The effect of animal age on air pollutant concentration in a broiler house

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ABSTRACT: The results of a study assessing the level of airborne contamination in intensive broiler breeding facilities are presented. The content of corpuscular particulates of various origin (dust, bacteria, fungi), ammonia and carbon dioxide was determined. The investigations were conducted in a poultry house on a family farm in the area of moderate continental climate during spring 2006. The air concentration of bacteria ranged from 1.7×10^4 to 2.2×10^5 cfu/m^3, of fungi from 9.8×10^3 to 8.5×10^4 cfu/m^3, of dust from 1.8 to 4.8 mg/m^3, and of ammonia from 4 to 27.47 ppm. Total dust and fungi concentrations measured at the end of fattening period were almost identical to the initial ones, whereas the concentrations of bacteria and ammonia showed a sinusoidal rise from the beginning to the end of fattening period. In general, the analyzed air pollutants reached relatively high levels in the mid-fattening period and also show significant differentiation between fattening periods as demonstrated by *t*-test yielding statistical significance at a level of $P < 0.05$.

Keywords: broilers; airborne bacteria; airborne fungi; airborne dust; poultry age

Intensive poultry production, chicken fattening in particular, is a significant source of air contamination that may greatly influence animal health and weight gain. In addition, it may also pose a health risk for poultry stockmen and those living in proximity (Donham and Cumro, 1999; Donham et al., 2002; Whyte, 2002). Chickens emit to the environment considerable amounts of dust produced by epithelial desquamation as well as from feed, skin, faeces, etc. (Takai et al., 1998). In addition to dust pollution, the air in this housing type is also contaminated by various microorganisms and gases. Besides mechanical effects of these pollutants on the animals, they may also exert infectious, immunosuppressive or allergenic effects. These effects may be additionally aggravated by poor housing microclimate conditions, the temperature-humidity complex in particular.

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. Hartung (1994) reported the concentration of airborne microorganisms in layer housing to range from 360 to 3 781 cfu/l air and Müller (1987) from 17 to 5 860 cfu/l air. In the extensive study carried out by Seedorf et al. (1998), total airborne microorganism concentration in animal housing, expressed as a logarithm, was about 9.5 log cfu/h per 500 kg body weight (b.w.) in broiler houses. The emission of Enterobacteriaceae was much lower, with the highest concentration measured in layer housing

(7.1 log cfu/h per 500 kg b.w.). The emission of fungi was about 7.7 log cfu/h per 500 kg b.w. in broiler housing. Accordingly, airborne dust and other particulates pose a health risk for both humans and animals. Literature data show the highest concentrations of airborne dust, endotoxins and microorganisms to be emitted by poultry.

Ammonia volatilization greatly contributes to environmental contamination. Therefore, considerable efforts have been invested to reduce the formation of ammonia by the use of either feed or faeces additives. Moore et al. (1996) and Brewer (1998) concluded that the use of alum reduces ammonia release from poultry litter. The mean concentration of ammonia in poultry housing (with solid floor) ranges from 10 to 20 ppm.

The highest air pollutant concentration is found in houses for intensive broiler breeding. Therefore, the aim of the present study was to determine airborne concentrations of bacteria, fungi, dust and ammonia in poultry housing during six weeks of intensive broiler breeding.

MATERIAL AND METHODS

Measurements were performed in a poultry house on a family farm in northwest Croatia. The poultry house 38.00 × 8.00 m in size, 3.40 m in height, accommodated 5 300 Hobb broilers, 17 birds/m^2. Samples were collected in the poultry biozone during the fattening period, in April and at the beginning of May, at weekly intervals. Broilers were kept on 5–7 cm deep litter (sawdust and wood shavings). The ventilation was provided with 4 inlet and 4 outlet ventilators and 8 side windows 1.00 × 1.20 m in size, heating with a central thermogen, and artificial lighting with 16 regularly distributed bulbs.

Bacterial counts in air samples were determined with a Merck MAS-100 device (Merck KgaA, Darmstadt, Germany) on a commercial nutrient agar (Biolife, Milan, Italy). The medium was incubated for 24 hours in an incubator at 37°C. The grown colonies (cfu/m^3) were counted with an optic mechanical colony counter, and the results were corrected using the respective table and mathematical equation (Anonymous, 1998). The identification of bacterial colonies was performed according to the procedure described by Quinn et al. (1994) and API system (bio-Mérieux, Marcy-l'Etoile, France). The fungi were identified by means of native preparations. Dust was sampled onto filters (Whatman International Ltd., Maidstone, UK) with an SKC pump (SKC Ltd., Blandford Forum, UK). The airflow was 4.0 l/min. Filters were weighed before and after sampling in a controlled laboratory at an air temperature of 22°C and relative humidity of 45% (±5%). Air temperature (°C), relative humidity (%) and airflow rate (m/s) were determined with a TESTO device (Testo Inc., Germany). The concentration of ammonia and carbon dioxide was determined with a Dräger-Multiwarn II device (Dräger, Darmstadt, Germany). All data were analyzed by Microsoft Excel and Statistica 6 software, including descriptive statistics and determination of statistical significance at the 5% level (Student's *t*-test, $P < 0.05$) (Anonymous, 1994; Petz, 2001).

