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Treatment of poultry litter does not improve performance or carcass lesions in broilers¤

El tratamiento de la cama no afecta el desempeño ni las lesiones en la canal del pollo de engorde

Desempenho produtivo e lesões na carcaça de frangos de corte não são afetados pelo tratamento da cama de frango

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Summary

Background: broilers spend most of their lives in contact with litter; litter quality can affect their health and performance. **Objective:** the effects of litter treatment on performance and carcass lesions were evaluated in five consecutive flocks with 640 male broilers each. **Methods:** a completely randomized model was used comprising eight treatments and four replicates. The treatments included (1) untreated litter, (2) litter subjected to in-house composting, (3) litter treated (LT) with aluminum sulfate, (4) LT with gypsum, (5) LT with quicklime, (6) LT with dolomitic limestone, (7) LT with zeolite, and (8) LT with charcoal. Chopped elephant-grass hay was used as poultry litter in all flocks. **Results:** none of the litter treatments were found to influence the performance and carcass lesions of the male broilers in all five flocks. Furthermore, poultry litter treatments were not economically viable. **Conclusion:** poultry litter treatments did not affect the performance and scores of carcass lesions of male broilers, but increased the cost of poultry production.

Keywords: *broiler carcass scratches, broiler production, poultry litter conditioners, poultry litter quality.*

Resumen

Antecedentes: los pollos de engorde pasan la mayoría de su vida en contacto con la cama; la calidad de la cama puede afectar la salud y desempeño del ave. **Objetivo:** fueron evaluados los efectos de diferentes

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tratamientos de la cama sobre el desempeño y lesiones en la canal de pollos de engorde durante cinco lotes consecutivos con 640 aves cada uno. **Métodos:** se empleó un modelo completamente aleatorizado con ocho tratamientos y cuatro repeticiones. Los tratamientos incluyeron (1) cama no tratada, (2) cama sometida a compostaje en el galpón, (3) cama tratada (CT) con sulfato de aluminio, (4) CT con yeso agrícola, (5) CT con cal, (6) CT con calcáreo dolomítico, (7) CT con zeolita y (8) CT con carbón vegetal. Heno de pasto elefante picado fue usado como cama en todos los lotes. **Resultado:** los tratamientos no influenciaron el desempeño ni las lesiones en la canal de los pollos en ningún lote. Además, ninguno de los tratamientos de las camas fue económicamente viables. **Conclusión:** el tratamiento de la cama de pollo no solo no afecta el desempeño ni las lesiones en la canal de los pollos sino que eleva los costos de producción de las aves.

Palabras clave: *acondicionador de cama de pollo, calidad de la cama de pollo, producción de pollos de engorde, rasguños en la canal de pollos.*

Resumo

Antecedentes: os frangos de corte passam a maioria de suas vidas em contato com a cama e a qualidade desta pode afetar a saúde e o desempenho produtivo da ave. **Objetivo:** Avaliou-se os efeitos dos tratamentos da cama de frango sobre o desempenho no crescimento e lesões na carcaça de frangos de corte. **Métodos:** avaliaram-se 640 aves por lote, durante cinco lotes consecutivos, analisaram-se empregando um modelo completamente casualizado com oito tratamentos e quatro repetições. Os tratamentos consistiram de (1) cama não tratada, (2) cama submetida a compostagem no galpão, (3) cama tratada (CT) com sulfato de alumínio, (4) CT com gesso agrícola, (5) CT com cal virgem, (6) CT com calcário dolomítico, (7) CT com zeolita e (8) CT com carvão vegetal. Feno de capim elefante picado foi usado como cama em todos os lotes. **Resultado:** os diferentes tratamentos não influenciaram o desempenho na produção e as lesões na carcaça dos frangos em nenhum lote, entretanto, os tratamentos da cama foram economicamente inviáveis. **Conclusão:** o tratamento da cama de frango não afeta o desempenho produtivo e os escores de lesões na carcaça dos frangos de corte, além, eleva os custos da produção avícola.

