**Chemicals as conditioners on the quality of the poultry litter of coffee’s husk.**

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**Abstract**

The poultry litter keeps the birds comfortable and absorbs the humidity generated in the environment, reducing the feet injuries. Then, its quality is essential. The objective of the present study was to evaluate the quality of the coffee husks's poultry litter, treated with chemical conditioners, based on its humidity, N-ammonia, pH and bacteria total counting. The experiment was carried out in Minas Gerais state, Brazil, in a coffee producer region. It were used three facilities, in which it were placed circular boxes, each of them divided in seven parts, 2 m2 each one, where it were put the different types of poultry litter, being that the seven treatments: sawdust and coffee husks litter, being this last, new and untreated or treated with different conditioners and reused. Twenty-two chicks were distributed in each treatment (154 birds per facility, 11 birds m-2). Litter samples were collected at 7, 21 and 42 days of birds age. The hydrated lime increased the pH in the initial phase (7 days) and decreased the moisture of the reused litter, compared to the new one. The gypsum reduced the pH of the litter at the end of the second phase. The N-ammonia content of the reused litter, without treatment, was superior compared to the new one, untreated and treated with lime. There was no effect on the standard counting of bacteria and on the surface temperature of the litter. Then,the use of chemical conditioners in the poultry litter constitutes a good strategy to control its quality, as well as the environmental conditions to produce poultry meat.

**Keywords**: Chemical additives, N-ammonia, organic compound, poultry production, coffee production

**Produtos químicos como condicionadores da qualidade da cama de frango de casca de café**.

**Resumo**

A cama de frango mantém as aves confortáveis e absorve a umidade gerada no ambiente, reduzindo assim as injúrias nos pés. Por conseguinte, a qualidade da cama de frango é essencial. O objetivo do presente estudo foi avaliar a qualidade da cama de frango feita a partir de cascas de café, tratada com condicionadores químicos. Esta avaliação foi baseada em sua umidade, concentração de N-amônia, pH e contagem bacteriana total. O experimento foi conduzido no estado de Minas Gerais, Brasil, em uma região produtora de café. Foram utilizadas três instalações, nas quais foram instalados boxes circulares, cada um deles dividido em sete partes, de 2 m2 cada, onde foram colocados os diferentes tipos de cama aviária, correspondendo estas aos sete tratamentos experimentais: casca de café, nova e não tratada; casca de café, nova e tratada com superfosfato simples (30 kg t-1); casca de café, nova e tratada com gesso agrícola (40% do peso total); casca de café, nova e tratada com cal (0,5 kg m-2); casca de café, reutilizada (2 lotes); e serragem. Vinte e dois pintinhos foram distribuídos em cada tratamento, perfazendo um total de 154 aves por instalação, a uma densidade de 11 aves m-2. Foram coletadas amostras das várias camas aos 7, 21 e 42 dias de idade das aves. A cal hidratada proporcionou um aumento do pH na fase inicial do ciclo de produção (7 dias), bem como uma diminuição da umidade na cama reutilizada, em comparação com a nova. O gesso reduziu o pH da cama no final da segunda fase do ciclo de produção. O teor de N-amônia cama reutilizada sem tratamento foi maior em relação à nova, não tratada e tratada com cal. Não houve efeito de condicionadores químicos na contagem bacteriana e na temperatura da superfície da cama. Dessa forma, o uso de condicionadores químicos aplicados à cama de frango constitui uma boa estratégia para o controle de sua qualidade e das condições ambientais para a produção de frangos de corte.

**Palavras-chave**: Aditivos químicos, N-amônia, composto orgânico, avicultura, cafeicultura

**Introduction**

Recently, concerns about the welfare led researchers to focus attention on raising poultry on a litter of good quality, specifically with low humidity. In this way it is allowed to these animals the right to be free to show behavioral patterns related to the aviary litter and its welfare (Shepherd & Fairchild, 2010). Another concern, according to Fiorentin (2006) and pointed out by Fraser *et al.* (2013) is the reduction of the concentration of pathogens in the litter in order to prevent diseases. The control of the level of bacteria and the reduction in ammonia emission are also first-rate cares for the export market.

