternakan dan Kesehatan Hewan, 2023). The statistics show that laying chickens can produce up to 9,000 tons of excrement daily. Considering the volume of ammonia gas generated, this figure is extremely high. According to data compiled by EDGAR (2015) ammonia gas emissions in some Indonesian regions, particularly in Java and South Sulawesi, vary from $2.4\text{e}+2$ to $>1.2\text{e}+3$ tons/year/grid cell. The greatest exposure number for this ammonia gas emission means that the pollution is no longer environmentally safe and needs to be handled further.

Respiratory issues may arise due to ammonia contamination of the air. When ammonia concentrations range from 5 to 50 ppm, they create nervous weariness and dry nose; when they reach 1000–1500 ppm, they can cause fatal delayed pulmonary edema, dyspnea, chest discomfort, and respiratory tract spasms (Akbar et al., 2021; Faisyah et

al., 2020). Farm laborers and laying hens will have health issues due to ammonia from poultry waste (Bist et al., 2022).

Reducing ammonia emissions is crucial for environmental health. Various methods have been explored to mitigate ammonia, including biological treatments (Hagenkamp-Korth et al., 2015; Zubair et al., 2020) and chemical interventions (Eglite et al., 2021; Naujokienė et al., 2021). Some limitations exist, such as increased equipment expenses, implementation challenges, and additional adverse effects brought on by the chemicals used. Filtration in the form of adsorbents is one such approach (Hanusová, 2016). Adsorption is the process that occurs as a material is taken up by a solid's surface. The absorbed material and its absorption are attracted to one another in the adsorption phenomena. In the adsorption process, zeolite or activated carbon are typically used as the adsorbent media (Alaqarbeh et al., 2021). Activated carbon is the most commonly used adsorbent due to its affordable raw materials and simple manufacturing technique. By heating carbon-containing materials to high temperatures, activated carbon is created as a porous solid. Activated carbon's adsorption capability increases with its surface area (Fatimah & Azinuddin, 2022; Saleem et al., 2019).

Numerous earlier studies examined attempts to use activated carbon in a variety of ways to lower ammonia gas emissions. According to a previous study by Imam et al. (2022), cages with fans adjusted with activated carbon filters saw an 84% reduction in ammonia concentration. According to a different study by Ketwong et al. (2019), using activated carbon from coconut shells can reduce ammonia levels by up to 58%. In an additional investigation by Wang et al. (2022), the use of activated carbon reduced ammonia in food waste that was composted by up to 34%.

Currently, there is limited research on using activated carbon to reduce the concentration of ammonia, particularly in laying hen farms. Activated carbon was used in several previous studies to reduce ammonia gas emissions from livestock waste, but these studies might also need expensive and complex equipment installation. An urgent requirement is for a easier application, particularly in smallholder farms. Therefore, this study aims to explore the feasibility of using coconut shell-based activated carbon as a cost-effective and simple solution to reduce ammonia emissions from laying hen manure.

2. Materials and Methods

2.1 Materials

The materials used in this research included manure samples from laying hens, coconut shells-activated carbon, phosphoric acid (H_3PO_4), and plastic clips. The tools used were a manure container, grinder, plastic spoon, 60-mesh sieve, scales, pH meter, oven, furnace, and conway cup.

2.2 Research Method

In this study, thirty-six 70-week-old Isa Brown strain laying hens were used. The cage used is a battery model. Each plot's cage measures 45 cm in length, 30 to 35 cm in width, and 60 cm in height. This flock of chickens receives concentrated feed twice a day, at 08.00 and 16.00. Water for drinking is available at all times.

Coconut shell preparation involves separating dirt (soil, gravel), which may be followed by manual washing and cleaning. Followed by oven-dried at 105 °C. To turn the cleaned sample into charcoal or carbon, it is carbonized in a furnace set at 400 °C for three hours. The resulting carbon is then immersed in a 3 M H_3PO_4 solution until 7 hours, then ground with a grinder until it is smooth and sieved through a 60-mesh sieve. After that, soak for seven hours. The filtered sample is passed through Whatman filter paper, and hot water is used to wash it until the filtrate has a neutral pH (between 6 and 7) as determined by universal pH paper. After being cleaned, the activated carbon is dried at 110 °C in an oven (Zhang et al., 2017).

