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Original Research

Effect of Disinfectants on Physicochemical Parameters of Litter, Microbiological Quality of Poultry House Air, Health Status and Performance of Broiler Chickens

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Abstract

The applied disinfectants affected the improvement of physicochemical parameters of litter by decreasing its moisture and pH.

It was demonstrated that the addition of decontaminating agents to litter resulted in a beneficial decline in the microflora of poultry house air. The total count of mesophilic bacterium was reduced most effectively by means of a disinfectant, whereas the total number of fungi and moulds – by calcium oxide (CaO). But no differences were observed in ammonia concentration in the air of the hen houses examined.

In poultry houses in which disinfectants were added to litter, the reported death rate and culling percentage were lower as compared to a control broiler house. Birds reared in a broiler house in which litter was disinfected with CaO achieved the highest European Index of Productivity (EIP).

Keywords: disinfectants, poultry litter, air, broilers, EIP

Introduction

Litter present in rooms for poultry constitutes a significant environmental factor because it affects not only zoohygienic conditions of the rooms but also, indirectly, the health and performance of birds. Keeping the physical parameters of litter (i.e. temperature, moisture and pH) at an appropriate level improves the microclimate of rooms. Too wet litter is the main source for an increase in the water vapor content in the air in the utility room. In addition, in the first weeks of poultry rearing, high temperature affords excellent conditions for the growth of pathogenic microflora that may induce a number of lesions [1, 2]. An increase in the number of bacteria responsible for degradation of organic substances in litter is accompanied by increased emission of detrimental gaseous admixtures, ammonia in particular, from litter. Wathes et al. [3] has demonstrated that the maximum emission of ammonia from litter occurred when its moisture reached 40-60%.

Both reducing litter humidity as well as neutralizing ammonia in air and litter are hardly feasible, especially in the presence of birds. The results of many investigations have demonstrated that its emission might be reduced by the use of several additives in the litter. Chemical compounds applied to this end may either retard decomposition of uric acid or – by interacting with the released ammonia – neutralize it [4-7]. The chemical additives used include both organic and mineral preparations. Due to natural origin and availability, increased attention is being paid to additives of mineral origin which, through their positive effect on the litter, indirectly affect the improvement of microclimate in utility rooms. One such natural additive, known and valued for years, is lime. It has been widely applied in animal production as a strong disinfectant used before introducing animals to utility buildings [8]. However, domestic and worldwide literature provides scarce data on specified doses of lime that might be applied on the litter before introduction of the birds and rearing. The lime applied should reduce the number of uricolytic bacteria originating from litter, and consequently the quantity of ammonia emitted from litter might be expected to decrease.

The presented research was carried out to evaluate the effect of selected commercial disinfectants and calcium oxide applied onto/under litter on physicochemical parameters of litter, reduction in air microflora of poultry house and rearing performance of broiler chickens.

Material and Methods

Experiments were carried out in the Summer season, in four poultry houses located in the province of Pomorskie. In each poultry house, meat type Ross 326 broiler chickens, fed with a standard diet, were kept at the number of 21,000 birds (stocking density: 16 birds/m^2). A drip watering system was installed in poultry houses.

Before the birds were placed in the rearing rooms, disinfectants were applied in a single dose of 50 g/m^2 onto or under the 15-cm thick litter (depending on the agent applied):

- Poultry house 1 – a commercial product (Profistreu®) whose activity, according to the label, improves hygiene and climate in utility building. The product contained organic and inorganic active substances and essential oils;
- Poultry house 2 – an ecological commercial product (Stalosan®F) containing natural phosphates, inorganic copper, inorganic iron and white clay. The preparation was poured on the litter also in the subsequent weeks of rearing, i.e. following producer's instructions - every 7th day;
- Poultry house 3 – calcium oxide (CaO). CaO was sprinkled once, before putting in birds, on a 5 cm layer of cut straw, and then covered with another 10 cm layer.
- Poultry house 4 – control room, with no disinfectant.

Temperature and humidity conditions in the houses were maintained at a required level by means of a computer-aided ventilation-heating system.

To evaluate the litter parameters, the following measurements were performed:

- temperature (ºC) and moisture (%) of deep litter (10 cm) – with a digital tester of hay and straw humidity (DRAMIŃSKI);
- litter pH – with an agriculutral digital tester of soil and fluid acidity (DRAMIŃSKI), on a previously prepared suspension of litter in distilled water (10 g of litter per 25 ml of water);
- content of nitrogen compounds – with a PC-Checkit photometer. Following producer's recommendations, the obtained content of nitrogen compounds was converted into NH_3 (1g N = 1.28 g NH_3).