The litter for aviaries should have the function of thermal insulation, moisture absorption, dilution of urates and feces (Hernandes *et al*., 2002), and provide comfort to the birds, allowing the expression of all its genetic potential and decreasing the rate of injuries in the chest, knee and feet (Angelo *et al*., 1997). The suitable material for that, must meet certain characteristics such as average particle size, softness, absorbency and release of moisture, thermal insulation, low cost and be easily obtained (Noll, 1992 quoted by Santos et al., 2000). When chickens are present, the pH ranges from 6 to 9 (Jeffrey *et al*., 1998), the air humidity may vary from 26.5 to 67.8% (Miele & Milan, 1983) and the air temperatures range from 20 to 32 °C depending on the age of the birds (Avila *et al*., 2008). Due its composition, the litter is a great niche for bacteria to multiply, which is inevitable (Fraser et al., 2013). According to Carr (1990), the ammonia concentration increases with the increasing in pH. The release of ammonia reduces when pH is under 7, but increases when it is above 8, being the decomposition of uric acid favored at alkaline pH conditions (Terzich, 1997). Broiler chickens have been shown to avoid ammonia at 20 ppm and higher, even if they have been exposed to such concentrations for most of their lives (Fraser *et al*., 2013).

When added to the litter, some substances act as conditioners. According to some results of recent researches (Zapata Marin *et al*., 2015), the reduction in the moisture content improved the litter quality by decreasing the volatilization of ammonia and changing the pH, as a result of the application of agricultural gypsum (Prochonow *et al*., 2001), aluminum sulfate (Moore *et al*., 2000), calcium oxide and simple superphosphate (Gloria *et al*., 1991).

The effect of addition of these substances on poultry litter can be explained by their action over this biological system, reducing the activity of bacteria and fungi (Ferreira *et al*., 2004). As a consequence of that, may be reduced the ammonia production or be decreased its volatilization (Mcward & Taylor, 2000; Fraser *et al*., 2013; Zapata Marin *et al*., 2015).

Considering the importance in using coffee husk in bedding systems for poultry production in Brazil, due to its high availability in some specific regions, this work was carried out aiming to evaluate the quality of the poultry litter of coffee husk, treated with chemical conditioners.

**Material and Methods**

 *Local*

The study was carried out during the winter in Brazil, in a poultry farm in Vicosa city, located in “Zona da Mata” of Minas Gerais state, considered an important region in coffee production. Minas Gerais state is the main Brazilian coffee producer, having produced in the last four years, in average 24,5 bags per hectare (Brazil/CONAB, 2014). The local of this experiment is at 718 m altitude, latitude 20 º 41 '09 ' South and longitude 42 º 37' 11 West. The climate according to Köppen, is Cwa (warm temperate rainy, with a dry winter and hot summer).

 *Facilities*

It were used three similar poultry facilities in the same productive site, positioned side by side and oriented from East to West. The three facilities have 14 m wide, 55 m long and 2.9 m of height. They were apart one from another, approximately in 8 m. The roof was composed of clay tiles, eaves of 0.65 m, without ridge vent. The ceiling was made of yellow polyethylene installed 2.9 m from the floor. The north and south faces of the buildings had walls of masonry (concrete blocks) with 0.3 m height, above which were attached wire mesh untill the height of the ceiling. The curtains of yellow polyethylene had manual moving, pulling it down to open and pulling it up to close. These poultry houses were equipped with positive ventilation, with fans positioned in its laterals, as well as with evaporative cooling system, consisting of nebulizers.

 *Experimental Features*

Within each facility it was placed a circular boxing divided in seven parts, each one of 2 m2 in area, corresponding such parts, to seven treatments (Figure 1A). The circular shape was adopted to guarantee a homogeneous distribution of heat to the birds, considering that in the center of each boxing was installed a gas heater (Figure 1B).