Palavras chave: *arranhões na carcaça de frangos, condicionador de cama de frango, produção de frangos de corte*, *qualidade da cama de frango.*

Introduction

Broilers spend most of their lives in contact with litter; litter quality can affect their health and performance. It is common to raise several flocks on reused litter. However, litter that is wet, sticky, with high pH, and produces excessive ammonia can negatively affect broiler performance (Nagaraj *et al.*, 2007).

Several litter treatments can reduce litter moisture, bacterial activity, and can chemically link to ammonia preventing its volatilization. Low moisture in litter reduces bacterial populations and decrease ammonia volatilization creating a more suitable environment for birds and better productive performance.

Aluminum sulfate, a proton donor, converts volatile ammonia (NH_3) produced in litter to non-volatile ammonium ions (NH_4^+). Gypsum can also react with ammonia by binding to it as ammonium sulfate (Oliveira *et al.*, 2004). Quicklime, dolomitic limestone, and charcoal can retain moisture and reduce ammonia production in litter. Zeolite has the ability to absorb and bind ammonia, reducing its volatilization (Li *et al.,* 2008).

Substances such as sodium bisulfate (Nagaraj *et al.,* 2007), propionic acid (Garrido *et al.*, 2004), aluminum sulfate (Loch *et al.*, 2011), and aluminum chloride (Choi and Moore, 2008) reduce litter pH and ammonia-producing bacterial populations. In-house composting among flocks reduces and inactivates viruses in the litter through formation of heat and products that control virus (Macklin *et al.*, 2006; Wilkinson, 2007). However, this does not always lead to improvements in broiler performance compared to the improvement shown in broilers using conditioners such as aluminum sulfate (Miles *et al.*, 2003), simple superphosphate (Ferreira *et al.*, 2004), ferrous sulfate, aluminum chloride (Do *et al.*, 2005), and sodium bisulfate (Nagaraj *et al.*, 2007).

Litter moisture is a predisposing factor for contact dermatitis. When litter moisture exceeds 46% its surface becomes wet and friable and can cause footpad dermatitis and hock burns in broilers. Excreta adherence also causes prolonged contact with corrosive substances in the litter (Eichner *et al.*, 2007). Thus, litter treatment with substances that reduce ammonia formation helps to improve broiler carcass quality along with lesion scores in breasts, hocks, and footpads (McWard and Taylor, 2000). This study evaluated performance and carcass lesions in broilers reared on litter subjected to different treatments over five consecutive flocks.

Materials and methods

The experiment was conducted from January 2009 to November 2009 in the poultry facilities of Instituto Federal Goiano de Rio Verde, GO, Brasil. Five consecutive flocks of broiler chickens were raised: first from January to March, second from April to May, third from June to July, fourth from August to September, and fifth from October to November. Each flock comprised 640 one-day-old male chicks, with 41.77 ± 4.04 g average initial weight. Birds were housed in a conventional poultry house divided into 32 experimental boxes with an area of 2 m^2 each, yielding a stocking density of 10 birds/m^2.

Birds received a pre-starter commercial diet from the first to the seventh day of age, a starter diet from the eighth to the 21^{st} day of age, a growth diet from the 22^{nd} to the 34^{th} day of age, and a final diet from the 35^{th} to the 42^{nd} day of age.

The study used a completely randomized design with eight treatments and four replicates. Treatments were as follows: 1) untreated litter (control treatment); 2) in-house composting of litter using a plastic tarpaulin; 3) litter treated (LT) with aluminum sulfate ($Al_2[SO_4])_3 \cdot 14H_2O$ (0.56 kg/m^2); 4) LT with gypsum ($CaSO_4 \cdot 0.5H_2O$[40% of the total weight]); 5) LT with quicklime (CaO[0.5 kg/m^2]); 6) LT with dolomitic limestone ($CaMg(CO_3)_2$[1.5 kg/m^2]); 7) LT with zeolite ($(Na_4K_4)(Al_8Si_{40}O_{96}) \cdot 24H_2O$[5% of the total weight]); and 8) LT with charcoal (20% of the total weight). Several of these substances have been used in studies elsewhere (Moore *et al.*, 2000; Oliveira *et al.*, 2004; Turan, 2008).