Manure was collected in the morning from each cage compartment using plastic bags. For each treatment, 50 g of manure was used. Activated carbon and husk carbon were then sprinkled over the collected manure. The manure was stored for seven days before being analyzed.

2.3 Experimental Design

This study used a Completely Randomized Design (CRD) with four treatments. The treatments involved the addition of coconut shell-activated carbon to 50 g of manure, as follows:

K0 : 50 g of manure (control, no activated carbon)

K1 : 50 g of manure + 10% coconut shell-activated carbon

K2 : 50 g of manure + 20% coconut shell-activated carbon

K3 : 50 g of manure + 30% coconut shell-activated carbon

2.4 Parameter Analysis

2.4.1 Manure Shrinkage (g)

Weighing the manure both before and after storage allows one to calculate the shrinkage of the manure. The final weight values are subtracted from the starting results (Najib et al., 2023).

2.4.2 Degree of Acidity (pH)

By placing a pH meter (Hana) into the manure and monitoring it until a consistent pH level is reached, one can determine the degree of acidity (pH) in the material. The pH analysis was calculated by averaging the dung sample weight (5 g) overall treatments. Then, place the sample of manure in a measuring cup and mix to dissolve it by adding 50 ml of purified water or a 1:10 ratio. A pH meter calibrated with a pH 7.0 buffer solution should be used to determine the pH of manure (Combs et al., 2003).

2.4.3 Smell of Manure

The method for measuring manure odor was carried out using organoleptic tests using 15 people who were asked to act as panelists. The criteria for panelists are students majoring in animal husbandry, at least 18 years old, and in good health (not having respiratory problems). Manure was placed 10-30 cm away from the panelists. The rating score for the smell of manure is 1 = extremely strong, 2 = strong, 3 = quite strong, 4 = less strong, and 5 = not strong (Kristiana et al., 2020).

2.4.4 Ammonia Level

Weigh ± 1 g of sample then place it in the outer conway cup. Pipette 1 ml of H_3BO_3 put it in the inner conway cup then drop it with the mix indicator. Add 1 ml of saturated Na_2CO_3 to the outer conway cup and stir gently until mixed with the sample. Cover the mixture and let it sit overnight. Titration using 0.01 N H_2SO_4 (Masterson, 2013).

2.5 Data Analysis

The Completely Randomized Design (CRD) method of variance analysis was applied to the collected data. The Duncan test is used if the treatment has an impact (Mead et al., 2011).

3. Results and Discussion

Changes in ammonia levels can be indicated by several supporting parameters, including; manure shrinkage, temperature, pH, and the value of ammonia levels (Mohammed-Nour et al., 2019). Table 1 shows the performance values and ammonia levels in the manure of laying hens given activated carbon from coconut shells-activated carbon at different levels.

Table 1. Shrinkage value, temperature, pH, and ammonia levels of manure from laying hens given activated carbon from coconut shells (K) at different levels

Parameters	Treatments			
Coconut shells-activated carbon*	K0	K1	K2	K3
Manure shrinkage (g)	0,67±0,58 ^a	1,23±0,25 ^{ab}	0,86±0,11 ^{ab}	1,46±0,15 ^b
pH of manure	8,31±0,03 ^c	7,88±0,07 ^b	7,77±0,06 ^{ab}	7,69±0,10 ^a
Manure odor	1,95±0,04 ^a	2,55±0,19 ^a	3,38±0,40 ^b	4,49±0,54 ^c
Ammonia levels (g/L)	1,71±0,05 ^a	2,00±0,10 ^b	1,67±0,06 ^a	1,74±0,09 ^a

Note: ^{a-b}) Different notations in the same column show significant differences ($P < 0.05$). *) K0 = 50 g manure + without coconut shells-activated carbon; K1=50 g +10 % coconut shells-activated carbon; K2= 50 g + 20 % coconut shells-activated carbon; K3 = 50 g + 30 % coconut shells-activated carbon.

