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THE EMISSION FACTORS DETERMINATION AT DIFFERENT BREEDING TECHNOLOGY OF LAYING HENS

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Abstract

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The study deals with emission factor determination at different breeding technology of lying hens. Concentration of ammonia and greenhouse gases were investigated under the laboratory condition for hens breeding of enriched cages, in comparison with conventional breeding technology with exhaust air cross flow (1), technology for layered straw on to dropping belt (2) and technology with exhaust air under the cage's grate (3).

Keywords: enriched cages, greenhouse emission, ammonia, emission factor

INTRODUCTION

Comparing the calculated emission factors can be noted, that with using breeding technology 3, we have achieved a significant improvement in CO_2 (82% compared with the technology 1, resp. and 24% compared with the technology 2). The results also showed significantly better emission factor for N_2O (58% resp. 70%), NH_3 (275% resp. 78%), H_2S (45% resp. 47%) and CH_4 (113% resp. 53%).

According to obtained results the study shows, that the reduction of ammonia and greenhouse gas emissions can be achieved not with using any pollutants reduction substances, but only with changing technology of air exhaust system from monitored houses. After converting the emission factor from selected folder into the relative values, the values of emission factor will not exceed the limit according the Journal ME SR 6/1999 (EF for NH_3 at breeding of laying hens in cages is 0.19 kg. pcs. yr^{-1}).

Demonstrating the impact of ammonia emissions and greenhouse gases for environmental degradation mankind stood in front of new challenges. A high priority becomes protecting the environment and reducing harmful substances. The environmental protection must be part of person's life in twenty-first century. It is known fact that a major producer of ammonia is currently agriculture and livestock. It is simple clear that livestock cannot live without the production of ammonia and greenhouse gas emissions, but it can be reduce to rational level Havliček *et al.* (2007). This is an area to which we would like to focus our research attention.

MATERIAL AND METHODS

The measurements were taken under the laboratory condition at the Department of Production Engineering, Slovak University of

Agriculture in Nitra, with experimental equipment from MBD Nitra, Ltd. was used. The experimental equipment was approved by the State Veterinary and Food Administration with the assigned official permit number SK P 25011.

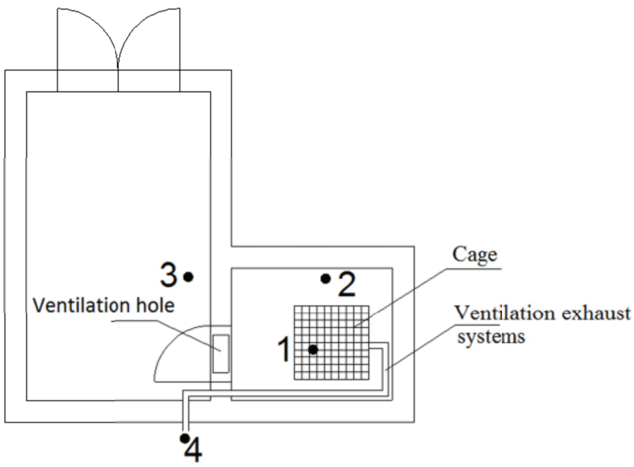
The enriched cage was used for the experiment (Fig. 1). The hall, in which the cage was placed, ensured the possibility of exhausting air cross flow, is conventional technology (hereinafter technology No. 1). Technology No. 2 is characterized by the same, i.e. conventional way of air exhausting, but with layered straw on to dropping belt. By the technology No. 3, the air was directly exhausted under the grate of cage (3). Ten laying hens – hybrid TERA SL were placed into the cages (Slovak Government Regulation Act No. 736/2002 Coll, of 11 December 2002).

The laboratory was equipped with ventilation exhaust systems with one outlet port located over the front door. The air was exhausting through a single exhaust fan placed on the opposite side with conventional way of air exhausting. Exhaust air using conventional methods could be connected to a pipe under the cage. Ventilation exhaust systems were with continuous power control. Laying hens were fed a standard compound feed ad libitum with manual loading. The droppings were collected on the imitated manure belt and removed manually.

Sensors Location to Measure Ammonia and Greenhouse Gases

There were four sensors in cage of laying hens: sensor No. 1 was placed at the level of their heads, sensor No. 2 in operation high away of the airflow axis, sensor No. 3 in the next entrance room, where the temperature-controlled air were exhausted through the hole in the door to a room with a cage. Sensor No. 3, was recording "clean air values". Another sensor (No. 4) was located on the outside wall of the object (Fig. 2). This sensor was measured concentrations of releases harmful gases. Air quality was measured at the levels of laying hen heads

1: *Enriched cage*
[sourse: own]



2: *Scheme of the measuring points location in house*
[sourse: own]

and operation. At the same time air velocity, noise and concentration of dust were measured.

Measured Data Evaluation

To ensure objectivity and comparability of data measurement, the emission factor equations presented at study Jelínek *et al.* (2004) were used. Experimental data were collected on entering the hall, at the level of laying hens, at the operating level and at the output from the hall into the atmosphere. Thus, the data of this study were to determine:

- concentrations of ammonia and greenhouse gases during the four seasons,
- concentrations of ammonia and greenhouse gases in intake air,
- concentration of ammonia and greenhouse gases in exhausted air.

