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Effect of the Additional Natural Compound in Litter on Performance and Health Parameter of Broiler

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ABSTRACT

This study investigated the impact of adding natural compounds, including zeolite, charcoal, Quicklime, and limestone, to broiler litter on broiler chickens' performance and health parameters. The experiment was conducted using a completely randomized design with five treatments: T1 = fresh rice husk without additional compound, T2 = 10% zeolite, T3 = 10% charcoal, T4 = 5% quicklime, and T5 = 5% limestone. The results showed that adding natural compounds improved broilers' growth rate, with the highest final body weight observed in the T5, 2459.78 g. Mortality rates did not differ significantly among treatments. The addition of natural compounds did not affect ($P > 0.05$) the relative weight of the immune organ, except the liver. The addition of natural compounds did not significantly affect blood parameters, including red blood cell count, white blood cell count, and haemoglobin levels ($P > 0.05$). Additionally, the incidence of footpad dermatitis was lower in litter treated with natural compounds than in untreated litter. In conclusion, adding natural compounds to broiler litter can enhance broiler performance and health without adverse effects, promoting overall growth and reducing footpad dermatitis.

Keywords: broiler litter, footpad dermatitis, health parameters, natural compounds, performance.

INTRODUCTION

The trend of broiler production is increasing yearly due to the demand for chicken meat. The broiler's performance depends on several factors, including genetic characteristics and environmental conditions such as feed, temperature, and maintenance. Better performance of broilers can be achieved by a modern intensive farming system characterized by good quality breed, feed, and housing that notice comfort and health conditions (Onu et al., 2011). Good litter condition is one of the main factors in broiler housing management to ensure the optimum result of production. The quality of litter used in broiler production has been associated with the birds' performance, behavior, and welfare(Brink et al., 2022). The health condition of the chicken also influences its performance. The health condition of the chicken can be evaluated by measuring the immune organ weight, haematology condition, and the assessment of footpad dermatitis (FPD) (Bilgili et al., 2009; Vicuña et al., 2015).

Several attempts are made to increase or maintain litter quality during broiler production. Some methods include reducing the moisture and pH by using different litter materials or mixing litter with some minerals such as zeolite (Brink et al., 2022; Schneider et al., 2016). Some other studies used Quicklime (CaO) mixed with wood shaving as a litter on the broiler (Ruiz et al., 2008). Zeolite is mixed with chopped elephant grass hay (Loch et al., 2011). The other methods include spraying probiotics on the litter to reduce ammonia emissions (Hendalia et al., 2012). Some natural compound has been added to maintain the litter condition. Loch et al. (2011) reported that aluminium sulfate reduced the chopped elephant-grass litter pH and volatilized ammonia.

The previous studies of litter treatment primarily evaluate the performance and litter condition; however, there is a lack of reports regarding the effect of litter treatment on the health condition of the chicken. Moreover, natural compounds such as zeolite, charcoal, Quicklime, and limestone are inexpensive and easy to find. Thus, this study aims to evaluate the utilization of natural compounds, namely zeolite, charcoal, Quicklime, and limestone, as additives to broiler chicken litter, which influences the health and performance of the broiler.

MATERIALS AND METHODS

The experiment was conducted at the poultry facilities located at the Faculty of Animal Science, Universitas Gadjah Mada, Indonesia, from February 15 to March 11, 2022. 1350 Indian River strain broilers were divided into five treatments with nine replications. A completely randomized design was used, and each replication was indicated in a different pen, each with a size of 2 m^2 containing 30 birds. The chicken was raised in the broiler shed with closed-housed system ventilation. The rice husk was used as the litter material in this study. The temperature and humidity were set according to management guidelines; there was 32 °C and 70% humidity during the brooding phase, then gradually changed to 21°C and 70% humidity during the grower and finisher phase. Before the placement of the day-old chick in the house, the litter was divided into five treatments: T1 = fresh rice husk without any additional compound, T2 = 10% zeolite, T3 = 10% charcoal, T4 = 5% quicklime, T5 = 5% limestone. The percentage of the additional compound was based on the weight of the litter. The additional compound was mixed evenly with the rice husk before placement at each pen inside the house. The limestone and Quicklime were obtained from a local quarry, while charcoal and zeolite were obtained from a local market.

