Polish J. of Environ. Stud. Vol. 19, No. 5 (2010), 1045-1050

Original Research

Microbial Air Contamination in Poultry Houses in the Summer and Winter

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Received: 6 October 2009
Accepted: 9 March 2010

Abstract

The aim of the present study was to evaluate the degree of microbial air contamination in three laboratory rooms designed for raising broiler chickens under identical conditions, in the summer and winter. It was found that in identical poultry houses and under identical management conditions, certain differences can be observed with regard to temperature and humidity parameters and the degree of microbial air contamination, both in the summer and winter. The concentrations of aerobic mesophilic bacteria and fungi were higher in the winter than in the summer in all rooms. Various levels of microbial air contamination had no effect on broiler production results.

Keywords: airborne bacteria, poultry houses, broiler

Introduction

In intensive production systems, stocking density in poultry houses is very high, thus making it difficult to maintain optimal microclimate and sanitary conditions. The health status of both birds and personnel is affected by air microflora. High temperature, humidity, and particulate pollution levels in poultry buildings (observed in particular in litter rearing) support the growth and development of microorganisms [1-4]. Herbut et al. [5], Kluczek et al. [6], and Sikorska [7] analyzed microbial air contamination in poultry houses and found that the main source of microbes is birds, followed by feed, litter, and droppings, and that microbial counts are affected primarily by the efficiency of a ventilation system and air dustiness.

Many authors [3, 8] share the opinion that the maximum permissible level of microbial air contamination in poultry houses is 250,000 microbes per m^3. According to Krzysztofik [9], the concentrations of airborne bacteria and fungi in poultry buildings must not exceed 100,000 CFU/m^3 and 2,000 CFU/m^3, respectively. Based on the current proposals put forth by a team of experts of the Interdepartmental Commission for Maximum Admissible Concentrations and Intensities for Agents Harmful to Health [10], the maximum admissible concentrations of mesophilic bacteria and fungi in the working environment are 100,000 CFU/m^3 and 50,000 CFU/m^3, respectively. However, as shown by the results of numerous studies [1, 2, 11-14], the total concentrations of bacteria and fungi in poultry houses are substantially higher and may reach even 26.7 mln microbes per m^3 of air, depending on the management system [8]. Exposure to high levels of microbiological air pollution poses a huge threat to human and animal health as well as to the natural environment surrounding poultry farms [2, 10, 14-16].

Laboratory rooms designed for chicken rearing have to meet the standards set for commercial broiler houses. If research results are to be reliable and comparable with the actual conditions of large-scale poultry farming, identical house microclimate parameters should be ensured.

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Therefore, the aim of the present study was to evaluate the degree of microbial air contamination in three laboratory rooms designed for raising broiler chickens, in the summer and winter.

Materials and Methods

The study was conducted at the Animal Research Laboratory of the Department of Animal and Environmental Hygiene, Faculty of Animal Bioengineering, University of Warmia and Mazury in Olsztyn, during summer (22 May-29 June) and winter (3 January-7 February). A total of 120 chickens were placed in each of three rooms (each with an area of 9.25 m^2, total capacity of 26.2 m^3, and stocking density of 15 birds per m^2). The experimental rooms were equipped with a mechanical ventilation system with a controlled ventilation rate. The birds were kept on straw litter. House microclimate parameters and environmental conditions were monitored in accordance with the methodology of animal hygiene studies [8]. Air temperature and relative humidity were measured with an Infrared Psychrometer AZ -8857, and cooling rates were measured with Hill's dry katathermometer twice a week at 7:00, 13:00, and 21:00.

Microbial air contamination was determined by the sedimentation method, using Petri dishes. Air sampling was performed in each room, at three sites indoors and one site outdoors, twice a week at 7:00, 13:00, and 21:00. A total of 108 air samples were collected in each room. The airborne bacteria collected on agar medium (the total counts of aerobic mesophilic bacteria, PN-EN ISO 4833:2004) were incubated at 37ºC for 1 day, and airborne fungi were incubated on Sabourad's medium (PN-ISO 7954:1999) at 25ºC for 5 days. The number of microbial colonies on plates was determined with a Colony Star counter. The concentrations of mesophilic bacteria and fungi per m^3 of air (CFU/m^3) were calculated using Omelianski's formula [9].