RESULTS AND DISCUSSION

Air hygiene is an important factor to be considered in intensive poultry breeding as it has considerable impacts on the health of both animals and humans working in this industry. The air in animal facilities can be a reservoir of primary and

Table 1. Mean levels of total bacterial count, fungi count, dust concentration and microclimate parameters in the poultry house air during a 6-week fattening period

Parameter	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
Bacteria (cfu/m^3)	1.7×10^4	1.6×10^5	9.0×10^4	8.7×10^4	2.2×10^5	1.8×10^5
Fungi (cfu/m^3)	3.0×10^4	8.5×10^4	3.8×10^4	2.3×10^4	2.2×10^4	9.8×10^3
Dust (mg/m^3)	1.80	4.30	4.80	2.60	3.60	2.00
Temperature (°C)	30.14	26.84	25.76	23.67	22.92	20.57
Rel. humidity (%)	48.78	57.22	63.16	52.20	62.00	63.74
Airflow rate (m/s)	0.09	0.13	0.07	0.07	0.09	0.1
NH_3 (ppm)	4.00	6.11	26.22	8.67	27.47	12.44
CO_2 (%)	0.31	0.30	0.22	0.07	0.13	0.07

Table 2. Descriptive statistical analysis of bacteria, fungi, and microclimate factors recorded in the poultry house during a 6-week fattening period

Parameter	Week	*n*	Arithmetic mean	Minimum	Maximum	Variance	SD	SE
Bacteria (cfu/m^3)	1	9	1.66×10^4	9.80×10^3	2.90×10^4	1.16×10^8	1.08×10^4	6.21×10^3
	2	9	1.57×10^5	1.30×10^5	1.90×10^5	9.33×10^8	3.06×10^4	1.76×10^4
	3	9	8.93×10^4	8.10×10^4	9.70×10^4	6.43×10^7	8.02×10^3	4.63×10^3
	4	9	8.70×10^4	8.10×10^4	9.50×10^4	5.20×10^7	7.21×10^3	4.16×10^3
	5	9	2.20×10^5	1.60×10^5	2.80×10^5	3.60×10^9	6.00×10^4	3.46×10^4
	6	9	1.73×10^5	1.60×10^5	1.80×10^5	1.33×10^8	1.15×10^4	6.67×10^3
Fungi (cfu/m^3)	1	9	3.00×10^4	2.80×10^4	3.30×10^4	7.00×10^6	2.65×10^3	1.53×10^3
	2	9	8.50×10^4	7.70×10^4	9.40×10^4	7.30×10^7	8.54×10^3	4.93×10^3
	3	9	3.80×10^4	3.10×10^4	4.80×10^4	7.90×10^7	8.89×10^3	5.13×10^3
	4	9	2.33×10^4	2.30×10^4	2.40×10^4	3.33×10^5	5.77×10^2	3.33×10^2
	5	9	2.20×10^4	1.60×10^4	2.60×10^4	2.80×10^7	5.29×10^3	3.06×10^3
	6	9	9.63×10^3	1.20×10^3	2.30×10^4	1.37×10^8	1.17×10^4	6.76×10^3
Microclimate	Temperature (°C)	6	24.90	20.57	29.58	10.07	3.17	1.30
	Humidity (%)	6	57.84	48.71	63.74	39.19	6.26	2.56
	Airflow (m/s)	6	0.10	0.07	0.13	0.00	0.02	0.01
	NH_3 (ppm)	6	14.15	4.00	27.47	104.75	10.23	4.18
	CO_2 (%)	6	0.19	0.07	0.32	0.01	0.11	0.05
	Lighting (lx)	6	21.19	18.78	24.00	4.71	2.17	0.89

SD = standard deviation; SE = standard error of mean

potentially pathogenic microorganisms involved in the aetiology of infectious and allergic diseases (Wathes, 1994).