3.1 Manure Shrinkage

The shrinkage of the manure of laying hens by administering activated carbon from coconut shells can be seen in Table 1. The investigation findings indicated that K3 (30% coconut shells activated carbon) had the highest manure shrinkage value when employing this type of carbon. This value was considerably greater than K0 (no coconut shells activated carbon) ($P < 0.05$). However, there was no significant difference ($P > 0.05$) between K1 (10% coconut shells activated carbon) and K2 (20% coconut shells activated carbon). In general, there was a drop in practically every treatment, however, the administration of activated carbon caused a larger decline. The fact that there was not a significant difference between treatments K0 and K1 and K2 suggests that bias may have occurred during the data collecting and analysis process. Manure shrinkage ranged from 0.66 g to 1.47 g.

Manure from laying hens given activated carbon showed higher manure shrinkage than controls. Weight loss in manure indicates evaporation during storage, resulting in

reduced water content in manure. Chai (2022) explained that fresh manure contains 75 % water content which is reduced during storage. The process of forming ammonia is also greatly influenced by the water content in manure. Bist et al. (2022) also explained that the water content of manure reaching 75% will increase ammonia emissions in poultry farms.

According to Wyer et al. (2022), the synthesis of NH_3 molecules involves 2 microbiological processes. The uricase enzyme converts uric acid ($\text{C}_5\text{H}_4\text{O}_3\text{N}_4$), which is present in the first reaction, into carbon dioxide (CO_2) and ammonia (NH_3) when it comes into contact with oxygen (O_2) and water (H_2O). The urease enzyme breaks down urea ($\text{CO}(\text{NH}_2)_2$) when it comes into contact with water (H_2O), producing carbon dioxide (CO_2) and ammonia (NH_3). Greater manure shrinkage may indicate less ammonia emissions. In a study by Wardah & Sihmawati (2020), the dry quality of manure is one sign of low ammonia levels. Based on a different study by Bleizgys & Naujokienė (2023), ammonia emissions would be less intense when livestock dung was dry. In this investigation, the activated carbon adsorbent derived from coconut shells showed a propensity to quicken the shrinkage process of manure.

3.2 pH of Manure

The pH value of the manure of laying hens with the administration of activated carbon from coconut shells is shown in Table 1. The analysis's findings revealed that K3 (30 % activated carbon from coconut shells) had the lowest pH value. In comparison to treatments K0 (0 % coconut shells activated carbon) and K1 (10 % coconut shells activated carbon), this value was significantly lower ($P < 0.05$), although it was not significantly different ($P > 0.05$) from K2 (20 % coconut shells activated carbon). The pH value ranged from 7.68 to 8.32.

The pH of laying hen manure treated with activated carbon decreased consistently as the concentration increased. Despite this, K1 has a higher pH than K2. The lack of a discernible difference between the two treatments could be the result of possible bias in the study's data collection. The lowest pH of laying hen manure in the coconut shell activated carbon treatment (K) was 7.69 at a 30% concentration (K3). According to Marang et al. (2019), a manure pH of less than 8.0 can reduce ammonia volatilization.

Ammonia volatilization, as described by Pan et al. (2016), is the process where nitrogen (N) is lost to the environment in the form of ammonia.

The neutral-alkaline pH levels found in this research may be the result of maximal protein use, which increases the formation of uric acid. As to Marang et al. (2019), the properties of uric acid have the potential to elevate the pH level of manure. Manure's alkaline pH causes gram-negative bacteria to proliferate more quickly, which in turn causes ammonia to volatilize. According to Tawfik et al. (2023), elevated pH levels will result in elevated ammonia concentrations and imbalanced anaerobic processes. In contrast, gram-negative bacteria will be inhibited by a pH of neutral acid, which will limit the volatilization process. According to this study, manure's pH value decreases with increasing activated carbon concentration.