The data concerning house microclimate parameters and microbial contamination levels were verified statistically by a one-factor analysis of variance. The statistical analysis of data involved the determination of arithmetic means ($\bar{x}$). The significance of differences between the mean values of the investigated parameters was determined by Duncan's test. Calculations were performed using Statistica 8.0 PL software.

Results and Discussion

In the summer, temperature in the investigated poultry rooms ranged from 15.3 to 23.6ºC, relative humidity from 44.83 to 67.23% and air cooling rates from 0.399 to 1.166 m/s (Table 1). Although broiler chickens were placed in three identical laboratory rooms, certain differences in microclimate parameters were noted between them from the very beginning of the experiment. Over the entire rearing period, mean daily temperature in room 1 (22.9ºC) was significantly lower than in room 3 (24.5ºC, P<0.01) and slightly lower than in room 2 (23.7ºC). Relative humidity in room 1 (66.91%) was significantly higher than in room 3 (58.92%, P<0.01) and room 2 (60.70%, P<0.05). The experimental rooms differed also with regard to air cooling rates. The highest cooling rate was noted in room 3 (0.171 m/s vs. 0.083 m/s in room 1, P<0.05). An analysis of indoor microclimate conditions suggests that broiler chickens could be exposed to heat stress, particularly toward the end of the experiment when indoor temperatures exceeded the level of 18-20ºC set forth in the Regulation of the Minister of Agriculture and Rural Development of 2 September 2003 specifying the minimum welfare standards for farm animals (Journal of Laws 2003, No. 167, item 1629 as amended).

During the summer season, the permissible limits of bacterial aerosol concentrations were exceeded in the second week of broiler rearing in all experimental rooms (Table 2). The concentrations of airborne bacteria in room 1 (633,666 CFU/m^3) were significantly higher than in room

Table 1. Average values of microclimate parameters in the summer.

Microclimate parameters	Weeks of the study	Outdoor	Room 1	Room 2	Room 3
Temperature (ºC)	1	15.3	23.3	24.5	25.1
	2	17.2	22.1	22.6	23.2
	3	13.9	20.6^{b}	22.0	23.0^{a}
	4	22.2	24.6	25.5	25.8
	5	23.6	24.7^{b}	25.5	26.2^{a}
	6	19.9	22.3	22.7	23.8
	1-6	**19.0**	**22.9^{B}**	**23.7**	**24.5^{A}**
Relative humidity (%)	1	44.83	43.58	46.28	41.28
	2	49.11	68.75^{Aa}	62.69^{b}	58.68^{B}
	3	46.31	67.00	61.79	58.63
	4	45.60	58.36	49.64	49.59
	5	67.23	78.73	72.93	69.24
	6	61.55	73.39	63.66	67.24
	1-6	**53.13**	**66.91^{Aa}**	**60.70^{b}**	**58.92^{B}**
Air movement (m/s)	1	0.785	0.009	0.005	0.007
	2	1.166	0.005	0.003	0.009
	3	1.184	0.007	0.013	0.035
	4	0.541	0.099	0.172	0.148
	5	0.399	0.073	0.231	0.257
	6	0.408	0.268	0.424	0.491
	1-6	**0.769**	**0.083^{b}**	**0.154**	**0.171^{a}**

Values denoted by different letters are significantly different:
^{A,B}– at a level of P<0.01
^{a,b} – at a level of P<0.05

Table 2. Concentrations of airborne bacteria in the summer (CFU/m³).

Weeks of the study	Outdoor	Room 1	Room 2	Room 3
1	786	93,576	121,884	98,556
2	2,359	633,666[a]	324,500[b]	544,022
3	16,513	970,748[a]	949,123[a]	691,201[b]
4	9,436	994,076	912,034	699,457
5	26,736	1,045,320	940,998	1,539,409
6	7,077	582,685	651,097	486,750
1-6	**11,366**	**752,437**	**697,944**	**729,112**

Values denoted by different letters are significantly different: [a,b] – at a level of P<0.05

Table 3. Fungal air concentrations in the summer (CFU/m³).

