Effects of an enzymatic additive on ammonia concentration on a broiler farm.

Effets d'un additif enzymatique sur les concentrations en ammoniac dans un bâtiment de volailles de chair.

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Abstract

Various chemical-biological additives, designed to reduce emissions of harmful gases in poultry housing, are increasingly available on the market. This paper reports a monitoring operation set up to verify the suitability of one of these additives in a broiler production facility. The trial was conducted in a single facility by comparing one building treated with one of the above-mentioned additives with another untreated building. The comparative study was based on detecting the concentration of ammonia at a height of 1.6 metres along the ventilation axis of the building. The monitoring operation lasted for 17 days of the production cycle, for a total of 68 samples/building. With analogous environmental conditions, the ammonia concentration detected was 53% higher in the untreated building.

Résumé

Divers additifs chimiques et biologiques, destinés à réduire les émissions de gaz indésirables en bâtiments d'élevages avicoles, sont de plus en plus répandus sur le marché. Cet article rapporte un travail d'évaluation de l'efficacité de l'un de ces additifs testé dans un bâtiment de poulets de chair. L'essai a été mené sur un bâtiment traité avec l'additif en comparaison avec un bâtiment analogue témoin. L'étude comparative a porté sur la concentration en NH_3 à une hauteur de 1.6 m le long de l'axe de ventilation du bâtiment. La période de suivi de 17 jours au cours du cycle de production a permis de prélever 68 échantillons / bâtiment. Avec des conditions environnementales similaires, les concentrations en NH_3 détectées étaient supérieures de 53% dans le bâtiment témoin.

1. Introduction

To reduce the concentration of harmful gasses inside the broilers housing, the most widespread technology used is that of correct ventilation assisted by a suitable system of control and regulation that makes it possible to achieve the best results while reducing animal discomfort to the minimum.

As an auxiliary aid to the ventilation systems, a number of additives are available on the market that can help to reduce the emission of harmful gasses inside the housing (1, 2). This monitoring project was designed to verify the suitability of one of these products on a broiler farm.

The additive in question is a polyenzymatic compound of biological origin designed for the treatment of organic substances for the purposes of deodorization, metabolization, and humification. The composition of the product is shown in Table 1. It is claimed to synergize and strengthen the action of the indigenous microbiotic flora useful for the transformation of the organic substance into stabilized compounds, without bringing in new species. Ammonia emissions would be limited as a result of nitrogen fixation into proteic compounds.

Lithothamnium calcareum algae	*40%*
Refermented lavic crushed stone and dolomites	*20%*
Culture based on vegetal lecithin and organic substrata from fermentation	*20%*
Macroelements (N-P-K-Ca-Mg) of vegetal origin	*7%*
Microelements of vegetal origin	*3%*
Humic acids	*3%*
Enzymes: amylase, cellulase, lactase, lipase, pancrease, protease, phosphorylase, invertase	*2%*
Nucleic acids	*trace*
Low-release organic nitrogen and excipients	*to 100*

Table 1
Average composition of the additive

During the course of 1996-97, two monitoring cycles were carried out on the ammonia concentration of two housings on a broiler farm: the first was treated with the additive in the measure of 2 kg per 1000 m^2 as of the 24th day of age of the broilers; the second was not treated.

2. Materials and methods

The comparison between treated and untreated housing was made measuring the ammonia concentration at 1.6 m of height at the centre of the transverse section along the axis of ventilation. The housings are made of prefabricated reinforced concrete of 16 x 150 m (2400 m^2) each with a total capacity for 29,000 heads (0.083 m^2/head). The air exchange is obtained by means of a series of 12 axial extractors of 1200 mm diameter situated along the longitudinal side of the housing at a distance of approximately 12.5 metres between them. The air enters from a series of windows that can be regualted in height, which are situated along the entire opposite longitudinal side. This system creates air circulation that is transverse with respect to the axis of the housing. The ventilation is controlled by varying the rotation speed of the fans with 5 speeds based on the information supplied by a pair of temperature probe positioned along the longitudinal axis of the housing.

The flooring is in solid reinforced concrete and covered at the moment of entry of the broilers with a layer of about 5 cm of chopped straw. This operation requires nine 300 kg round bales, approximately 1.1 kg m^2. Feed produced in the farm mill is used, distributed *ad libitum* during the first 22 days, with a starting mixture containing 23.3% raw protein and 3.1 Mcal/kg of metabolizable energy and, from the 22nd to the 55th day of the cycle, with a mixture containing 21.4% raw protein and 3.2 Mcal/kg of metabolizable energy.