Devices Used in the Experiment

Device Photo-acoustic Multi gas Monitor INNOVA 1412 with multi-channel sampling system INNOVA 1309 (Brűel & Kjaer) was used for measuring of greenhouse gases emission. The values of temperature and relative humidity were continuously measured and recorded with COMMETER D3120. The values of relative humidity were used for calculating correction of ammonia and greenhouse gases concentration. Over the air velocity measured with Anemometer ALMEMO 3290 – 5 the airflow values were determined.

Data Analysis

The measured data were analysed using Excel. The averages values of ammonia and greenhouse gas concentrations were calculated from selected values to the basic set. Calculation was done for real laying hen's house with dimensions of 12 m × 100 m, with the number 18 720 pcs of hens.

RESULTS AND DISCUSSION

This chapter presents, the obtained results, according to methodology and statistical analyses.

Emission Factor Determination

1. *Conversion from volume concentration to the mass concentration of the pollutant*

INNOVA has an integrated program to measure the values in mg.m^{-3}.

I: *Ventilation system efficiency*

Ventilation efficiency, m^3. h^{-1}	Technology 1 a 2	Technology 3
QI	120	96
QII	139	109
QIII	187	153
QIV	237	192
QV	263	214

[sourse: own]

2. *Volume flow determination of the exhaust gas*

Amount of exhausted air was calculated from the measured values of air velocity and the diameter of the ventilation hole. The ± values for each evaluated technology of laying hens breeding were determined from measurements.

Tab. I shows the same ventilation system efficiency of air velocity for technology 1 and 2. Results obtained at technology 3 shown, that at the same measurements air velocity ventilation efficiency was lower, what was done because of the fan and drilled holes on ventilation exhaust system. Company MBD, Ltd., which made enriched battery cage, recommends a minimum amount of air 5 m^3.h^{-1} per 1 kg of live weight. This value is used by dimension of ventilation efficiency in laying hen houses. The average weight of laying hens was 1953.5 g, we set the amount of air 10 m^3.h^{-1} for hen. According that, minimum ventilation efficiency was set up. For technology 1 and 2 were: QI = 120 m^3.h^{-1} and technology 3: QII 3 = 109 m^3.h^{-1}. This ventilation efficiency was used during winter, spring and autumn. During the summer ventilation efficiency for technology 1 and 2, was increased to QV – 263 m^3.h^{-1}. For technology 3, ventilation efficiency during summer increased to QIII – 153 m^3.h^{-1}.

3. *The total flow rate average of exhaust gas*

The obtained value for technology 1 and 2 was 170 m^3.h^{-1} and technology 3 = 120 m^3.h^{-1}.

4. *The mass flow calculation of pollutant and emission factor*

The calculated values are presented in Tab. I.

5. *Calculation of the emission factor for given category and age of livestock*

Calculation of the emission factor is presented in Tab. II.

II: *Calculated emission factor*

Emission factor, kg. pcs^{-1}.year^{-1}	Technology 1	Technology 2	Technology 3
CO_2	14.664	13.123	8.048
N_2O	0.005	0.008	0.003
NH_3	0.004	0.002	0.001
H_2S	0.016	0.023	0.011
CH_4	0.479	0.423	0.225

[sourse: own]

III: *Percentage comparison of emission factors depending on the conventional technology*

Gas	Technology 1,%	Technology 2,%	Technology 3,%
CO_2	100	–12	–82
N_2O	100	+38	–58
NH_3	100	–110	–275
H_2S	100	+31	–45
CH_4	100	–13	–113

[sourse: own]

IV: *Conversion of ammonia and greenhouse gas concentrations from selected values to the basic set*

Gas	Technology 1		Technology 2		Technology 3	
	Lower value mg	Upper value mg	Lower value mg	Upper value mg	Lower value mg	Upper value mg
CO_2	910.085	913.658	899.114	903.94	862.15	864.3
N_2O	1.004	1.008	1.144	1.175	1.000	1.004
NH_3	0.054	0.059	0.041	0.045	0.039	0.042
H_2S	0.338	0.344	0.322	0.333	0.272	0.28
CH_4	3.273	3.379	2.868	3.04	2.208	2.298

[sourse: own]

Comparison of Breeding Laying Hens Technologies

Tab. III shows decrease of emission factor for technology 2 and 3, compared with technology 1.

If we take look by different kind of breeding technology and different gases, we can see, that emission factor is decreasing, except the breeding technology 2 in two points. Gas N_2O had showed increase of 38% and H_2S increase of 31%.

Conversion of Selected Values to the Basic Set

Calculation was done for real laying hen's house with dimensions of 12 m × 100 m, with the number 18 720 pcs of hens (Tab. IV).

Comparing the our calculated emission factors with the results obtained by another authors, such as Nimmermark *et al.* (2005) who reported the emission factor values for NH_3 46–280 g. pcs. yr^{-1}, Müller *et al.* (2003) reported 17 to 63 g. pcs. yr^{-1} for battery cage, 50–136 g. pcs.yr^{-1} for aviaries and 296–389 g. pcs .yr^{-1} for houses with deep-pit system, results of our study have achieved lower values.