 

**B.**

**A. m...**

**Figure 1**. Circular boxing divided into seven parts corresponding to the treatments (A), - detail of the heater in the center of the circle and the bottles of gas, outside the circle (B)

In the initial stage of the heating process, the chicks were confined in an area corresponding to one-third of the total area of each circle, called growth areas. These areas were separated by partition walls of pressed wood. As the chicks have been growing, it was increased this area up to 2 m2, at the end of 21 days of life of them, which was kept until 42 days of life, according to the management adopted by the producer.

Each boxing was equipped with appropriate feeders and drinkers, like the "pressure cups", which were different from those normally used in the second stage of the production cycle, i.e., the automated hanged tubes.

Thus, each part of the boxing received a treatment (1 to 7), as following: (CN) new poultry litter of coffee husk without treatment; (CN + SS) new poultry litter of coffee husk treated with superphosphate (30 kg.ton-1) (Gloria et al., 1991; Oliveira et.al., 2004); (CN + gypsum) new poultry litter of coffee husk treated with agricultural gypsum at a proportion of 40% of the total weight of the litter (Bruno et al., 1999); (CN + lime) new poultry litter of coffee husk treated with lime (0.5 kg.m-2) (Oliveira et.al., 2003); (CR) coffee husk poultry litter reused from two lots; (CR + lime) coffee husk poultry litter reused and treated with lime (0.5 kg m-2) and (CM) new poultry litter of wood shavings (Figure 2). The application of such additives was made in the eve, before the distribution of the birds in the boxes. In all of those treatments the litter was 6 cm thick. In the treatments “CR” and “CR + lime” it was applied a poultry litter previously used in two consecutive batches of creation, being that before submitted to the fermentation process in piles to reduce the microbial load. All the conditioners were thoroughly mixed to the poultry litters.

  

**C.**

**B.**

**A.**

Figure 2. Materials used as poultry litter: coffee husk (A): reused litter of coffee husk (two lots) (B), wood shavings (C)

*Animals*

Twenty-two chicks, Ross lineage, males, were distributed in each treatment, totaling in each facility 154 birds, which were raised until 42 days of age.

*Litter Management and Sampling*

After filling all the parts in each boxing, it was measured the thick of the poultry litter before th**e** housing of the birds. After that, weekly, were measured and recorded the thickness and quality of each type of poultry litter. And, after that, each one of the seven types of poultry litter was mixed up.

The quality of each material, based on the moisture content, pH, ammonia-N and total counting of bacteria, was measured from samples collected in six random points inside the boxing, at the beginning, middle and end of the experimental period, avoiding some points under the feeders and drinkers. These analyses were carried out in the Water Quality Laboratory, Agricultural Engineering Department, Federal University of Vicosa, according to Kiehl (1985) and Apha (2005). Samples of these same materials were also sent to Unit for Studies on Avian Health, Veterinary Department, Federal University of Vicosa, in order to determine the standard counting of total bacteria (Sampaio *et al*., 1999).

Every day in the morning, afternoon and night was measured the temperature of the surface of the poultry litter at three different points in each treatment, by means of an infrared sensor. Similarly, it was obtained the air temperature at the level of the birds by means of sensors coupled to a data acquisition system for temperature and humidity.

 *Statistical Procedures*

The experimental design was in randomized blocks. To study the variable N-ammonia, pH, moisture and standard counting of total bacteria, that correspond to the characteristics of the poultry litter, it was used the subdivided plots, being the treatments the plot factors (CN, CN + SS, CN + gypsum, lime + CN, CR, CR + lime and CM). The period (before the housing of the birds, at 7, 21 and 42 days after) was the sub-plot factor. For the litter temperature, the same experimental scheme was applied. The difference was related to periods, which were designated as the six weeks in which it was carried out the experiment.

For all analyzes mentioned, it was used the F-test (ANOVA). The averages were compared by the Tukey test, 5% level of probability.

**Results and discussion**

From statistical analyzes for moisture content, pH and ammonia-N, it were identified differences (P <0.05) between the treatments, but there was no effect of these treatments (P> 0.05) on the standard counting of total bacteria.

The mean values for moisture content, ammonia-N and, the standard counting of total bacteria in the litter, under the effect of the different treatments are presented in Table 1.