Litter samples to be analyzed were collected once in each week of rearing, at eight sites of each poultry house. Two of eight samples were taken about 20 cm from drinking bowls.

For analyses of microbiological contamination, samples of the air were collected in Petri dishes in each poultry house, once a week, over the entire production cycle, at 5 measuring sites, and at one site outside of the houses. Quantitative identification of bacteria and fungi was performed with the sedimentation method (Koch's plate method) using selective solid culture media:

- common agar (total count of mesophilic aerobes) (PN EN ISO 4833);
- Sabouraud's medium (total count of fungi and moulds) (PN EN ISO 79 54 1999).

The inoculated plates with agar medium were incubated at 37ºC for 24 h, while in the case of fungi (cultured on Sabouraud's medium) the incubation was run at 25ºC for 5 days. The number of colonies grown on each plate were counted with a COLONY STAR counter. Total bacteria count (CFU/m^3) was computed based on the formula by Omeliański [9]. The genus spectrum of fungi and moulds occurring in the poultry houses was determined additionally due to their contribution in degradation of uric acid to ammonia [10].

Measurements of ammonia concentration in the air of poultry houses were performed at each week of chicken rearing, at 7:00, 13:00 and 21:00, using indicatory tubes (Matbon), at six measuring sites at bird head height.

The health status of broiler chickens was assessed based on the register of their culling percentage and death rate.

The evaluated parameters of broiler production performance were the feed intake, body weight, feed: gain ratio, and the European Index of Productivity (EIP) [11]. Body weight was obtained by weighing a randomly selected batch of birds (n=50) every 7th day, and the EIP was calculated following the formula:

$$EIP = \frac{\text{mean body weight (kg) x survivability (\%)}}{\text{Feed: gain raio (kg/kg) x days of rearing}} \text{x } 100$$

Results and Discussion

The addition of disinfectants to the litter resulted in a decrease of the microbial count of poultry houses air, compared to the control room (Table 1). An intensive increase in the number of mesophilic aerobes was observed in all poultry houses in the fourth week of the experiment. It should be emphasized, however, that their numbers were still considerably lower than those recorded in the control room. Mean values computed for the entire rearing period indicated that the lowest bacterial count in air was found in

Table 1. Microbiological contamination of air in poultry houses in the experimental period.

Week of experiment	Total bacteria count (CFU/m^3)					Total count of fungi and moulds (CFU/m^3)				
	Poultry house 1	Poultry house 2	Poultry house 3	Control	Outsider	Poultry house 1	Poultry house 2	Poultry house 3	Control	Outside
1.	1.00*10^5	2.72*10^5	2.71*10^5	1.23*10^5	3.15*10^3	1.40*10^5	1.01*10^5	1.76*10^5	1.09*10^5	2.25*10^4
2.	2.08*10^5	1.93*10^5	1.65*10^5	2.77*10^5	3.15*10^3	1.04*10^5	1.22*10^5	1.00*10^5	1.79*10^5	1.83*10^4
3.	2.53*10^5	3.88*10^5	4.02*10^5	7.28*10^5	1.57*10^4	1.09*10^5	2.37*10^5	2.42*10^5	2.37*10^5	1.42*10^4
4.	7.50*10^5	6.95*10^5	9.14*10^5	1.97*10^6	1.94*10^4	3.39*10^5	2.94*10^5	2.90*10^5	7.92*10^5	1.10*10^4
5.	1.96*10^6	2.16*10^6	2.39*10^6	4.25*10^6	3.56*10^4	1.30*10^6	2.39*10^6	1.50*10^6	2.33*10^6	4.19*10^4
6.	5.64*10^6	4.27*10^6	3.92*10^6	8.65*10^6	3.04*10^4	3.17*10^6	2.56*10^6	2.29*10^6	4.27*10^6	4.51*10^4
$\bar{x}$ for total experimen-tal period	**1.49*10^6**	**1.33*10^6**	**1.34*10^6**	**3.18*10^6**	**1.79*10^4**	**8.60*10^5**	**9.51*10^5**	**7.67*10^5**	**1.56*10^6**	**2.55*10^4**

Table 2. Changes in basic physicochemical parameters of litter in the experimental period.