Chopped elephant grass hay was used as litter in all treatments and flocks (11 kg/box; particle size about 5 cm), except for treatments using gypsum, zeolite, and charcoal, which corresponded to 40, 5, and 10% of the total litter weight, respectively, added only before the first flock started. The other conditioners were added to the litter in each flock and thoroughly mixed into the litter on the day before the arrival of the chicks.

After the withdrawal of each flock, the poultry house remained open for 14 days. During this period, clods were removed from the surface of the litter and the litter was revolved every two days for 14 days. Litter submitted to in-house fermentation remained under a plastic tarpaulin for 12 days and uncovered for two days and was revolved for drying. Chicks were placed on the litter on the following day. Chicks were weighed when they reached 21 and 42 days of age to determine weight gain. Ration was also weighed to determine the ration consumption and the feed: gain ratio. The survivability rate was also determined.

Hock and footpad lesions were analyzed in two slaughtered birds per replicate using the following scores (McWard and Taylor, 2000): 0, normal (with no burns, crusts, or lesions); 1, footpad or hock burns (only the dermis) in one or both feet; 2, footpad or hock with crusts (healed lesions) in one or both feet; and 3, footpad or hock with lesions (open wounds) in one or both feet. Breast lesions were measured using the following scores (Angelo *et al.,* 1997): 0, no lesions; 1, lesions but no inflammation; and 2, lesions and inflammation.

To determine economic efficiency (EE) of litter treatments, a 1600 m^2 chicken farm with 20,000 birds per flock in five consecutive flocks was considered; 600 kg of bedding material were used for every 1000 birds and placed before the first flock was installed. A selling price (SP; Brazilian Real) of R$ 2.20/kg was assumed for the chickens (IEA, 2013), taking into account the mortality rate in each flock. The cost of the litter substrate and treatments were: elephant-grass hay, R$ 850.00/ton; plastic canvas, R$ 300.00 for 4 rolls each with an area of 400 m^2; aluminum sulfate, R$ 0.56/m^2; gypsum, R$ 90.00/ton; quick lime, R$ 135.00/ton; dolomitic limestone, R$ 20.00/ton; zeolite, R$ 28.00/kg; and charcoal, R$ 500.00/ton. The cost of the feed offered (FO) was R$ 0.70/kg, and the gross margin (GM) was calculated by subtracting the costs of bedding and FO from the SP. The methodology was based on a study by Attia *et al.* (2014), as follow:

EE = {Net revenue [market price of chicken (per kg) × body weight gain] - total costs [chick price + total cost of feeds + litter cost + litter treatment cost]}/ total costs × 100.

Data analysis

A statistical analysis of performance, score lesions, and economic viability was conducted with SAEG software (version 9.0, Funarbe, Viçosa, MG, Brasil). Means were compared using Tukey's test, except for carcass lesion scores, which were compared by the Kruskal–Wallis test, both with 5% significance. The model used was:

$$y_i = \mu + A_i + e_i$$

Where:

μ: general mean.
A_i: effect of the litter treatment.
e_i: random error.

Results

Treatments did not influence broiler performance ($p>0.05$) at 21 and 42 days of age (Tables 1 and 2) or survivability (Table 3).

Table 1. Performance of broilers raised on litters submitted to different treatments for five consecutive flocks, at 21 days of age.