After the treated litter was set in the house at a five cm thick male broiler, one-day-old chicks of the Indian River strain were obtained from a commercial hatchery and placed in a closed house system. A gas brooder was used to heat the pen; the baby chick feeders and nipple waterers were also provided. On days 7, 14, 21, 28, and 34, the body weight (g), cumulative feed consumption (g/bird), feed conversion ratio, and percentage of mortality were determined. At day 32, the blood samples of six chickens per treatment were collected from the brachial wing vein. The sample was then analyzed for the haematological value, including the red blood cell (RBC), white blood cell (WBC), and haemoglobin value. One bird per replicate was slaughtered at day 35 and eviscerated for immune organ and FPD evaluation.

Footpad lesions or dermatitis were assessed based on the methods of Sorin et al. (2013). The footpad lesions were categorized into one of three classes:

0 = having no lesions or tiny superficial lesions with slight discolouration on a limited footpad area, mild hyperkeratosis (thickening of the outer layer of the skin), or healed lesions.

1 = Mild lesions characterized by discolouration of the footpad, superficial lesions, dark papillae, and hyperkeratosis.

2 = Severe lesions, identified by the presence of ulcers, scabs, or signs of haemorrhages or swollen footpads, indicating that the epidermis was affected.

The FPD score was calculated using the following formula:

FPD score = [100 x (0 x total number of footpads with score 0 + 0.5 x total number of footpads with score 1 + 2 x total number of footpads with score 2)] / (total number of footpad scored)

$$\text{Incidence of FPD \%} = \frac{(Total\ number\ with\ score\ 1\ +\ total\ number\ with\ score\ 2)}{(\text{Total number of footpads scored})}$$

Statistical analysis was conducted using the General Linear Models (GLM) procedure in version 17 of the SPSS software. To assess the statistical significance of differences between the control and experimental groups, one-way analysis of variance (ANOVA), followed by Duncan's post hoc multiple range test, was used.

RESULTS AND DISCUSSION

The chicken body weight at day 7 of the untreated litter (control) was significantly higher compared to the other treatment; however, at day 21 of age, the limestone treatment was significantly higher (P<0.05) than the other treatment. The highest final body weight was recorded in T5, the quicklime-treated litter at day 34 (Table 1). These results indicate that adding natural compounds to the litter improved the growth rate of broilers, especially in the final production phase. Cumulative feed consumption increased with age but did not differ significantly among the treatments (P>0.05). The FCR significantly differed among the treatments on day 7, 21, 28, and 34 (P<0.05). The T3 (charcoal treatment) showed the highest FCR on days 21, 28, and 34 (P<0.05). However, the efficiency of broiler production is indicated by a low value of FCR. Therefore, adding zeolite, Quicklime, and limestone to the litter could be a potential strategy to improve broiler growth performance and reduce FCR.

Mortality is one of the main factors in broiler production that should be considered; the mortality did not differ significantly among the treatments throughout the study period (P>0.05), indicating that the addition of natural compounds in the litter did not have any negative impact on broiler health and welfare. These findings suggest that adding natural compounds such as zeolite, Quicklime, and limestone in broiler litter can enhance overall growth and increase feed conversion without adverse effects. The performance results obtained in this study exhibited slight variations compared to the findings in the referenced study of Ruiz et al. (2008) and Schneider et al. (2016). According to their study, the performance of broilers was not affected by the inclusion of natural compounds such as zeolite and Quicklime. The difference between this study and previous study may be due to the different litter material, housed type used and broiler strain. However, in the other study, applying lime in the litter improves poult performance and reduces the aerobic bacteria (Bennett et al., 2005). Some other studies also reported that the treatment using Quicklime in the litter significantly reduces the pathogenic bacteria (Lopes et al., 2013).

The use of natural compounds in poultry production has become a topic of interest due to the potential for improving growth performance and reducing negative impacts on animal health and welfare. The results obtained from this study show that the addition of zeolite, Quicklime, and limestone in broiler litter can enhance overall growth without any adverse effects. The highest final body weight was recorded in the quicklime-treated litter at day 34, indicating that adding natural compounds improved growth rates, especially at the final production phase. The improvement observed in broiler growth may be attributed to several reasons. For example, it is well-known that zeolites possess cation-exchange properties that limit the growth of pathogenic bacteria, thereby creating a healthy environment (Lyu et al., 2021).