The broilers are admitted with a difference of one day between one housing and the other. During the initial period, the temperature is maintained at 26°C and reduced by 1.5° per week.

The raising cycle lasts for a total of 55 days. At the 40-45th day, the hens (about 30-35% of the head present) are taken away, and the roosters are left to occupy the entire housing. Broiler hens of an average of 1.7 kg/head, and roosters of 2.6-2.7 kg/head are produced, with an average mortality rate of 2.5-3% and a feed conversion index of 0.49 kg of meat/kg of feed. Table 2 summarizes the production parameters of the two cycles. At the end of the cycle, the litter is accumulated at the centre of the housing and transported to a nearby compost and pelletizing centre. The average production is 37 t of litter as is with 23-30% moisture, equivalent to 1.3-1.4 kg/head. Considering 5 fattening cycles, the annual production is about 6.5-7 kg/broiler place·year.

Cycle	*Period*	*No.Head*			*Meat production*	*Feeding*
		Inlet *[n°]*	*Outlet* *[n°]*	*Death-rate* *[%]*	*[t]*	*[t]*
1st cycle						
- treated	autumn	27500	26472	3.7	65.1	130.2
- untreated		29000	28205	2.7	70.5	141.0
2nd cycle						
- treated	summer	28600	25969	9.2	61.1	126.0
- untreated		30050	27884	7.2	64.5	133.1

Table 2
Animal performance

The following environmental parameters were recorded :

- outside temperature,
- inside temperature,
- inside relative humidity,
- litter temperature,
- ventilation rate (as a percentage of the maximum value),
- ammonia concentration.

Two portable dataloggers were used for the environmental parameters, and two programmable sequential samplers equipped with 8-input solenoid valve unit were used for measuring ammonia concentration. The samplers were programmed to take air samples at the centre of a section of the housing for 3-6 consecutive hours. The air flow thus measured was scrubbed in a 1% sulphuric acid solution.

During the first production cycle, a total of 9 days were monitored, divided into three sequences of three days each (144 samples total); in the second, 15 days were monitored, with sequential samplings of 6 hours each (120 samples total).

The litter at the end of the cycle was weighed, sampled, and analyzed.

3. Results

Table 3 shows the average environmental parameters and ammonia concentration measured during the course of the monitoring period, and Figures 1 and 2 show the respective trends. The ammonia concentration measured during the first cycle monitored was higher in the untreated housing by 46%: 29.4 mg/m^3 (42 ppm) for this housing against 15.8 mg/m^3 (22.6 ppm) for the treated housing. Analogously, during the second experimental cycle, the ammonia concentration of the untreated housing was higher by 58%: 18.6 mg/m^3 (26.6 ppm) for the control housing against 7.6 mg/m^3 (11.1 ppm) for the treated housing.

Cycle	*Temperature*				*Inside relative humidity*	*Ventilation rate*	*Ammonia concentration*
	Outside	*Inside*	*Litter*	*Out-In*		*(1)*	
	[°C]	*[°C]*	*[°C]*	*[°C]*	*[%]*	*[%]*	*[mg/m^3]*
1st cycle							
- treated	*14.7*	*19.6*	*24.0*	*4.9*	*77.8*	*n.d.*	*15.80*
- untreated	*14.7*	*20.4*	*24.1*	*5.9*	*75.5*	*d.d.*	*29.4*
2nd cycle							
- treated	*17.3*	*21.7*	*26.5*	*4.5*	*74.8*	*52.7*	*7.6*
- untreated	*17.3*	*23.4*	*28.2*	*6.1*	*79.0*	*52.5*	*18.6*