Treatment	1st flock			2nd flock			3rd flock			4th flock			5th flock		
	WG	RC	FGR	WG	RC	FGR	WG	RC	FGR	WG	RC	FGR	WG	RC	FGR
Untreated litter	885	1394	1.57	838	913	1.09	800	1066	1.33	985	1392	1.41	910	981	1.07
L + composting	897	1353	1.51	826	996	1.21	796	1122	1.41	1021	1260	1.24	925	976	1.05
L + aluminum sulfate	896	1351	1.51	813	951	1.17	792	1019	1.28	985	1277	1.29	910	1080	1.18
L + gypsum	862	1423	1.65	852	966	1.13	817	1095	1.33	1042	1355	1.30	885	1100	1.24
L + quicklime	881	1456	1.65	825	971	1.17	769	1252	1.62	997	1195	1.21	885	1095	1.24
L + dolomitic limestone	846	1411	1.67	856	985	1.15	865	1141	1.31	1012	1286	1.27	900	1102	1.22
L + zeolite	884	1475	1.66	826	926	1.12	816	1087	1.33	995	1209	1.22	925	1042	1.13
L + charcoal	871	1344	1.55	840	1013	1.20	837	1100	1.32	1071	1334	1.25	930	1109	1.19
CV (%)	3.16	8.71	9.47	4.94	1.56	5.40	4.02	2.03	4.62	4.24	2.71	4.57	4.19	3.92	3.71
p value	0.18	0.71	0.54	0.81	0.86	0.66	0.40	0.66	0.18	0.10	0.46	0.33	0.55	0.73	0.55

WG = weight gain (g); RC = ration consumption (g); FGR = feed: gain ratio; L = litter: CV = coefficient of variation.

Table 2. Performance of broilers raised on litters submitted to different treatments for five consecutive flocks, at 42 days of age.

Treatment	1st flock			2nd flock			3rd flock			4th flock			5th flock		
	WG	RC	FGR	WG	RC	FGR	WG	RC	FGR	WG	RC	FGR	WG	RC	FGR
Untreated litter	2663	4947	1.85	3036	4633	1.53	2920	4472	1.52	2777	4383	1.57	2736	4056	1.48
L + composting	2632	4879	1.85	2896	4603	1.59	2861	4449	1.55	2813	4090	1.45	2686	3900	1.45
L + aluminum sulfate	2625	4784	1.83	2877	4456	1.55	2847	4614	1.61	2877	4457	1.55	2623	4186	1.60
L + gypsum	2573	4914	1.91	2871	4542	1.58	2901	4582	1.57	2902	4170	1.44	2698	4197	1.56
L + quicklime	2564	5026	1.95	2793	4646	1.66	2777	4720	1.69	2712	4206	1.55	2605	4045	1.56
L + dolomitic limestone	2608	4863	1.86	2847	4613	1.62	2939	4528	1.53	2787	4516	1.62	2755	3632	1.32
L + zeolite	2651	5103	1.92	2809	4436	1.58	2860	4311	1.50	2792	4427	1.58	2673	3776	1.43
L + charcoal	2677	4845	1.81	2848	4777	1.67	2899	4583	1.58	2818	4536	1.61	2773	4231	1.53
CV (%)	4.06	5.74	7.48	4.66	6.17	5.93	4.09	9.36	6.52	4.01	4.07	9.22	4.58	5.02	7.61
p value	0.76	0.80	0.81	0.32	0.75	0.35	0.63	0.93	0.26	0.41	0.68	0.51	0.92	0.24	0.36

WG = weight gain (g); RC = ration consumption (g); FGR = feed: gain ratio; L = litter: CV = coefficient of variation.

Table 3. Survivability of broilers raised on litters submitted to different treatments for five consecutive flocks, at 21 and 42 days of age.