Week of experiment	Temperature °C				Relative humidity %				pH			
	Poultry house 1	Poultry house 2	Poultry house 3	Control	Poultry house 1	Poultry house 2	Poultry house 3	Control	Poultry house 1	Poultry house 2	Poultry house 3	Control
1.	30.0	30.5	30.0	28.5	11.60	11.25	10.75	15.80	5.34	5.00	5.05	4.89
2.	24.5	23.7	24.0	24.2	13.63	16.08	16.32	18.90	5.10	5.28	4.67	5.66
3.	22.3	22.0	23.2	22.7	19.06	21.42	22.10	24.10	5.23	5.73	5.56	6.42
4.	24.6	24.2	25.0	25.5	20.67	23.50	24.92	31.80	5.76	5.64	5.33	6.67
5.	24.3	24.2	23.8	21.3	34.58	40.67	40.50	43.80	5.78	6.65	6.17	6.99
6.	22.5	22.2	23.0	22.2	36.67	37.33	34.75	36.20	6.49	6.34	6.79	7.54
$\bar{x}$ for total experimental period	**24.7**	**24.5**	**24.8**	**24.1**	**22.70^b**	**25.04^b**	**24.89^b**	**28.24^a**	**5.62^b**	**5.77^b**	**5.65^b**	**6.13^a**

^{a,b} - $P \leq 0.05$

poultry houses with litter treated with ecological preparation (Poultry house 2) and CaO (Poultry house 3). In Poultry house 1, microbiological contamination of air was found to be higher than in the two latter houses. The obtained counts of mesophilic aerobic bacteria were, however, twice as high the control poultry house. In the study, special attention was paid to the effects of CaO. Its application requires caution since its doses are likely to evoke irritations and burns of the mucous membranes and wet skin. In addition, contact with water results in an increased temperature of lime, which may negatively affect birds staying on litter [8]. Studies by Majewski et al. [12] have demonstrated that CaO is a good agent for disinfection of poultry litter as it is characterized by a wide spectrum of actions, e.g. it reduces bacteria as well as fungi in moulds occurring in litter. Furthermore, litter subjected to disinfection processes by (means) use of CaO might be re-applied in the rearing of another batch of birds. Studies by other authors [13-15] have confirmed that pouring through the litter of various types (shavings, rice hulls) with lime diminishes bacterial counts as well as reduces the occurrence of *Salmonella* and *Campylobacter* bacteria that pose a serious problem to poultry breeders.

In considering the intensity of fungi and mould occurrence in the air of poultry houses (Table 1), it should be noted that their distinctly lower numbers were obtained upon the application of CaO (Poultry house 3). The other two disinfectants significantly reduced fungi numbers in the air as compared to the control poultry house. Upward trends in the numbers of fungi and moulds in the air in the subsequent weeks of broiler chickens rearing differed than those reported for the total count of mesophilic aerobes. In the fourth week of the experiment, the number of fungi and moulds increased rapidly in the control poultry house (Table 1). A considerable increase was also noted upon the use of the specialist preparation (Poultry house 1). In contrast, in the other two houses, such an increase was observed by the fifth week of rearing.

Table 3. Ammonia content of litter in the entire experimental period.

Week of experiment	Total content of nitrogen (N) converted into NH_3 (mg/kg)			
	Poultry house 1	Poultry house 2	Poultry house 3	Control
1.	2.76	4.80	7.44	27.60
2.	14.40	30.00	28.80	31.20
3.	33.60	72.00	54.00	57.60
4.	37.20	56.40	66.00	86.40
5.	56.40	78.00	81.60	58.80
6.	64.80	92.40	72.00	57.60
$\bar{x}$ for total experimental period	**35.40**	**56.60**	**51.64**	**52.00**

As indicated by Karwowska [16], fungi and moulds of the genera *Asperillus* sp., *Penicillium* sp., *Cladosporium* sp. and *Alternaria* sp. are most common in buildings for poultry. In the current study, the genus spectrum was considerably wider and represented mainly by *Penicillium* sp., *Aspergillus* sp., *Fusarium* sp., *Cladosporium* sp., and *Scopulariopsis* sp., and to a lesser extent by *Rhizomucor* sp., *Rhizophus* sp., *Mucor* sp., *Culvularia* sp., and *Geotrichum* sp. According to Dobrzański, after Vogels and Van Der Drift [10], those microorganisms are capable of uric acid degradation, thus increasing ammonia emission from litter.

