The Microbiologic Quality of the Air in Broiler Houses

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Abstract
The aim of this paper was to assess the microbiologic quality of air in broiler houses. The number of bacteria (mesophile, staphylococci, streptococci and gram-negatives) and fungi was determined in 6 broiler houses with chicken of different ages (1-6 weeks old) through specific methods. The results were statistically processed by using the SPSS software, version 17. The number of bacteria and fungi varied in the 6 broiler houses, ranging from 2.25 x 10^5 to 2.17 x 10^6 for the total number of mesophilic bacteria, between 3.5 x 10^4 – 1.27 x 10^6 for staphylococci, 7.4 x 10^4 – 5.01 x 10^5 for streptococci, 3.5 x 10^3 – 1.53 x 10^4 for gram-negatives and from 1.67 x 10^4 to 8.13 x 10^4 for fungi, respectively. The number of bacteria and fungi were significantly lower for the younger chicken ($p < 0.05$). The proportions of groups with hygienic significance within the total mesophilic bacteria number were: 15.7% - 68.6% staphylococci, 6.7% - 45.6% streptococci and 0.2% - 4.5% gram-negatives. The comparative appraisal of the microbiologic quality in the broiler houses showed better air quality in the youngest chicken's house (one week of age). The obtained results indicate the necessity for increased ventilation and for air disinfection during the chicken's fattening period.

Keywords: airborne bacteria, airborne fungi, gram negative, mesophilic bacteria, poultry age.

1. Introduction

The air in livestock buildings contains a large variety of different gases, microorganisms and considerable amounts of dust. These particles have a complex nature, can carry substances such as endotoxins and antibiotic residues, can remain suspended in the air for longer periods and can therefore be inhaled by animal and man. Strong epidemiological evidence suggests that dust associated with bacteria can cause directly infectious and allergic diseases in animals and farm workers [1-3]. Major quantities of these compounds are emitted in the environment where the health of nearby residents may be harmed by regular exposure and where the small particles may contribute to atmospheric pollution and global dimming [4, 5]. Particularly high amounts of dust [6], microorganisms and endotoxins [7, 8] are reported in poultry houses. The air concentration of microorganisms in poultry housing reported in scientific literature greatly varies, which could in part be ascribed to the different methods of sampling used in different studies. In broiler houses, the cultivable concentrations of bioaerosols ranged from 10^4 to 10^7 cfu/m^3 for bacteria, from 10^2 to 10^4 cfu/m^3 for gram-negative bacteria, and from 10^2 to 10^5 cfu/m^3 for fungi [9, 10, 7, 11]. Reducing air pollutants in animal houses is an urgent requirement for the development of future poultry production. It will provide a safer and healthier work environment for employees, and a better atmosphere for animals – by improving their health, welfare and performance [12, 10].

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Keeping in mind all these aspects, the aim of this work was the assessment of the microbiologic quality of the air in broiler houses.

2. Materials and methods

Measurements were performed in 6 poultry barns with chicken of different ages (1-6 weeks) in a commercial farm in Cluj county, over the period March - April 2009. The poultry houses, which were 100.00 × 12.00 m in size, 3.50 m in height, accommodated 22000-21000 Ross broilers, 17-18 birds/m^2, depending on their ages. Broilers were kept on 15 cm deep litter (wood shavings). The ventilation was provided with air inlets and fans, heating with a thermogen, and artificial lighting with fluorescent tubes. In each barn six determinations were performed (in the morning, at noon and in the evening, in two different days). Bacterial numbers in air samples were determined with a Merck MAS-100 device (Merck, Germany). Bacteria and fungi were collected and grown in Petri dishes on different standard culture mediums: Columbia agar for mesophilic bacteria, Chapmann agar for staphylococci, Endo agar for gram negative bacteria, blood agar for hemolytic bacteria and Sabouraud agar for fungi. Air was sampled in a volume of 1 L because preliminary studies showed that bacteria and fungi are in great numbers in poultry barns. Plates (a total number of 180 plates) with the usual bacterial nutrient Columbia agar and with selective culture mediums were then incubated for 24 h in an incubator at 37°C. The material sampled on Sabouraud agar was incubated for 5 days at 22°C. The grown colonies were calculated by a mechanical optic colony counter, and results were corrected using the conversion formula devised by Feller [13]. The average number of bacteria and fungi was calculated in the form of colony-forming units in one cubic metre (cfu/m^3). All data were analyzed with SPSS version 17 software, including descriptive statistics (mean, standard deviation, median, minimum, maximum) and Mann-Whitney test. We also calculated the percentage of germ-groups with hygienic significance (staphylococci, streptococci, gram-negatives) within the overall number of mesophilic bacteria.