Treatment	Survivability (%)				
	1st flock	2nd flock	3rd flock	4th flock	5th flock
21 days of age					
Untreated litter	100.00	100.00	98.21	98.98	95.23
L + composting	100.00	100.00	98.21	97.45	98.75
L + aluminum sulfate	98.86	96.31	95.45	97.76	98.75
L + gypsum	100.00	100.00	97.25	96.87	96.36
L + quicklime	100.00	100.00	92.33	98.99	95.11
L + dolomitic limestone	98.75	98.81	95.71	100.00	96.42
L + zeolite	100.00	98.75	96.55	98.67	98.81
L + charcoal	98.68	100.00	95.64	100.00	97.55
CV (%)	1.52	2.09	2.81	1.78	3.00
p value	0.66	0.19	0.42	0.18	0.37
42 days of age					
Untreated litter	97.36	97.50	92.67	95.06	94.04
L + composting	100.00	97.50	92.73	91.36	98.75
L + aluminum sulfate	95.45	96.31	92.73	96.98	98.75
L + gypsum	92.20	97.50	92.61	96.86	95.11
L + quicklime	97.50	98.75	92.67	97.55	93.86
L + dolomitic limestone	97.55	96.43	95.23	95.98	92.73
L + zeolite	98.68	96.25	95.11	96.25	98.80
L + charcoal	97.36	93.98	92.67	97.55	96.36
CV (%)	4.42	4.26	5.57	1.76	4.06
p value	0.35	0.85	0.98	0.56	0.18

L = litter; CV = coefficient of variation.

No difference was observed ($p>0.05$) in lesion scores for hocks, footpads (Table 4), and breasts (data not shown because no breast lesions were observed on the evaluated birds).

Table 4. Lesion scores for hocks and footpads of broilers raised on litter submitted to different treatments for five consecutive flocks, at 42 days of age.

Treatment	Lesion score									
	1st flock		2nd flock		3rd flock		4th flock		5th flock	
	H	FP	H	FP	H	FP	H	FP	H	FP
Untreated litter	0.3	1.1	0.0	1.0	0.0	0.8	0.3	1.3	0.2	1.0
L + composting	0.4	0.9	0.0	1.0	0.0	0.6	0.5	1.0	0.1	0.9
L + aluminum sulfate	0.6	0.9	1.0	1.0	0.0	0.3	0.3	1.3	0.0	0.7
L + gypsum	0.6	0.7	0.5	0.5	0.0	0.0	0.7	1.3	0.3	0.5
L + quicklime	0.4	0.9	0.5	1.5	0.0	0.2	0.3	1.0	0.5	0.8
L + dolomitic limestone	0.6	1.2	1.0	1.5	0.1	0.4	0.5	2.0	0.6	0.9
L + zeolite	0.5	0.9	0.0	1.0	0.0	0.2	1.0	1.5	0.0	0.7
L + charcoal	0.4	1.1	0.0	1.0	0.2	0.8	0.5	1.3	0.2	1.0
p value	0.28	0.16	0.35	0.17	0.14	0.07	0.40	0.81	0.59	0.95

H = hock; FP = footpad; L = litter.

Treatments affected the economic viability of the farm ($p<0.04$). The use of LT with aluminum sulfate and quicklime for five consecutive flocks resulted in the lowest economic efficiency (Table 5).

Table 5. Economic viability of using poultry litter, treated or not, based on elephant grass hay after the fifth flock.

Poultry litter	Economic efficiency (%)
Untreated	35.05
L + composting	35.03
L + aluminum sulfate	28.74
L + gypsum	33.56
L + quicklime	27.69
L + dolomitic limestone	34.74
L + zeolite	29.66
L + charcoal	31.14
CV	6.71
p value	0.04

L = litter; CV = coefficient of variation.

Discussion

Treatments did not influence broiler performance and survivability. Poultry litter, including untreated litter, was in good condition at the end of each flock (Loch *et al.,* 2011). This finding is in agreement with studies suggesting that excessively wet litter, with high ammonia production, presence of microorganisms and, consequently, poor quality could negatively affect productive performance of broilers (Ritz *et al.*, 2009). The negative effect was not verified in this experiment.

Maurice *et al.* (1998) studied the addition of zeolite (10% of litter weight) to poultry litter and Ferreira *et al.* (2004) evaluated the addition of gypsum (40% of the litter weight) and hydrated lime (0.5 kg/m^2) to the poultry litter and neither found differences in productive performance of birds because of the treated litter used. Ruiz *et al.* (2008) treated broiler litter with quick lime (10 and 15%) and found no effects on body weight and feed: gain ratio of the birds.

