POLLUTION OF INDOOR ENVIRONMENT IN POULTRY HOUSING

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Abstract. The paper describes the influence of the technology and technological equipment on the indoor environmental conditions inside the buildings for poultry housing. The microclimatic conditions were controlled during the long time experiment provided by the interdisciplinary research group of the Czech University of Life Sciences Prague during the recent years. Two sections of the experimental building for housing of domestic animals were equipped by different technological equipment for laying hens. The aim of this paper is to present the results of the parameters, which represent the main factors of pollution of indoor environment during the winter period. The aerosol microclimate (dust sedimentation method), main noxious gases (carbon dioxide and ammonia) and microbiological contamination (fungi and bacteria) of the air were measured and evaluated. The results of the long-term measurement demonstrate that the most difficult situation from the point of view of indoor pollution during the winter was in boxes of the section equipped with the floor housing technology.

Keywords: hens, pollution, dust, gases, microbiology.

Introduction

Many different housing systems are used worldwide for layers. The most common housing system used on the large commercial farms in the Czech Republic was accommodation in the compact battery cages. To meet the rules of the Council Directive [1], the standard of these housing systems was changed during the last years and many new technological systems with different equipment have been introduced to keep layers in non-cage systems or enriched cages. The attention to the problems of production and quality of eggs in relation to the housing technology has been paid by the scientists during the previous research [2 – 4].

This paper describes the influence of the technology and technological equipment on the indoor environmental conditions inside the buildings for poultry housing. The microclimatic conditions were controlled during the long time experiment provided by the interdisciplinary research group of the Czech University of Life Sciences Prague during the recent years.

The influence of the housing technology on the indoor microclimate is more obvious during the winter period, as the ventilation rate is in minimum level, which enables to compare and evaluate both different housing systems.

Materials and methods

Two sections of the experimental building for housing of domestic animals were equipped by different technological equipment. The first section was equipped by the three tiers battery of traditional cages with housing of 72 laying hens, and the second one (60 laying hens) by the typical floor housing technology on deep litter, corresponding with the alternative technology with nests etc. Besides the main production parameters (egg production, feed consumption, losses of hens, quality and properties of the eggs etc.) also all main microclimatic parameters (temperature, humidity etc.) were measured.

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The temperatures and humidity of the air were measured by thermocouples and capacitive humidity sensors FHA 646, noxious gases by sensors: carbon dioxide sensor FYA 600 based on infrared optics and ammonia sensor ADOS 592 NH3. The measuring instruments Therm 2590-9 and Therm 5990-2 logged all measured parameters.

The dust contamination was measured and evaluated by a special gravimetric sedimentation method. The use of the traditional dust concentration method (e.g., gravimetric filtration, conimetric, light-dust monitoring, real-time particles counting and analysis, or another similar method) was not suitable for this case of the research (changes of concentration according to the different activities inside the sections during the days, movement of disturbed laying hens etc.); therefore, the 10 special small bowls (diameter 110 mm) were installed in each section in 2 m level for collection of dust above the living area of hens during 36 days period. The weight of dust (after standard drying) was measured by the precise weighing instrument KERN 440-35N.

The microbiological analyse was provided in laboratory by samples from 0.021 m^3 air, collected by the instrument Aeroscop MERC, cultivated by PDA (potato-dextrose agar OXOID CM 139; 100 %) and NA (nutrient agar OXOID CM 003; 100 %).

Results and discussion

The temperature and humidity sensors were installed near to the level of the housed hens; there were three sensors in the case of the section equipped by the compact battery, one per each floor level (t_1 and rh_1 in 1st tier, t_2 and rh_2 in 2nd tier, t_3 and rh_3 in 3rd tier; and three sensors in the case of compact battery in the section with the floor housing technology, one per each part of box (t_1 and rh_1 near window, t_2 and rh_2 centre, t_3 and rh_3 near door). The results are in Tables 1 – 4, compared with the outside temperature t_e and humidity rh_e.