Table 1. Effect of the addition of different compounds of broiler litter on performance, including body weight, feed consumption, feed conversion ratio, and mortality

Parameter	T1	T2	T3	T4	T5	SEM	SL
Body Weight (g)							
Day 7	183.89^{a}	175.44^{b}	177.78^{b}	166.67^{c}	178.44^{b}	0.935	*
Day 14	534.78	520.11	518.44	515.78	524.56	3.196	ns
Day 21	1107.56^{ab}	1077.11^{ab}	1072.11^{b}	1108.00^{ab}	1119.44^{a}	6.418	*
Day 28	1817.44	1813.44	1755.11	1828.56	1810.78	12.069	ns
Day 34	2445.78^{ab}	2438.11^{ab}	2344.44^{b}	2505.56^{a}	2459.78^{ab}	17.048	**
Cumulative feed consumption (g/bird)							
Day 7	208.22	208.83	207.74	208.35	206.95	0.982	ns
Day 14	628.37	627.41	629.88	625.97	628.11	2.846	ns
Day 21	1311.46	1309.77	1331.29	1318.95	1317.24	4.289	ns
Day 28	2409.87	2416.17	2470.53	2452.55	2415.49	11.587	ns
Day 34	3477.03	3490.54	3569.42	3556.61	3491.42	17.370	ns
Feed conversion ratio							
Day 7	1.13^{b}	1.19^{ab}	1.17^{b}	1.25^{a}	1.16^{b}	0.012	*
Day 14	1.17	1.20	1.21	1.21	1.20	0.008	ns
Day 21	1.18^{b}	1.21^{ab}	1.24^{a}	1.19^{ab}	1.17^{b}	0.008	*
Day 28	1.33^{b}	1.33^{b}	1.41^{a}	1.34^{b}	1.33^{b}	0.011	*
Day 34	1.42^{b}	1.43^{b}	1.52^{a}	1.42^{b}	1.42^{b}	0.012	*
Mortality (%)							
Day 7	0.37	1.85	1.11	1.11	0.37	0.228	ns
Day 14	2.22	3.70	3.33	2.22	1.48	0.395	ns
Day 21	2.96	4.07	3.70	4.44	2.59	0.467	ns
Day 28	3.70	5.18	6.67	5.55	3.70	0.667	ns
Day 34	3.70	5.18	6.67	5.55	3.70	0.667	ns

^{a,b,c} Means with different superscript letters in the same row are significantly different (P<0.05), T1 = rice husk untreated litter; T2 = 10% zeolite (based on the weight of the litter); T3 = 10% charcoal (based on the weight of the litter); T4 = 5% quicklime (based on the weight of the litter); T5 = 5% limestone (based on the weight of the litter), *: significant at (p< 0.05); **: significant at (p< 0.01); ns: non-significant at p > 0.05, SL: significant level, SEM: standard error of means.

The results of the immune organ relative weight in Table 2 showed that the addition of different compounds of broiler litter had a significant effect on the relative weight of the liver ($P<0.05$) but had no significant effect on the spleen, thymus, and bursa Fabricius ($P>0.05$). The liver is one of the vital organs of the immune system and is responsible for many immune functions. The changes in liver size may indicate the immune response of the chicken against the diseases. The liver of infected chickens by the virus was swollen and yellow-brown with necrotic foci (Ren et al., 2019). The current study revealed that adding different compounds to broiler litter significantly affected the liver's relative weight. The highest liver relative weight was observed in the T1 (control) with a mean value of 2.17%, while the lowest liver relative weight was observed in the T4 treatment (5% quicklime based on the weight of the litter) with a mean value of 1.79%. This result indicates that treating litter using natural compounds, especially Quicklime and limestone, reduces the litter's pathogens and hence does not affect the morphological change of the liver. These findings are consistent with previous studies that reported the effect of disinfected litter treatments on a lower morphological disorder of the liver compared to the untreated litter (Witkowska et al., 2006). The spleen, thymus, and bursa Fabricius are also vital immune organs that play critical roles in the immune response of broiler chickens. However, the results of this study showed no significant differences in the relative weight of these organs among the different treatments. The results indicated that adding natural compounds to the litter did not harm the chicken's immune system. The value of the immune organ, especially the liver's relative weight in this study, is in agreement. It has a similar value to previous studies by Rashidi et al. (2020); the relative weight of the liver in this study was 1.89% to 2.17%, and the relative weight of the liver in the Rashidi et al. (2020) study was 2.07% to 2.54%.