During the experiment we kept in mind for controlling the moisture of droppings. The droppings moisture did not increase during experiment, what is necessary. As far as liquid increase in droppings, extreme values begin to raise pollutants.

Comparing the calculated emission factors with using breeding technology 3, over other technologies a significant improvement was obtained in CO_2 values (82% compared with technology 1, resp. 24% compared with the technology 2). The study also achieved statistically significantly values of emission factor for N_2O (58% resp. 70%), NH 3 (275% resp. 78%), H_2S (45% resp. 47%) and CH_4 (113% resp. 53%).

Ministry of Environment SR 6/1999 states emission factor for NH_3 0.19 kg. pcs. yr^{-1} in hen houses. During our study the states level of NH_3 did not exceeded.

Can be achieved surprisingly good results, but it should be remembered that it was done under the laboratory conditions in the lobby with independent heating. We agree with Rotz (2004), Powers *et al.* (2005) and Havlíček *et al.* (2007) who reported that it is important to create an appropriate dietary diet low in undigested protein. It is also very important to keep the quality of droppings up and not to increase its moisture Knížatová *et al.* (2009). This result can be confirmed by our experience that if the water was drained with dropping belt, ammonia and CH_4 values began to rise. These values were recorded during off periods measured.

SUMMARY

Protecting the environment and behave ecologically is also part of agriculture. If agriculture belongs to one of the major producers of pollutants, must deal with their possible reduction either in the livestock or crop production. Agriculture is clear evidence that environmental protection should be a major focus not only for the protection of air, soil or water, but also improving farming technologies in livestock production. This part of agriculture should be focused at reducing the production of pollutants. There is way how to achieved improvement of environmental quality

in hen houses. It would have positive impact for lower production costs and ultimately improve the quality of food.

The aim of this study was based on experimental measurements to determine the emission factor for ammonia and greenhouse gases at various breeding technologies of laying hens. Both proposed breeding technology, we tested reached values in lower concentrations of ammonia and greenhouse gases than conventional technology. The results obtained show, that the change in breeding technology we have achieved a more propitious value of the gas concentration. The significant results were obtained at the technology 3 compared with other used technologies. Likewise the highest values were found out using conventional breeding technology.

The results were also confirmed in the determination of the emission factor. At the used technology 3 emission factor reached the lowest values. None of the tested breeding technology we detected emission factor, which would exceed permitted levels referred to in the Journal of ME SR 6/1999. After converting the emission factor from selected folder into the relative values, the values of emission factor will not exceed the limit according the Journal ME SR 6/1999 (EF for NH_3 at breeding of laying hens in cages is 0.19 kg. pcs. yr^{-1}).

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REFERENCES

HAVLÍČEK, Z. et al. 2007. *Nové trendy v ochraně životního prostředí v podmínkách chovu hospodářských zvířat.* Brno: Mendelova zemědělská a lesnická univerzita v Brně.

JELÍNEK, A. et al. 2004. Research of biological agents effects on reduction of ammonia concentration in stables of intensive farm animals breeding. *Research institute of agricultural engineering,* 50(2): 43–53.

KNÍŽATOVÁ, M. et al. 2009. Koncentrácie a emisie amoniaku a skleníkových plynov v chove brojlerových kurčiat v letnom období a ich závislosť od vybraných vlastností podstielky. *Acta technologica agriculturae*, 12(1): 1–5.

MÜLLER, H. J. et al. 2003. Livestock Production and Emission of Volatile Gases. In: *International Symposium on Gaseous and odour emissions from animal production facilities.* Horsens 1–4 June 2003 [online]. Available at: http://jordbrugsteknik.dk/CIGR/CIGR2003.pdf. [Accessed 2011, March 10].

VLÁDA SLOVENSKEJ REPUBLIKY. 2003. *Nariadenie vlády Slovenskej republiky č. 326, z 9 júla 2003, ktorým sa mení a dopĺňa nariadenie vlády Slovenskej republiky č. 736/2002 Z. z., ktorým sa ustanovujú minimálne požiadavky na ochranu nosníc.*

NIMMERMARK, S. and GUSTAFSSON, G. 2005. *Influence of temperature, humidity and ventilation rate on the release of odour and ammonia in a floor housing system for laying hens*. [online]. Available at: http://www.cigrjournal.org/Home/Archives. [Accessed 2012, November 26].

POWERS, W. J. et al. 2005. *Air Emissions in Poultry Production: Current Challenges and Future Directions*. [online]. Available at: http://japr.fass.org/content/14/3/613.full.pdf [Accessed 2012, December 01].

ROTZ, C. A. 2004. *Management to reduce nitrogen losses in animal production.* [online]. Available at: http://journalofanimalscience.org. [Accessed 2012, December 17].

MŽP SR. 2013. *Vestníky MŽP SR,* 6/1996, 6/1999, 1/2000, 5/2001, 6/2007. [online]. Available at: http://www.minzp.sk. [Accessed 2013, February 18].

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