3.3 Manure Odor

Table 1 shows the odor of laying hen dung that has been treated with activated carbon made from coconut shells. The analysis results revealed that K3 (30 % coconut shells activated carbon) had the least strong odor when employing activated carbon made from coconut shells. Compared to K0 (0 % coconut shells activated carbon), K1 (10 % coconut shells active carbon), and K2 (20 % coconut shells activated carbon), this value was significantly greater ($P < 0.05$). The manure odor value ranged from 1.94 to 4.50.

According to this investigation, adding more activated carbon will mask the manure's smell further. Previous studies by Ambarsari et al. (2023) discovered that adding activated carbon derived from coconut shells reduced the ammonia odor value in wastewater sludge at an ice cream production. In a different investigation, Harihastuti et al. (2021) who produced activated carbon filters in a feed mill factory discovered a drop in the ammonia odor value.

The adsorption process of manure odor by activated carbon is primarily driven by weak attractive interactions between the adsorbate and the adsorbent (Ganjoo et al., 2023). Furthermore, Ambarsari et al. (2023) clarified that smells in waste materialize because there are no covalent connections between the molecules of the adsorbent and the adsorbate. Because the adsorbent can be rapidly removed from the adsorbent surface, the intensity of this odor may increase. Ammonia and other polar molecules can be drawn

to the non-polar chemicals found in activated carbon. This is the reason why ammonia in manure treated with activated carbon starts to smell more faintly.

3.4 Ammonia Levels

The ammonia levels in the manure of laying hens using activated carbon from coconut shells can be seen in Table 1. The analytical results indicated that K2 (20 % coconut shells activated carbon) had the lowest amounts of ammonia when employing activated carbon made from coconut shells. When compared to K1 (10 % coconut shells activated carbon), this value was significantly lower ($P < 0.05$), but it was not statistically different ($P > 0.05$) from K0 (0 % coconut shells active carbon) or K3 (30 % coconut shells activated carbon). Ammonia levels ranged from 1.66 g/L to 2.10 g/L.

The absence of a significant difference between treatments K0, K2, and K3 suggests potential biases in the data collection process during analysis. Data collection of manure ammonia levels before the storage procedure, which can be indicative of a decline, is a limitation in this study, even though the storage process caused ammonia levels to decrease in practically all treatments. The findings of this investigation demonstrated that the lowest ammonia levels were achieved when treated with 20 % (K2) of coconut shells activated carbon, or 1.67 g/L. A related study by Ketwong et al. (2019) discovered that giving coconut shells-activated carbon to chicken farms for 60 minutes reduced the amount of ammonia by as much as 71.5 %. Using rice husks, Bai et al. (2021) were able to absorb ammonia odor and lower ammonia concentration by as much as 80 %.

According to Ganjoo et al. (2023), Van der Waals forces may have contributed to the drop in ammonia levels, which is similar to the odor values discovered earlier in this investigation. Additionally, Ambarsari et al. (2023) clarified that smells in waste arise because adsorbent and adsorbate molecules do not form covalent connections. The adsorbent can rapidly be released from the adsorbent surface, which could increase the odor. The non-polar functional groups in activated carbon molecules can draw polar chemicals with strong odors, including ammonia (Park et al., 2023). The waste odor will be reduced by drawing ammonia molecules into the activated carbon cavity. Coconut shells have non-polar functional groups that can draw odorous polar substances like

ammonia to the activated carbon molecules (Park et al., 2023). The waste odor will be reduced by drawing ammonia molecules into the activated carbon cavity.

4. Conclusion

Treatment K2 (20% coconut shell-activated carbon) has been shown to increase manure shrinkage, lower pH values, and reduce ammonia levels, effectively masking the ammonia smell when applied to laying hens' manure at varying concentrations. Administering activated carbon derived from 20 % coconut shells is the best recommended course of treatment. Several limitations in this research process, such as the data collection process and measurement of ammonia levels before and after storage, can be recommendations for further research to describe in more detail how much ammonia levels decrease with the administration of activated carbon.

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