The results presented in Table 3 demonstrate the impact of different compounds of broiler litter on RBC, WBC, and Hb levels in broiler chickens. No significant differences were observed among the treatment groups ($P > 0.05$) regarding the RBC levels. The mean of RBC values ranged from 2.77 to $3.03\times10^6/\mu l$, indicating that the different broiler litter compounds did not substantially affect RBC production in the chickens. The results of RBC in this study are slightly higher than the previous study by Khoso et al. (2018), which shows the average RBC value of the broiler was $2.14\times10^6/\mu l$. Similarly, there were no significant differences in WBC levels among the treatment groups ($P > 0.05$). The WBC values ranged from 84.82 to $99.13 \times 10^3/\mu l$, suggesting that the different compounds of broiler litter did not significantly impact the immune response or inflammation in the broiler chickens. Furthermore, the Hb levels also showed no significant differences among the treatment groups ($P > 0.05$). The mean Hb values ranged from 14.87 to 16.33 g/dL, indicating that the different compounds of broiler litter did not significantly influence the oxygen-carrying capacity of the blood. Based on the blood cell profile, the addition of natural compounds in the litter did not negatively affect the broiler, especially regarding the bird's health. The RBC value in this study was similar to the other study (Wang et al., 2003).

Table 2. Effect addition of different compounds of broiler litter on immune organ relative weight (% of body weight)

Parameter	Immune organ relative weight (% of body weight)						
	T1	T2	T3	T4	T5	SEM	SL
Liver	2.17^a	1.93^{ab}	1.99^{ab}	1.79^b	1.89^b	0.041	*
Spleen	0.11	0.12	0.11	0.09	0.11	0.006	ns
Thymus	0.17	0.16	0.17	0.21	0.17	0.013	ns
Bursa Fabricius	0.15	0.12	0.16	0.15	0.14	0.008	ns

^{a,b,c} Means with different superscript letters in the same row are significantly different ($P<0.05$), T1 = rice husk untreated litter; T2 = 10% zeolite (based on the weight of the litter); T3 = 10% charcoal (based on the weight of the litter); T4 = 5% quicklime (based on the weight of the litter); T5 = 5% limestone (based on the weight of the litter), *: significant at ($p< 0.05$); **: significant at ($p< 0.01$); ns: non-significant at $p > 0.05$, SL: significant level, SEM: standard error of means.

Table 3. Effect addition of different compounds of broiler litter on Red Blood Cell (RBC), White Blood Cell (WBC), and Haemoglobin (Hb) level

Parameter	T1	T2	T3	T4	T5	SEM	SL
RBC ($\times 10^6/\mu l$)	3.03	2.77	2.97	2.83	2.97	0.051	ns
WBC ($\times 10^3/\mu l$)	98.25	84.82	99.13	94.98	96.27	2.189	ns
Hb (g/dL)	16.33	14.87	16.22	15.90	16.32	0.301	ns

T1 = rice husk untreated litter; T2 = 10% zeolite (based on the weight of the litter); T3 = 10% charcoal (based on the weight of the litter); T4 = 5% quicklime (based on the weight of the litter); T5 = 5% limestone (based on the weight of the litter), ns: non-significant at $p > 0.05$, SL: significant level, SEM: standard error of means.

Observation of footpad dermatitis was conducted in all five litter treatments. Fig. 1 illustrates examples of foot pad lesions for scoring. Table 4 presents the incidence and footpad dermatitis (FPD) score. The footpad dermatitis (FPD) scores in this study ranged from 66.67 to 138.89, which exceeded the threshold value proposed by the EU standard of 50 points (Sorin et al., 2013). The FPD scores in this study were slightly higher than the study of Sorin et al. (2013), which shows the score points ranged from 60 to 80. The FPD score was higher in group T1 (Fig. 2), which the control rice husk untreated litter. It may be because the moisture level and the microbial count were higher in the control group. Several experiments have demonstrated that the occurrence and severity of footpad dermatitis (FPD) are influenced by various factors, including litter material (Bilgili et al., 2009), feed nutritional value (Sorin et al., 2013), moisture level of the litter (Martland, 1985), ammonia and bacterial level (Haslam et al., 2006). Based on the footpad dermatitis evaluation, adding natural compounds to the litter positively affects the broiler, which has a lower FPD score than the control.