Weeks of the study	Outdoor	Room 1	Room 2	Room 3
1	6,291	114,021[A]	70,771[B]	35,910[C]
2	3,932	77,717	99,342	153,862
3	15,334	229,221	179,288	175,356
4	21,625	154,649	133,679	207,596
5	11,009	139,708	87,023	122,146
6	11,795	642,447	505,622	529,213
1-6	**12,152**	**232,538**	**189,152**	**219,296**

Values denoted by different letters are significantly different: [A,B,C] – at a level of P < 0.01

2 (324,500 CFU/m³ (P<0.05) and slightly higher than in room 3 (544,022 CFU/m³). Such a high number of culturable bacterial colony-forming units may result from the increase in relative air humidity (Table 1) noted in all rooms (68.77%, 62.69%, and 58.68% in rooms 1, 2, and 3, respectively), compared with the values of air humidity in the first week of the study (43.58%, 46.28%, and 41.28%, respectively). The high relative air humidity reported from the second week until the end of rearing, accompanied by a high temperature of 20.6-26.2ºC, supported the growth of bacterial (Table 2) and fungal (Table 3) microflora in successive weeks of the experiment. Statistically significant differences in the concentrations of airborne bacteria were also observed in the third week, between room 3 (691,201 CFU/m³, P<0.05) and room 1 (970,748 CFU/m³) and room 2 (949,123 CFU/m³). The highest concentrations of airborne bacteria in the investigated indoor environments were noted in the fifth week (1,539,409 CFU/m³ in room 3, 1,045,320 CFU/m³ in room 1 and 940,998 CFU/m³ in room 2). Higher air cooling rates in the sixth week of the experiment (0.268 m/s, 0.424 m/s, and 0.491 m/s in room 1, 2 and 3 respectively) contributed to a decrease in bacterial aerosol concentrations to 582,685 CFU/m³ in room 1,651,097 CFU/m³ in room 2, and 486,750 CFU/m³ in room 3. A similar trend was reported by Vučemilo et al. [14]. In their study, the concentrations of airborne bacteria in broiler houses reached the highest level in the fifth week of rearing, and they dropped in the last week of the experiment. In a study of broiler chickens conducted by Mituniewicz et al. [11], the counts of airborne bacteria increased in the third week, and remained at a high level until the end of the rearing period.

As regards fungal air contamination in the investigated rooms, significant differences (P<0.01) were found only in the first week of rearing (Table 3). The increase in fungal aerosol concentrations observed until week 3 (rooms 1 and 2) and week 4 (room 3) was followed by a decrease in week 5 of the experiment. In week 6, fungal counts increased fivefold in all rooms, to the level of 505,622 to 642,447 CFU/m³. The opposite trend was reported by Vučemilo et al. [14] who noted the lowest fungal concentrations (9.8×10^3 CFU/m³) in the last week of broiler rearing. The high number of fungal colonies isolated in week 4 of the present study was still threefold lower than that reported by Mituniewicz et al. [12] – $1.56\text{x}10^6$ CFU/m³.

In the winter, temperature in the analyzed poultry houses ranged from -5.6 to 4.9ºC, relative humidity – from 68.38 to 94.79% and air cooling rates – from 0.146 to 2.8 m/s (Table 4). Mean air temperature in the investigated rooms remained at a similar level of 24.6 to 24.9ºC throughout the experiment. The lowest relative air humidity was noted in room 3 (34.91%, P<0.01), in comparison with rooms 1 and 2 (41.97% and 39.04%, respectively). The recorded values were approximately 20% lower than in the summer, due to the use of additional heating in the winter. Over the entire rearing period, the highest air cooling rate was determined in room 3 – 0.110 m/s. This value was significantly higher than the average cooling rate recorded in room 1 (0.057 m/s, P<0.01) and significantly higher than the average cooling rate noted in room 2 (0.072 m/s, P<0.05).