**Table 1**. Effect of treatments (CN) new poultry litter of coffee husk without treatment; (CN + SS) new poultry litter of coffee husk treated with superphosphate; (CN + gypsum) new poultry litter of coffee husk treated with agricultural gypsum; (CN + lime) new poultry litter of coffee husk treated with lime; (CR) coffee husk poultry litter reused from two lots; (CR + lime) coffee husk poultry litter reused and treated with lime and (CM) new poultry litter of wood shavings on the moisture content, standard counting of total bacteria and N-ammonia

|  |  |  |  |
| --- | --- | --- | --- |
| **Treatments** | **Moisture content(%)** | **N-ammonia****(g kg-1)** | **Standard counting total bacteria****(UFC g-1)** |
| CN | 38.04 | a | 4.19 | b | 1.04 x 1012 | a |
| CN + SS | 34.10 | ba | 4.94 | ba | 0.75 x 1012 | a |
| CN + gypsum | 31.94 | ba | 4.85 | ba | 1.1 x 1012 | a |
| CN + lime | 34.55 | ba | 3.94 | b | 1.31 x 1012 | a |
| CR | 29.61 | ba | 6.46 | a | 1.15 x 1012 | a |
| CR + lime | 27.47 | b | 5.48 | ba | 0.86 x 1012 | a |
| CM | 39.64 | a | 4.83 | ba | 1.32 x 1012 | a |

Means followed by at least one letter in the column, do not differ, at 5% probability by the Tukey test.

It was observed effect (P<0.05) of the hydrated lime, but not of the other chemical conditioners on the moisture content of the reused coffee husk poultry litter. The new wood shavings poultry litter (CM), similar to the new coffee husk poultry litter (CN), showed the highest moisture content (39.64%) when compared to the reused litter treated with lime (CR + lime), Table 1.

The results for moisture content in the litter, as presented in Table 1, firstly can be attributed to the particle size that, being smaller increases the specific surface area favoring thereby the sedimentation and consequently the loss of water, because the difficult for absorption. The reused litter by presenting more stabilized or consolidated material, promotes less absorption of moisture and, more deposit of water on the surface which is spread to the environment, by the ventilation system. The age of the litter is an important factor affecting the moisture content. The new litter normally is able to absorb and keep the moisture. Finally, add substances to the litter will surely alter its ability for retention of moisture.

Oliveira *et al*. (2004) observed no effect (P> 0.05) of chemical conditioners such as aluminum sulfate, gypsum, superphosphate and lime on the dry matter content in a poultry litter of wood shavings. Similarly, Oliveira *et al*. (2003) observed no difference in moisture content (P> 0.05) on a new poultry litter of wood shavings (35.58%) and a reused one (42.16%), treated or not with different additives. Neme *et al*. (2000) also observed no difference by using gypsum.

Some authors (Santos et al., 2005; Hernandez *et al.,*2002; Macari & Campos,1997) refer to the importance to consider aspects like the absorption capacity of the materials, the thick adopted for the poultry litter and the density of occupation. All of that can influence the moisture content. In the present study it was used 6 cm thick in the litter and 11 birds m-2 density. In normal density (10 birds m-2), Oliveira *et al.* (2002) observed moisture content of 34.92 and 36.88% in litter of wood shavings and of sawdust, respectively. They concluded that the ideal material should be able to release and does not retain moisture, in the way it can be eliminated by ventilation. Likewise Angelo *et al.* (1997), found 36.61% moisture content in litter of wood shavings after a period of 49 days.

According to Almeida (1986), the litter should be managed so that its moisture is between 20% and 35%, because in moisture contents above that ones, the litter becomes plastered. For Avila *et al*. (2008), adequate facilities, curtains and adequate management of ventilation are essential items to maintain the quality of the litter, especially during critical weather.

There was no effect (P> 0.05) of treatments on the standard counting of total bacteria (Table 1). Although similar to other treatments (P> 0.05), the lowest value was found in the new litter treated with superphosphate, 0.75 x1012UFC g-1, coinciding with the treatment with one of the lowest initial value for pH (5.69). It is possible that the acidity has inhibited the proliferation of bacteria and the formation of ammonium compounds in the medium. The litter of wood shavings showed the highest value, 1.32 x1012UFC g-1, which coincides however, with the treatment of highest moisture content (39.64%).