The increased numbers of microorganisms occurring in air should be strictly linked with physicochemical parameters of litter that, combined with bird excreta, might constitute an excellent culture medium for their growth [17-19]. The applied disinfectants positively affected the physicochemical parameters of litter by decreasing its moisture and pH, which was confirmed by the statistical analysis on level $\alpha = 0.05$ (Table 2). In turn, litter's temperature was at a similar level in all experimental rooms. The presented results are similar to those obtained by Tymczyna et al. [20], who recorded the moisture of litter ranging from 27.5% to 57.1% in an eight-week experimental period. As claimed by Rachwal [21], litter moisture exceeding 30% is disadvantageous since it results in the formation of the so-called "dirt floor." It is also accompanied by increased emission of detrimental gaseous admixtures and physical evaporation which, in turn, creates favorable conditions for the incidence of alimentary tract diseases in poultry. Higher than 30% litter moisture was recorded in the control poultry house in the fourth week, whereas in the other houses it was recorded in the fifth week of the study (Table 2).

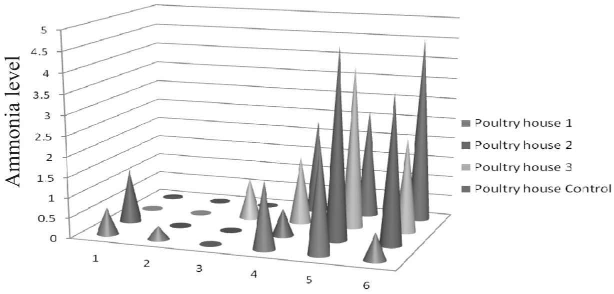

Fig. 1. Changes in NH_3 level in air of poultry house in particular weeks of experiment (ppm).

Maintaining litter acidity at a level below pH 6 facilitates growth inhibition of nitrifying bacteria that degrade uric acid in litter [18]. An increase in litter pH in the experimental poultry houses above the recommended level occurred at the end of the rearing period of broiler chickens. In contrast, in the control poultry house, intensive alkalization was observed as early as in the third week of rearing (Table 2).

Analyses of ammonia concentration in litter (Table 3) showed its highly diversified levels in particular weeks of rearing in all poultry houses examined. Taking into account the mean level of ammonia in litter computed for the entire rearing period, its lowest value was noted in poultry house 1, where litter was treated with the specialist preparation containing essential oils. However, it is worth noting that due to the high variability of data obtained in the study, it was difficult to interpret the results. More detailed analyses are required, especially in the case of lime. As demonstrated by other authors [13, 22, 23], a positive aspect of applying CaO as an additive to poultry litter is the retention of nitrogen as well as other mineral compounds. It is of significance to environmental protection since minerals remain in the litter which, after completing rearing, may constitute a natural fertilizer of good quality. The minerals will not be washed out, e.g. to underground water, and will become a source of nutrients to plants in a vegetative cycle, which may be an alternative to mineral fertilization.

Development of uricolytic microorganisms in litter, combined with its high moisture of 40-60%, is likely to cause intensified emissions of detrimental gaseous admixtures, ammonia in particular [3], and the litter loses its beneficial ability to absorb gases and the proceeding putrefying processes coupled with bird excreta evoke increased production of ammonia. Our analyses did not demonstrate any differences in the concentration of ammonia in the air of the examined poultry houses (Fig. 1). In all houses examined, the values were low (did not exceed 5 ppm), which was most likely due to intensive ventilation in the summer period.

The application of disinfectant additives also had positive effects on the results of productivity (Table 4). The highest value of the EIP was obtained in the poultry house submitted to the single application of CaO under litter. Such a beneficial value of the index was undoubtedly affected by the high final body weight, the lowest feed:gain ratio, as well as low death rate and culling percentage. Also noteworthy is the lowest EIP (309.34%) recorded in the poultry house in which litter was supplemented with the specialist preparation. This result was probably due to the higher feed utilization and higher death rate and culling percentage of the birds.

Table 4. Production performance of broiler chickens.

Specification		Poultry house 1	Poultry house 2	Poultry house 3	Control
Mean body weight in subsequent weeks (kg)	1	0.17	0.17	0.16	0.19
	2	0.44	0.45	0.45	0.39
	3	0.89	0.89	0.90	0.80
	4	1.38	1.36	1.38	1.32
	5	1.85	1.85	1.95	1.87
	6	2.51	2.49	2.60	2.47
Total feed utilization (kg)		96,590	90,020	91,980	97,810
Mean feed utilization per 1 bird (kg)		4.76	4.45	4.52	4.58
Feed utilization per 1kg of body weight (kg)		1.89	1.80	1.77	1.83
Deaths and culling (%)		4.50	3.86	3.27	5.30
European Index of Productivity (EIP) (%)		309.34	324.37	346.56	314.12

In summary, it should be noted that the application of additives/disinfecting preparations contributed to the improvement of bedding quality and the reduction of microbiological pollutants of the air. This was reflected in higher performance indicators in comparison to a control broiler house.

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