3. Results and discussion

The results obtained from the determinations in the 6 broiler houses are shown in Table 1. The mean numbers of bacteria and fungi varied in the broiler houses, ranging from 2.25 x 10^5 to 2.17 x 10^6 for the total number of mesophilic bacteria, between 3.5 x 10^4 – 1.27 x 10^6 for staphylococci, 7.40 x 10^4 – 5.01 x 10^5 for streptococci, 3.50 x 10^3 – 1.53 x 10^4 for gram-negatives and from 1.67 x 10^4 to 8.13 x 10^4 for fungi, respectively. Our results are in agreement with the data obtained in other studies. The air concentration of microorganisms in poultry housing reported in the literature greatly varies, which could in part be ascribed to different methods of sampling used in different studies. In broiler houses, the cultivable concentrations of bioaerosols ranged from 10^4 to 10^7 cfu/m^3 for mesophylic bacteria, from 10^2 to 10^4 cfu/m^3 for gram-negative bacteria, and from 10^2 to 10^5 cfu/m^3 for fungi [7, 10, 9, 11]. The total number of mesophilic bacteria, excepting the barn with one-week old chicken, was high, exceeding the recommended value (2.50 x 10^5 cfu/m^3) 1.4 - 8.7 times. The microbial load of the air, in terms of mesophilic bacteria, is influenced by several factors such as: the numbers of sheltered animals, the breeding technology, the type of the flooring, the bedding materials, the microclimatic conditions, the dust concentration, the ventilation level and so on. The great numbers of bacteria and fungi in broiler houses affect the health of the broilers and human employees, representing, in the same time, a polluting factor of the environment adjacent to the farms [1-3, 5].

Generally, we noted the increase of the bacterial numbers along with the increasing age of the chicken, the differences among different age categories being statistically highly significant (Mann-Whitney test $p < 0.01$) (Table 2), as it is stated in the literature as well. Vučemilo et al. [14] found the concentration of airborne microorganisms in a poultry house to rise with poultry age, ranging from 1.66 × 10^4 cfu/m^3 air in the first week to 2.2 × 10^5 cfu/m^3 air in the fifth week of intensive breeding. In case of fungi, very significant differences were found (Mann-Whitney test $p < 0.01$) among the barns, with only one exception, in the barns with chicken of two and three weeks of age (Table 2), but the number of fungi did not increase with the chicken's age, the greatest value being registered in the barn with

two week old chicken (Table 1) and not with those of six weeks of age. Unlike the results obtained by other authors [14], we did not observe lowering bacterial numbers in the barn with six weeks old chicken. In our study the highest values were determined at the end of the fattening period (in the barn with six weeks old chicken).

The proportions of groups with hygienic significance (staphylococci, streptococci, gram-negatives) within the total mesophilic bacteria number is shown in Table 3. While staphylococci slightly exceeded the recommended values in four of the barns and streptococci in three of the barns, the gram-negatives were within the admitted limits in all of the barns. A proper hygienic situation presumes that staphylococci should be less than 50% from the total number of mesophilic bacteria, streptococci and gram-negatives should be less than 25% from the total number of mesophilic bacteria [15]. With regard to the quality of aeromicroflora, Hartung [16] shows that gram-positive bacteria, such as staphylococci and streptococci, predominate in the air of poultry barns and our results support this finding.