The presence of organic matter (manure, feed and animal remains) favors the growth of the microorganisms that decompose uric acid present in excreta, increasing the ammonia release, thus raising the pH of the poultry litter. This influenced the presence of coli forms in the litter, which is in accordance to the results from Jorge (1991).

Still from the Table 1, there was significant difference (P <0.05) between the treatments on the N-ammonia on the litter. The reused litter (6.46 g kg-1) presented the concentration of ammonia-N greater than the new litter, treated with lime (3.94 g kg-1), and greater than the new litter without treatment (4.19 g kg-1). It is possible that the use of the poultry litter for more than one lot can justify the higher concentration of N-ammonia, since the amount of excretion deposited on the litter is increased at every batch. According to Hernandez *et al*. (2002), nitrogenous compounds and glycidyl are used in the physical-chemical and bacteriological processes that occur in the litter and may be related to the amount of ammonia released. Moisture content, pH and temperature are other factors that influence the ammonia volatilization.

The mean values of pH for the different treatments, as observed before and at 7, 21 and 42 days of life of the birds, are presented in Table 2.

**Table 2**.  Effect of treatments (CN) new litter of coffee husk without treatment; (CN + SS) new litter of coffee husk treated with superphosphate; (CN + gypsum) new litter of coffee husk treated with agricultural gypsum; (CN + lime) new litter of coffee husk treated with lime; (CR) coffee husk litter reused from two lots; (CR + lime) coffee husk litter, reused and treated with lime and (CM) new litter of wood shavings on the pH of the poultry litter, before the housing of birds at 7, 21 and 42 days of experiment.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatments** | **Before** | **At 7 days** | **At 21 days** | **At 42 days** |
|  | 7.77 | 5.83 | c | 4.19 | a | 9.11 | a |
| CN + SS | 5.25 | 5.69 | c | 4.94 | a | 9.15 | a |
| CN + gypsum | 5.15 | 5.66 | c | 4.85 | a | 8.44 | b |
| CN + lime | 7.73 | 6.57 | b | 3.94 | a | 8.88 | ba |
| CR | 8.40 | 8.25 | a | 6.46 | a | 9.14 | a |
| CR + lime | 9.77 | 8.24 | a | 5.48 | a | 8.97 | ba |
| CM | 5.22 | 6.57 | b | 4.83 | a | 9.22 | a |

 Means followed by at least one letter in the column, do not differ, at 5% probability by the Tukey test.

There was significant difference (P <0.05) between treatments on the pH of the litter. The pH of the new litter treated with lime (CN + lime), (6.57) was slightly higher (P <0.05) than the new one without treatment (5.83) at 7 days of experiment. Although similar (P> 0.05) to the control treatment (CN), the pH of the new litter treated with gypsum (CN + gypsum), (5.66), and superphosphate (CN + SS), (5.69), was lower (P <0.05) than that observed in the reused litter (8.25) in the initial phase of the experiment (Table 2).

About the pH, results similar to those presented in Table 2 were observed by Oliveira *et al.* (2004), that reported that the pH of the poultry litter was not influenced by use of the normal superphosphate and gypsum.

In the present work, at the end of the experiment (42 days), the new litter treated with gypsum had the lowest pH value (8.44). Similar results (8.11) were observed by Neme *et al*. (2000).

Considering that the pH at the end of the experiment (42 days) was high, all treatments have produced ammonia, since, according to Terzich (1997), one of the major bacteria involved on the urea lysis, the *Bacilius pasteurii*, cannot grow at neutral pH values, but develops in pH values above those. It was expected that the superphosphate, being an acidic substance, would keep the pH down untill the end of the experiment. It can be inferred that that product may have lost the efficiency to maintain the pH down, as the time went on or the dosage has been low, or, maybe one more application of it, would be necessary in the last days of the cycle.

The average surface temperatures of the poultry litter are shown in Table 3.

