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Concentration of Noxious Gases in Alternative Layer Housing Systems

Ammonia and carbon dioxide concentrations in the house air of two storey aviary housing systems for laying hens, with access to an outdoor area, were measured. The values varied widely daily, as well as monthly, whereby with extended hen life-time, increased concentrations in the stable air were observed. After opening the flaps to the outdoor area the value of ammonia and CO_2 rose significantly. However, the MAK (maximally allowed concentration of working place) values and recommendations for maximally permissible noxious gas concentrations in animal houses were not exceeded.

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Keywords

Laying hen husbandry, aviary housing systems, noxious gases

With the prohibition of conventional cage-husbandry for laying hens, starting in 2007 in Germany, and the increasing change to alternative husbandry housing systems, the problem of the noxious gas concentrations gains in importance. This is also true for the influences on health and productivity of the animal stock as well as for the emission-problem.

The gas ammonia is important in the laying hen husbandry. A laying hen produces about 170 g fresh excrement daily. Fresh excrement contains from 13 to 17 g/kg nitrogen. Temperatures around 35 °C , a pH value of 9 and a moisture content of 40 to 60% in the substrate offer optimal conditions for the formation and the release of ammonia [1].

In Germany there are no legally binding maximum values for the ammonia concentration in stables of laying hens. The values for the health protection of humans are called MAK (maximal allowed concentration value of working place and biological working material tolerance values). The MAK-value for the eight-hour contact with ammonia is 14 mg/m^3 air and the value for carbon dioxide is 9200 mg/ m^3 air. However, for the laying hens it should be noted that they are permanently exposed to the stable air and that through the material variety additional and cumulative effects are likely [2].

High ammonia concentrations in stable air can become a risk factor at longer time of reaction. They provoke irritations and a resulting damage of the mucous membranes of the respiratory tracts. Damages were ascertained for hens with values from 20 to 25 ppm [3]. If the breathing organs of the laying hens are damaged, Coli infections can occur inreasingly [4]. This can resukt in serious health problems and thus to activity depressions. The feed intake as well as the laying performance decreases and the body's resistance is weakened relatively to the infections, so there are direct economical losses to the producer [5]. Carbon dioxide is considered as an indicator for the quality of stable air and thus to a sufficient ventilation [6]. It reaches the stable air by exhaling and by microbial decomposing processes in excrements. High concentrations of carbon dioxide can lead to a decreased feed intake, and increased breathing and heart rate and in extreme cases to death [7].

After starting egg production by a company in former pig stables the following questions arose:

- How high are the noxious gas concentrations in large aviary housing systems?
- Will the MAK values be surpasssed?

In addition it should be determined which effect has the establishment of an outdoor area on the noxious gas concentrations in the internal areas of the stables. Therefore in the investigations the noxious gas concentrations were determined under different conditions (opened/closed flaps) and as a function of the keeping time.

Material and method

The investigations were carried out in two identically constructed old stables, which are equipped with a 2- floor aviary housing system „Natura European Union 2200 "(modified) of the company „Big Dutchman ". In each stable were 10,000 laying hens. In the formerly closed stables a ventilation system under partial vacuum was used. Additional - however still before beginning of the investigation- a winter garden was built and also wind-laterally outlet flaps, to improve the management and the conditions for the laying hens. The laying hens could use the outdoor area from 7:00 to 15:00 o'clock via the outlet flaps. The manure removal of the aviary housing system was done with the ventilated-excrement conveyer once a week. With the multi-gas monitor 1302 by Brüel and Kjaer, on the basis of the photo-acoustic infrared spectrophotometer, the concentrations of ammonia and carbon dioxide were recorded in the months June and October. Every second minute a measured value was registered and stored down automatically in the memory. One measurement usually lasted over 24 hours. The measurements took place in each case with opened and with

closed outlet flaps, in order to determine also the influence of the winter garden on the internal stable area. Apart from the mentioned measurements, the temperature, the relative humidity and the litter dampness was recorded.

Results

The outlet flaps influenced the air movement and the level of ammonia concentration in the stable. The change of the air flow in the stable by the outlet flaps was confirmed in other investigations, too [8].

After opening the outlet flaps (starting from 7:00 o'clock), an increase of the ammonia concentration could be recognised (*Fig. 1*). The increased air movement over the surface of the excrements could have led to an increased release of ammonia. After closing of the outlet flaps (15:00 o'clock) the values dropped again.

The measured values of carbon dioxide showed a similar course.

Table 1 shows the absolute values of ammonia and carbon dioxide as well as for the relative humidity with open outlet flaps.

Figure 2 and *table 2* show a comparison of ammonia concentrations in June and October of stables with closed outlet flaps.

The mean values of the ammonia concentration were in June with 1.89 mg/m^3 clearly lower than those in October with 3.12 mg/m^3. The higher values in October resulted from the rising excrement quantity in the outdoor area connecting with a higher farming duration of hens as well as the higher air humidity and litter dampness by what the ammonia formation is accelerated. Also the values of the carbon dioxide were clearly in October above the levels in June.