Table 1

Temperature in the section with housing in cages

Value	t_e, ºC	t_1, ºC	t_2, ºC	t_3, ºC
Minimum	-10.6	11.7	13.4	14.4
Maximum	2.1	20.6	21.8	22.0
Average	-2.4	17.8	19.3	19.8
Standard deviation	2.3	1.7	1.6	1.3

Table 2

Temperature in the section with housing in boxes

Value	t_e, ºC	t_1, ºC	t_2, ºC	t_3, ºC
Minimum	-10.6	11.3	11.6	11.4
Maximum	2.1	20.2	20.0	19.2
Average	-2.4	17.3	17.2	16.6
Standard deviation	2.3	1.3	1.2	1.1

Table 3

Relative humidity in the section with housing in cages

Value	rh_e, %	rh_1, %	rh_2, %	rh_3, %
Minimum	64.8	35.6	33.9	35.3
Maximum	96.4	57.1	53.1	50.6
Average	86.2	46.8	43.5	43.7
Standard deviation	5.7	2.5	2.1	1.8

Table 4

Relative humidity in the section with housing in boxes

Value	rh_e, %	rh_1, %	rh_2, %	rh_3, %
Minimum	64.8	50.2	51.4	50.3
Maximum	96.4	73.2	77.7	77.7
Average	86.2	62.1	65.4	66.5
Standard deviation	5.7	3.7	5.2	5.2

The results of the measured temperatures (Tables 1, 2) in winter confirm that the conditions in both sections were approximately similar from the point of view of average temperature during the period of the experiment. The higher temperature in the battery of cages was thanks to the bigger distance from the floor. The higher relative humidity (Tables 3, 4) in the section with housing in the boxes on the floor has relation to the high humidity of deep litter, which creates the conditions for an increased number of bacteria and other microbiological contaminants. The influence of the housing technology with the floor covered by deep litter on the indoor humidity and hygienic problems is described in [5].

Table 5

Concentration of CO_2 and NH_3

Value	CO_2, %		NH_3, ppm	
	Cages	**Boxes**	**Cages**	**Boxes**
Minimum	0.034	0.035	1.2	3.3
Maximum	0.150	0.287	5.9	15.1
Average	0.099	0.144	4.2	9.0
Standard deviation	0.021	0.050	0.7	1.7

The concentration of carbon dioxide and ammonia (Table 5) were in both cases higher in the section with housing in the boxes on the floor. The difference is bigger in the case of ammonia, which has relation to the floor with deep litter. It has been shown in several investigations that the floor housing systems for laying hens create higher concentrations of ammonia than the cage housing systems with frequent manure removal [5; 6].

A similar situation was described also in the publication [7] focused on evaluation of the quality of the indoor air in houses for laying hens testing different materials of litter and methods of ammonia reduction. The importance of intensive ventilation is emphasized.

Table 6

Sedimentation of dust

Value	Dust, $g \cdot m^{-2} \cdot d^{-1}$	
	Cages	**Boxes**
Minimum	0.117	1.228
Maximum	1.667	15.117
Average	0.582	7.862
Standard deviation	0.347	3.650

The continuous dust measurement by the sedimentation method very obviously approved the problems of aerosols influencing the indoor air quality. The dust concentration (Table 6) was according to our results approximately thirteen times higher in the section with housing in the boxes on the floor, than in the section with cages.

Table 7

Microbiological contamination

Value	Fungi, m^{-3}		Bacteria, m^{-3}	
	Cages	**Boxes**	**Cages**	**Boxes**
Minimum	23 571	28 810	104 762	125 714
Maximum	49 762	70 714	138 810	272 381
Average	32 476	56 571	116 810	194 333
Standard deviation	8591	14876	14457	34152

Similar importance and conclusions can be based also on the microbiological contamination. The suitable microbiological climate was exceeded in both sections. The results are presented in Table 7. The higher concentration of fungi (mainly *Cladosporium*, *Penicillium*, yeast cells) and also of bacteria (the most important were *Bacillus*, *Bc. mycoides*, *Actinomicetes*) occurred in the section with housing in the boxes on the floor.

Conclusions

The obtained results from the experiments increased the knowledge about microclimatic conditions in the buildings for housing of laying hens. The new legislation supposes modern technological equipment in these farms. Especially the use of alternative (non-cages) housing systems corresponding with the EU standards requires intensive ventilation during the whole year to avoid hygienic problems inside the buildings. Currently, many farms which were modernized and newly equipped still use the old equipment of ventilation. The results of this research confirm that it is necessary to modernize also the ventilation system. The optimization of noxious gases, aerosol and microbiological microclimate together with the other parameters of the indoor microclimate forms the suitable breeding conditions, which can result in better performance of hens and more efficient egg production.

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