Similarly as during summer, also in the winter the maximum allowable microbial contamination levels were exceeded in the analyzed poultry houses. In the winter season, the concentrations of airborne aerobic mesophilic bacteria increased steadily during the rearing period, reaching a maximum in room 1 (2,123,142 CFU/m³) and room 2 (2,689,314 CFU/m³) in week 5 (Table 5). In room 3 bacterial counts increased until the sixth of rearing, to a level of 1,915,546 CFU/m³. Over the entire experiment, room 3 was characterized by the lowest concentrations of airborne bacteria (767,921 CFU/m³), compared with room 2 (1,273,263 CFU/m³, P<0.05) and room 1 (1,018,617 CFU/m³). A rapid increase in bacterial air contamination in broiler houses in the fourth and fifth week of rearing was also reported by Szejniuk and Kluczek [3], and Baykov and Stoyanov [17].

During the entire rearing period, the highest fungal aerosol concentrations were noted in room 2 (416,142 CFU/m³, P<0.05), compared with room 1 (272,863

Table 4. Average values of microclimate parameters in the winter.

Microclimate parameters	Weeks of the study	Outdoor	Room 1	Room 2	Room 3
Temperature (ºC)	1	4.9	27.8	28.5	27.3
	2	4.6	25.5^{b}	27.0^{a}	26.5^{a}
	3	4.5	25.6	26.2	25.6
	4	-5.6	24.6^{a}	24.3	23.3^{b}
	5	1.3	21.5^{Ba}	21.0^{Bb}	22.4^{A}
	6	-2.7	20.5^{a}	19.6^{Bb}	$21.5A^{b}$
	1-6	**1.5**	**24.6**	**24.9**	**24.7**
Relative humidity (%)	1	68.38	34.29^{a}	32.74	29.99^{b}
	2	71.63	37.85^{A}	35.54^{a}	30.79^{Bb}
	3	80.75	50.05^{A}	48.08^{a}	42.95^{Bb}
	4	85.20	39.73^{A}	37.50^{a}	30.41^{Bb}
	5	94.79	46.63^{A}	41.56^{B}	39.20^{B}
	6	89.23	44.63^{A}	38.58^{B}	37.30^{B}
	1-6	**80.97**	**41.97^{Aa}**	**39.04^{Ab}**	**34.91^{B}**
Air movement (m/s)	1	1.784	0.012^{b}	0.024^{Aa}	0.004^{B}
	2	2.723	0.030^{a}	0.019^{b}	0.028
	3	1.942	0.071	0.049	0.059
	4	0.146	0.098	0.102	0.149
	5	2.183	0.064^{C}	0.119^{B}	0.217^{A}
	6	2.800	0.077^{C}	0.162^{B}	0.293^{A}
	1-6	**1.850**	**0.057^{B}**	**0.072^{b}**	**0.110^{Aa}**

Values denoted by different letters are significantly different:
^{A,B,C} – at a level of P<0.01
^{a,b} – at a level of P<0.05

Table 5. The concentrations of airborne bacteria in the winter (CFU/m^3).

Weeks of the study	Outdoor	Room 1	Room 2	Room 3
1	1,573	124,872	108,831	77,062
2	5,504	126,799	189,707	364,080
3	786	351,184	451,364	391,445
4	3,145	1 576,472^{a}	1,486,200^{a}	817,488^{b}
5	9 436	2,123,142	2,689,314^{a}	1,108,752^{b}
6	0	1,349,375	2,557,207	1,915,546
1-6	**3,932**	**1,018,617**	**1,273,263^{a}**	**767,921^{b}**

Values denoted by different letters are significantly different:
^{a,b} – at a level of P<0.05

CFU/m^3) and room 3 (251,533 CFU/m^3) (Table 6). As in the summer, also in the winter the number of fungal colonies increased steadily until week 5 in room 1 (424,629 CFU/m^3) and room 2 (811,512 CFU/m^3), and it remained at a high level to the end of the study in room 3 (507,195 CFU/m^3). The lowest counts of airborne bacteria and fungi recorded in the winter in room 3 could be due to the lowest relative humidity (34.91%) and the highest cooling rates (0.110 m/s) in this room, in comparison with the remaining two.