However, different results were reported by McWard and Taylor (2000) who found that broilers raised on LT with sodium bisulfate, an acidic substance, had higher body weight (2.74 kg) than those raised on untreated litter (2.60 kg), probably because acidic substances reduce litter pH and ammonia volatilization, resulting in better environmental conditions for the birds. Similarly, Bennett *et al.* (2005), supplemented 0.2% hydrated lime in the poultry litter and observed that birds raised on the treated litter had higher body weight (1465 g, compared to 1406 g in untreated litter) at 35 days of age, and attributed this to lower bacterial concentrations in the treated litter.

Using zeolite at doses of 0, 25, 50, and 75% of the litter weight, Eleroglu and Yalçin (2005) showed that body weight of broilers raised on treated litter increased linearly with zeolite inclusion. As feed consumption was not affected, it resulted in better feed: gain ratio for LT with zeolite, despite the level of inclusion in the litter. Karamanlis *et al.* (2008) also noted that body weight at 42 days of age was higher for birds raised on LT with zeolite at 2 kg/m^2 (2468 g, compared to 2317 g in untreated litter). It is possible that the improved results obtained with zeolite were associated with its ability to absorb and bind ammonia (McCrory and Hobbs, 2001).

Survivability was similar, indicating that even untreated litter had good physical, chemical, and microbiological conditions. This could be due to the good housing conditions, low microbial challenge, and low stocking density used.

Eleroglu and Yalçin (2005) also reported that survival rate did not change (93.1% on average for all treatments) when zeolite was included in the litter. Similarly, Nagaraj *et al.* (2007) studied sodium bisulfate (0.22 and 0.44 kg/m^2) and Ruiz *et al.* (2008) evaluated quicklime use in litter; both reported that treatments did not influence the survival rate of the birds.

However, Ferreira *et al.* (2004) noted that survival rate decreased in birds raised on LT with acidic substances (aluminum sulfate and simple superphosphate) at the end of the 2^{nd} and 3^{rd} flocks. The authors attributed this to the ingestion of acid litter because, according to Malone *et al.* (1983), birds can consume up to 4% of their litter. However, a reduction in survival rate was not observed in this work.

Carcass lesion scores were not affected by the treatments. This is important because footpad dermatitis in broilers has great importance owing to increasing exports of broiler feet. The most prevalent form of footpad dermatitis in turkeys and broilers is dermatitis associated with moisture and crust formation on the litter, resulting in the combined action of moisture and chemical irritants. This condition, usually known as contact dermatitis, can also affect breast and hocks. According to Nagaraj *et al.* (2007), litter moisture is considered a predisposing factor for contact dermatitis. Ammonia released from the litter can also irritate bird skin, causing footpad dermatitis and hock and breast burns. Thus, the extension of dermatitis prevalence is used as a welfare indicator and can also be used as an indicator of litter quality.

Maurice *et al.* (1998) evaluated zeolite (10% of the litter weight) finding no effects on hock scores in broilers at 42 days of age. Nagaraj *et al.* (2007) did not note differences in lesion scores in the footpads of broilers at 42 and 49 days of age raised on litters treated with sodium bisulfate, an acidic substance. Different results were observed by McWard and Taylor (2000) who treated litter with acidified clay, sodium bisulfate, and aluminum sulfate. They reported a slight reduction of lesion scores in breasts and footpads as compared with birds raised on untreated litter. No reports were found in the literature regarding performance and carcass lesions using dolomitic limestone or charcoal in the litter. Both substances have the ability to absorb moisture (Souza *et al.*, 2009), which could improve productive performance of birds; however, this was not observed in the present study. In conclusion, treatment of poultry litter did not influence productive performance or carcass lesions in broilers, and the use of aluminum sulfate or quicklime raised production costs.

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Conflicts of interest

The authors declare they have no conflicts of interest with regard to the work presented in this report.

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