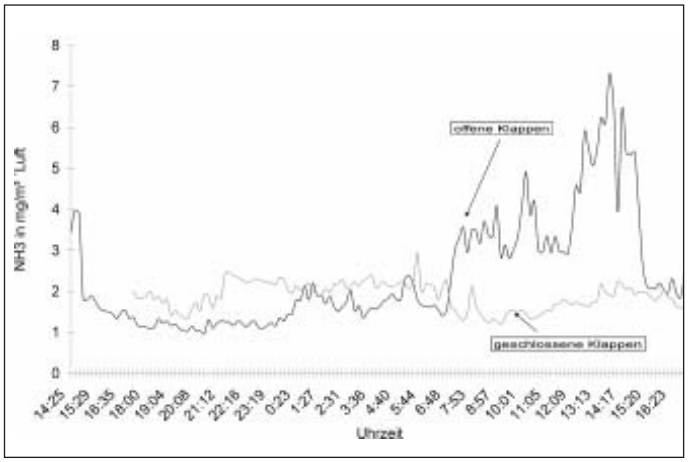

Fig. 1: Course of ammonia concentration (June)

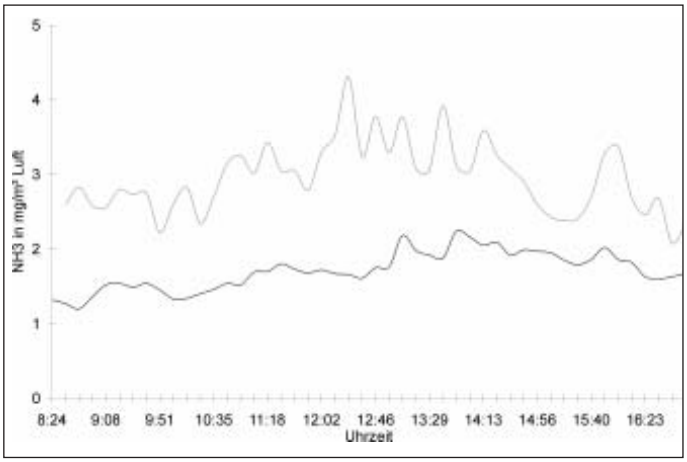

Fig. 2: Course of ammonia concentration (closed outlet flaps)

Results

The investigations show that in large aviary housing systems it is possible not to surpass the MAK values for ammonia and carbon dioxide. The relatively low concentrations can be explained considerably with the insertion of ventilated-excrement conveyer. Because of this the dry substance of the excrement is relatively high, whereby the decomposing rates decreased. However a clear increase of the ammonia concentrations as well as a smaller increase of the carbon dioxide concentrations was determined with the opening of the outlet flaps. Opening the flaps led to a failure of the ventilation system, which was designed for closed stables. The system did not work optimal anymore.

	Ammonia in mg/ m^3	Carbon dioxide in mg/ m^3	Relat. Humidity in %
Average value	2.38	1931	60.0
Minimum	0.97	1080	48.1
Maximum	7.31	2990	73.3

Table 1: Measured data of ammonia, carbon dioxide and relative humidity with opened outlet flaps (June)

	Ammoniak in mg/ m^3		Carbon dioxide in mg/ m^3		Relat. Humidity in %	
	June	October	June	October	June	October
Average value	1.89	3.12	1799	2123	55.1	59.3
Minimum	1.20	2.08	1210	1550	49.0	54.2
Maximum	2.94	4.32	2530	3640	64.3	65.0

Table 2: Measured data of ammonia, carbon dioxide and relative humidity with closed outlet flaps in June and October

Literature

[1] • *Bessei, W., und K. Damme*: Neue Verfahren für die Legehennenhaltung. KTBL-Schrift 378, Landwirtschaftsverlag GmbH, Münster-Hiltrup, 1998

[2] • *Hillinger, H.G.*: Stallgebäude, Stallluft und Lüftung. Enke Verlag, 1990

[3] *Al-Mashhadani, E. H., und M. Beck*: Effect of atmospheric ammonia on the surface ultrastructure of lung and trachea of broiler chicks. Poultry sci. 64 (1985), pp. 2056 - 2061

[4] • *Achilles, W., et al.*: Legehennen in alternativen Haltungsformen - Stand des Wissens. KTBL-Schrift 399, Landwirtschaftverlag GmbH, Münster-Hiltrup, 2002, S. 9 - 43

[5] *Deaton, I. W., et al.*: Effect of atmospheric ammonia on laying hen performance. Poultry science 61 (1982), no.9, pp. 1815 - 1817

[6] • *Tüller, R., und A. Allmendinger*: Geflügelställe: Stallbau, Klima, Einrichtung. Verlag Eugen Ulmer, Stuttgart, 1990

[7] • *Mehlhorn, G.*: Lehrbuch der Tierhygiene. Band 1, Gustav Fischer Verlag, Jena, 1979

[8] *Van den Weghe, S., und H. Van den Weghe*: Der Volierenstall für Legehennen. Landtechnik 55 (2000), H. 5, S. 362