As demonstrated by Karwowska [1], fungi of the genera *Asperillus* sp., *Penicillium* sp., *Cladosporium* sp., and *Alternaria* sp. are most commonly encountered in poultry houses. In the present study, the following genera were isolated most frequently: *Fusarium* sp., *Aspergillus* sp., *Penicillium* sp., *Geotrichum* sp., and *Scopulariopsis* sp. as well as, in substantially lower numbers, *Alternaria* sp., *Botrytis* sp., *Rhizophus* sp., *Rhizomucor* sp., and *Mucor* sp. Greater diversity of fungal flora was observed in the summer than in the winter. This most probably resulted from higher relative humidity levels during summer, which – accompanied by high temperatures (22.9-24.5ºC) – provided favorable conditions for microbial growth. A similar tendency was also observed by Mituniewicz et al. [12].

The production results of broiler chickens (Table 7) were comparable in all experimental rooms. However, in week 6 of the rearing period birds from room 3 were characterized by somewhat higher body weights, both in the summer (2,869 g) and in the winter (2,783 g), in comparison with chickens kept in rooms 1 and 2.

As shown by literature data, microbial air contamination levels in poultry houses vary widely [12, 14, 17, 18]. According to the cited authors, indoor air pollution in broiler farms is affected by a variety of factors, including production scale, stocking density, the age of birds and fattening stage. The results of the present study indicate that in identical poultry houses and under identical management conditions, certain differences can be observed with regard to temperature and humidity parameters and the degree of

Table 6. Fungal air concentrations in the winter (CFU/m^3).

Weeks of the study	Outdoor	Room 1	Room 2	Room 3
1	0	48,439	86,184	74,231
2	5,504	69,592^{b}	112,841	232,759^{a}
3	3,145	325,863	320,673	142,015
4	7,864	318,943	436,581	222,065
5	9,436	424,629^{b}	811,512^{a}	385,940^{b}
6	18,872	320,830	590,705	507,195
1-6	**7,077**	**272,863^{b}**	**416,142^{a}**	**251,533^{b}**

Values denoted by different letters are significantly different:
^{a,b} – at a level of P<0.05

Table 7. Broiler production results.

Specification		Room 1	Room 2	Room 3
Summer	Body weight 0-6 weeks (g)	2,829	2,842	2,869
	Feed intake per 1kg body weight gain (kg)	1.99	1.91	1.92
	Mortality (birds)	6	10	4
	Culling (birds)	5	1	2
Winter	Body weight 0-6 weeks (g)	2,741	2,723	2,783
	Feed intake per 1kg body weight gain (kg)	1.78	1.75	1.89
	Mortality (birds)	4	7	8
	Culling (birds)	2	2	3

microbial air contamination, both in the summer and winter. An analysis of microbial air contamination in poultry houses in the summer and winter revealed higher concentrations of aerobic mesophilic bacteria and fungi in the winter. This is consistent with the findings of Bakutis et al. [19], who also reported a faster growth rate of airborne bacteria in poultry buildings in the winter months. In the present study, bacterial air contamination determined for the entire experiment was higher in the winter than in the summer, by approximately 35% in room 1 and by around 85% in room 2. The degree of fungal contamination in winter and summer months was comparable in rooms 1 and 3, while in room 2 fungal concentrations increased by approximately 120% through winter. The most stable and uniform microclimate conditions were observed in room 3.

Conclusions

The results of the present study indicate that in identical poultry houses and under identical management conditions, certain differences can be observed with regard to temperature and humidity parameters and the degree of microbial air contamination, both in the summer and winter. The concentrations of aerobic mesophilic bacteria and fungi were higher in the winter than in the summer in all rooms. Various levels of microbial air contamination had no effect on broiler production results.

Acknowledgements

This work was supported by the Polish Ministry of Science and Higher Education within the framework of grant No. 2P06Z 048 29 (2005-07).

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