Table 1. Descriptive statistic analysis for bacteria and fungi in broiler barns

Parameter	Age (week)	n	Mean	Standard deviation	Median	Minimum	Maximum
Mesophilic bacteria (cfu/m^3)	1	6	2.25×10^5	1.22×10^4	2.27×10^5	2.09×10^5	2.41×10^5
	2	6	3.49×10^5	3.35×10^4	3.50×10^5	3.06×10^5	4.02×10^5
	3	6	5.35×10^5	3.70×10^4	5.43×10^5	4.84×10^5	5.73×10^5
	4	6	6.59×10^5	3.84×10^4	6.67×10^5	5.99×10^5	7.06×10^5
	5	6	1.33×10^6	2.17×10^5	1.31×10^6	1.03×10^6	1.59×10^6
	6	6	2.17×10^6	4.13×10^5	2.13×10^6	1.59×10^6	2.63×10^6
Staphylococci (cfu/m^3)	1	6	3.53×10^4	4.50×10^3	3.55×10^4	2.90×10^4	4.10×10^4
	2	6	1.59×10^5	8.71×10^3	1.57×10^5	1.48×10^5	1.72×10^5
	3	6	3.67×10^5	4.55×10^4	3.83×10^5	2.77×10^5	4.02×10^5
	4	6	3.51×10^5	1.52×10^4	3.44×10^5	3.39×10^5	3.79×10^5
	5	6	6.90×10^5	1.84×10^4	6.92×10^5	6.62×10^5	7.12×10^5
	6	6	1.27×10^6	7.80×10^4	1.26×10^6	1.15×10^6	1.39×10^6
Streptococci (cfu/m^3)	1	6	7.40×10^4	5.47×10^3	7.45×10^4	6.80×10^4	8.20×10^4
	2	6	1.59×10^5	1.39×10^4	1.55×10^5	1.46×10^5	1.78×10^5
	3	6	7.47×10^4	6.12×10^3	7.35×10^4	6.80×10^4	8.40×10^4
	4	6	1.79×10^5	1.02×10^4	1.80×10^5	1.67×10^5	1.94×10^5
	5	6	8.92×10^4	3.06×10^3	8.9×10^4	8.50×10^4	9.30×10^4
	6	6	5.01×10^5	3.19×10^4	5.01×10^5	4.58×10^5	5.45×10^5
Gram-negatives (cfu/m^3)	1	6	7.67×10^3	1.50×10^3	8.00×10^3	5.00×10^3	9.00×10^3
	2	6	1.53×10^4	3.72×10^3	1.55×10^4	1.00×10^4	2.10×10^4
	3	6	7.33×10^3	1.63×10^3	7.5×10^3	5.00×10^3	9.00×10^3
	4	6	1.23×10^4	2.66×10^3	1.15×10^4	9.00×10^3	1.60×10^4
	5	6	1.21×10^4	2.71×10^3	1.20×10^4	8.00×10^3	1.60×10^4
	6	6	3.50×10^3	2.26×10^3	3.00×10^3	1.00×10^3	7.00×10^3
Fungi (cfu/m^3)	1	6	3.28×10^4	3.66×10^3	3.25×10^4	2.80×10^4	3.90×10^4
	2	6	8.13×10^4	6.98×10^3	8.00×10^4	7.40×10^4	9.30×10^4
	3	6	2.23×10^4	5.20×10^3	2.25×10^4	1.50×10^4	2.90×10^4
	4	6	2.90×10^4	3.63×10^3	2.85×10^4	2.50×10^4	3.50×10^4
	5	6	1.67×10^4	5.00×10^3	1.65×10^4	1.10×10^4	2.30×10^4
	6	6	3.05×10^4	3.62×10^3	3.00×10^4	2.60×10^4	3.60×10^4

n = number of broiler barns

Table 2. The Mann-Whitney test for bacteria and fungi

Parameter	Comparison	Mann-Whitney U-statistic	P value
Mesophilic bacteria (cfu/m^3)	1 week–2 week	0.00	$p < 0.01$
	2 week–3 week	0.00	$p < 0.01$
	3 week–4 week	0.00	$p < 0.01$
	4 week–5 week	0.00	$p < 0.01$
	5 week–6 week	0.50	$p < 0.01$
Staphylococci (cfu/m^3)	1 week–2 week	0.00	$p < 0.01$
	2 week–3 week	0.00	$p < 0.01$
	3 week–4 week	7.00	$P > 0.05$
	4 week–5 week	0.00	$p < 0.01$
	5 week–6 week	0.00	$p < 0.01$
Streptococci (cfu/m^3)	1 week–2 week	0.00	$p < 0.01$
	2 week–3 week	0.00	$p < 0.01$
	3 week–4 week	0.00	$p < 0.01$
	4 week–5 week	0.00	$p < 0.01$
	5 week–6 week	0.00	$p < 0.01$
Gram- negatives (cfu/m^3)	1 week–2 week	0.00	$p < 0.01$
	2 week–3 week	0.00	$p < 0.01$
	3 week–4 week	1.00	$p < 0.01$
	4 week–5 week	17.5	$p > 0.05$
	5 week–6 week	0.00	$p < 0.01$
Fungi (cfu/m^3)	1 week–2 week	0.00	$p < 0.01$
	2 week–3 week	5.5	$p > 0.05$
	3 week–4 week	0.00	$p < 0.01$
	4 week–5 week	0.00	$p < 0.01$
	5 week–6 week	0.00	$p < 0.01$

$p < 0.01$ considered very significant
$p > 0.05$ considered not significant

Table 3. The proportion of hygienically significant germ groups within the total number of mesophilic bacteria in six broiler barns

Poultry barn / Bacteria	1	2	3	4	5	6
Staphylococci (%)	15.7	45.6	68.6	53.3	51.9	58.5
Streptococci (%)	32.9	45.6	14.0	27.2	6.7	23
Gram-negatives (%)	3.4	4.4	1.4	1.9	0.9	0.2

In the investigated broiler barns the gram-positive bacteria represented up to 90%. It is also asserted that the gram-negative bacteria isolated from the air of poultry barns represent a minor proportion within the totality of germs, between 0.02 and 5.2% [17], as it is evident in our determinations (Table 3). The poor microbiologic quality of the air in the investigated broiler houses is mainly caused by improper ventilation.

4. Conclusions

At the end of our study, we reached the following conclusions:

- the number of bacteria and fungi varied in the investigated broiler barns, being high in the barns with broiler chickens of 2 – 6 weeks of age;
- the microbial loading of the air was significantly higher in the barns with older chicken, the bacterial number increasing with the age of the chicken;
- in the majority of the barns the proportions of staphylococci and streptococci was increased, exceeding the recommended value;
- the number of gram-negative bacteria was within the admitted limits in all of the investigated barns.

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