Table 4. Incidence and footpad dermatitis (FPD) scores were observed at different addition compounds of broiler litter

Parameter	T1	T2	T3	T4	T5
FPD score 0 (%)	22.22	11.11	33.33	11.11	11.11
FPD score 1 (%)	11.11	55.56	44.44	33.33	44.44
FPD score 2 (%)	66.67	33.33	22.22	55.56	33.33
FPD incidence (%)	77.78	88.89	66.67	88.89	88.89
FPD score (points)	138.89	94.44	66.67	127.78	106.67

T1 = rice husk untreated litter; T2 = 10% zeolite (based on the weight of the litter); T3 = 10% charcoal (based on the weight of the litter); T4 = 5% quicklime (based on the weight of the litter); T5 = 5% limestone (based on the weight of the litter)

Score 0 Score 1 Score 2

Fig. 1. Footpad dermatitis scoring observed after slaughter.

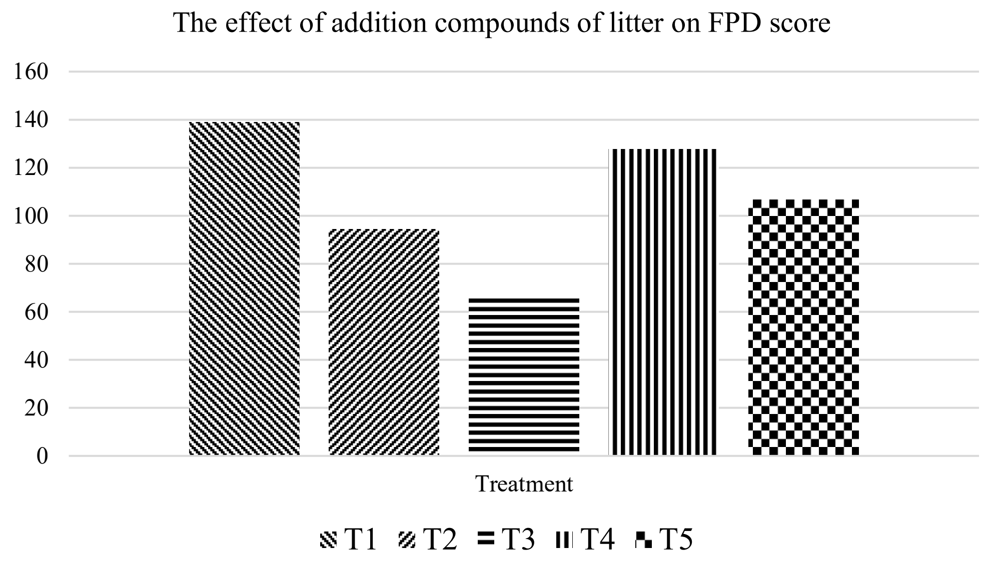

Fig. 2. Footpad dermatitis score evaluated after slaughter.
T1 = rice husk untreated litter; T2 = 10% zeolite (based on the weight of the litter); T3 = 10% charcoal (based on the weight of the litter); T4 = 5% quicklime (based on the weight of the litter); T5 = 5% limestone (based on the weight of the litter)

The enhanced performance observed with Quicklime in this study may be attributed to its ability to reduce pathogenic bacteria. Quicklime initiates an exothermic reaction upon contact with water and significantly elevates pH levels within the litter. The mere increase in litter temperature due to lime exothermic reaction might not be the sole reason behind the reduction in bacterial load. The temporary rise in litter temperature suggests that the chemical reaction involving calcium oxide and litter compounds, resulting in the formation of hydrated lime, carbon dioxide, and heat, could be a critical mechanistic factor in reducing bacterial populations (Lopes et al., 2013).

CONCLUSION

The present study showed that adding a natural compound to a broiler's litter improves the broiler's overall growth. The performance of the broiler was not negatively affected by the addition of natural compounds in the litter. Regarding the health of the broiler, an additional natural compound in the litter did not have a negative effect. In addition, it gave a lower footpad dermatitis (FPD) score.

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