Many authors have assessed the content of air pollution on poultry farms and its effect on poultry health and productivity. Vučemilo et al. (2006) found the concentration of airborne microorganisms in a poultry house to rise with poultry age, ranging from 3.22×10^3 cfu/m^3 air in the first week to 6.40×10^7 cfu/m^3 air in the fifth week of intensive breeding. The air level of ammonia was 14.8 ppm in the fifth week of fattening. Similar values of airborne microbiological contamination in the facilities of intensive poultry breeding were also reported in an earlier study (Vučemilo et al., 2005).

The results of the present study revealed the air concentration of almost all pollutants to rise with poultry age and body weight (Tables 1 and 2). The highest bacterial concentration of 2.2×10^5 cfu/m^3 air was measured in fattening week 5, and it declined to 1.8×10^5 cfu/m^3 air in week 6. A significant increase in the bacterial count was recorded between week 1 and week 2, as demonstrated by *t*-test yielding statistical significance at a level of $P < 0.05$ (Table 3). The predominant genera were *Staphylococcus, Streptococcus, Micrococcus* and *Bacillus*, whereas *Escherichia coli* and Enterobacteriaceae prevailed among the gram-negative bacteria.

The contamination by airborne fungi reached the highest level of 8.5×10^4 cfu/m^3 air between fattening week 1 and week 2, as demonstrated by *t*-test yielding statistical significance at a level of $P < 0.05$ (Table 3). This peak contamination was followed by an abrupt decline, as indicated by *t*-test at a level of statistical significance of $P < 0.05$, to be lowest at the end of the fattening period (9.8×10^3 cfu/m^3 air). The predominant genera were *Penicillium* and *Aspergillus*.

The dust concentration in the air of poultry house increased with poultry age up to week 3, when it reached the highest level of 4.8 mg/m^3 air, the difference being statistically significant ($P < 0.05$) (Table 3), followed by a statistically significant decrease in week 4 ($P < 0.05$), it rose again in week 5 and declined to 2.0 mg/m^3 air in week 6 ($P < 0.05$). This decrease in the airborne dust concentration could be explained by the increased litter humidity and poultry weight gain resulting in limited animal

Table 3. The *t*-test for dependent variables at $P < 0.05$

Parameter		*n*	*t*	*P*
Bacteria (cfu/m^3)	1 week–2 week	9	–6.98	0.02
	2 week–3 week	9	3.03	0.09
	3 week–4 week	9	0.62	0.60
	4 week–5 week	9	–3.53	0.07
	5 week–6 week	9	1.15	0.37
Fungi (cfu/m^3)	1 week–2 week	9	–9.04	0.01
	2 week–3 week	9	4.76	0.04
	3 week–4 week	9	2.80	0.11
	4 week–5 week	9	0.45	0.70
	5 week–6 week	9	2.54	0.13
Dust (mg/m^3)	1 week–2 week	6	–749.00	0.00
	2 week–3 week	6	–74.00	0.00
	3 week–4 week	6	329.00	0.00
	4 week–5 week	6	–299.00	0.00
	5 week–6 week	6	479.00	0.00

mobility and lower dust emission to the environment.

The airborne dust and microorganism concentration as well as the bacterial and fungi genera detected in the present study were consistent with literature data (Hartung, 1994; Seedorf et al., 1998; Baykov and Stoyanov, 1999; Szejniuk and Kuczek, 2000; Radon et al., 2002; Bakutis et al., 2004).

The factors influencing the airborne dust concentration include poultry age, litter, and the level of poultry activity. Litter is a major factor because the population of microorganisms varies depending on the dynamics of litter exchange.

In our study, the air concentration of ammonia was lowest in week 1 (4.00 ppm) as expected because the poultry were placed onto new litter. The air concentration of ammonia increased significantly in week 3 and week 5 (26.22 and 27.47 ppm, respectively), which could be associated with the increase in animal age and air humidity.

The concentration of airborne dust and fungi declined towards the end of fattening period, which was attributed to the decreased animal activity and increased litter humidity reducing pollutant emission to the environment. Similar conclusions were also reported by Saleh et al. (2005) investigating the effect of fattening poultry age and season on the bioaerosol concentration in poultry houses. They found the concentration of bioaerosol to be the highest in these facilities.

CONCLUSION

The airborne pollutant concentration in poultry houses increased with poultry age. However, the high concentration of some studied pollutants did not persist by the end of fattening period but it declined to the initial levels or even below them in weeks 5 and 6, e.g. total dust and fungi. The air concentration of bacteria and ammonia showed a sinusoidal rise to reach the peak in week 5 of the fattening period. Almost all studied pollutants showed a relatively high air concentration in the mid-fattening period. This study was carried out as a continuation of previous studies of airborne contamination in poultry houses, contributing to the understanding of the level and composition of air pollutants.

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