**Table 3**. Mean surface temperature, in °C, of the poultry litter in the different treatments, (CN) new litter of coffee husk without treatment; (CN + SS) new litter of coffee husk treated with superphosphate; (CN + gypsum) new litter of coffee husk treated with agricultural gypsum; (CN + lime) new litter of coffee husk treated with lime; (CR) coffee husk litter reused from two lots; (CR + lime) coffee husk litter, reused and treated with lime and (CM) new litter of wood shavings

|  |  |
| --- | --- |
| **Treatments** | **Weeks** |
| **1** | **2** | **3** | **4** | **5** | **6** |
| CN | 31.2 | a | 27.6 | ba | 27.2 | a | 26.5 | a | 26.7 | ba | 27.9 | a |
| CN + SS | 31.4 | a | 27.7 | ba | 27.3 | a | 26.6 | a | 27.1 | ba | 28.2 | a |
| CN + gypsum | 31.2 | a | 27.4 | ba | 27.1 | a | 26.6 | a | 26.6 | ba | 27.8 | a |
| CN + lime | 30.7 | a | 27.1 | b | 27.1 | a | 26.5 | a | 26.5 | b | 27.7 | a |
| CR | 32.1 | a | 27.9 | ba | 27.3 | a | 26.2 | a | 27.3 | a | 28.6 | a |
| CR + lime | 21.1 | a | 28.7 | a | 27.2 | a | 26.4 | a | 27.2 | ba | 26.6 | a |
| CM | 32.0 | a | 27.6 | ba | 26.6 | a | 26.7 | a | 26.8 | ba | 28.2 | a |

Means followed by at least one letter in the column, do not differ, at 5% probability by the Tukey test.

There was no effect (P> 0.05) of treatments on the surface temperature of the litter, except in the second and in the fifth week of birds life, when there was a significant difference (P <0.05) between the reused litter and the new one, treated with lime.

The average surface temperature of the litter in the first, third and in the fourth week of birds life, were similar to their comfort temperatures for this stage. However, the values of surface temperature of the litter at the end of the production period were higher than those considered appropriate for the welfare and the good performance of the poultry at this stage (Table 4).

**Table 4**. Average litter surface temperature, air temperature and comfort temperature for poultry, during the experimental weeks

|  |  |
| --- | --- |
| **Temperatures** | **Weeks** |
| **1** | **2** | **3** | **4** | **5** | **6** |
| T. Surface (°C) | 31.5 | 27.7 | 27.1 | 26.6 | 26.9 | 28.1 |
| T. Air (°C) | 25.3 | 24.4 | 24.2 | 23.2 | 21.3 | 22.0 |
| T.Comfort (°C)\* | 30-33 | 29-31 | 27-29 | 25-26 | 22-23 | 21 |

\* Baêta & Souza (2010); Abreu & Abreu, (2011)

Related to the temperatures, as presented in Table 3, according to Oliveira (2000), in the bedding systems, it must be considered the heat generated by the binomial "animal plus litter". In the present work, however, the air temperature was too below the surface temperature of the litter (Table 4), which can be attributed, in part, to the ventilation and to the period of data collection, the winter.

One of the functions of the litter, according to Paganini (2004), is to reduce the contact of the birds with a cold surface, which causes the loss of heat to the floor. Shallow litter of inadequate materials allows thermal conductivity between the floor and the air, making it difficult to maintain a suitable temperature to birds (Garcia and Caldara, 2011; Fraser et al., 2013).

**Conclusion**

According to the previously presented, it can be concluded that lime had effect on the moisture content of the reused litter, when compared to the new litter of coffee husk; the hydrated lime had effect on increasing the pH of the new litter and of the reused litter of coffee husk at 7 days. The gypsum was effective in lowering the pH of the new litter of coffee husk at 42 days. The content of ammonia-N of the reused litter without treatment was superior to the one found for the new litter of coffee husk without treatment and to the one found for the new litter treated with lime. There was no effect of the treatments on the "standard counting of total bacteria" and on the surface temperature of the litter, except in the second and in the fifth week of birds life, when there was a significant difference between the reused litter and the new one, treated with lime. Then, the use of chemical conditioners in the poultry litter constitutes a good strategy to control its quality, as well as the environmental conditions and welfare to produce poultry meat.

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