Note: (1) ventilation rate is expressed as percentage of maximun fan speed

Table 3
Average ambient data and ammonia concentration during monitoring periods

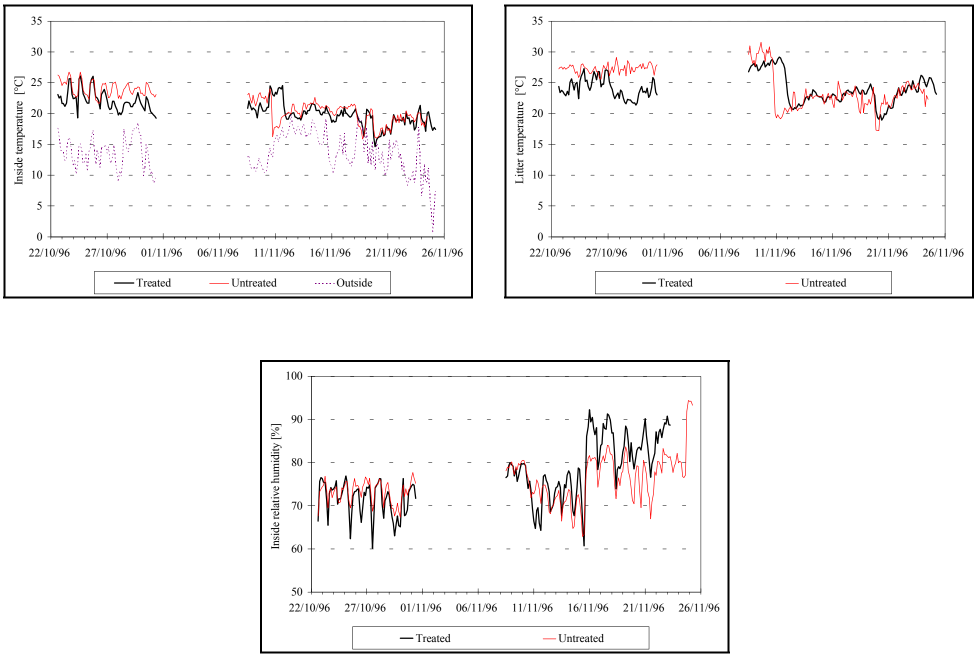


Figure 1
Monitoring data trend during first experimental period: outside, inside and litter temperature and inside relative humidity.

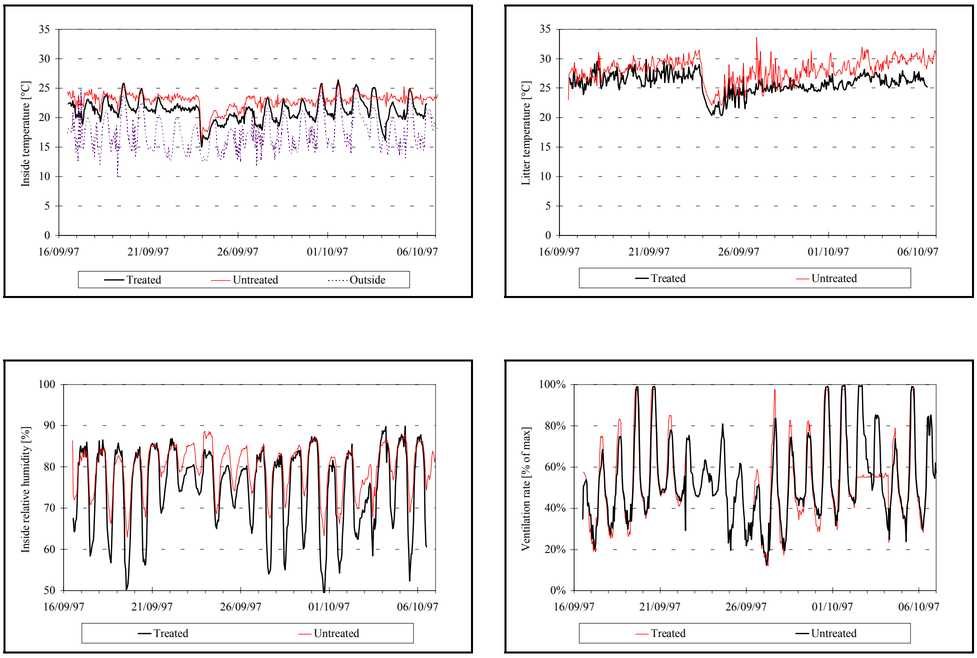
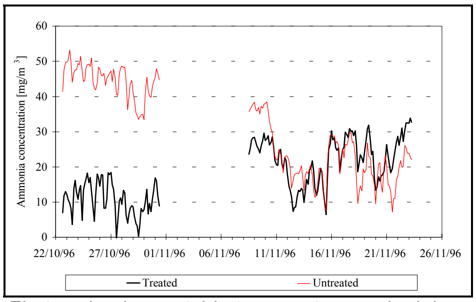


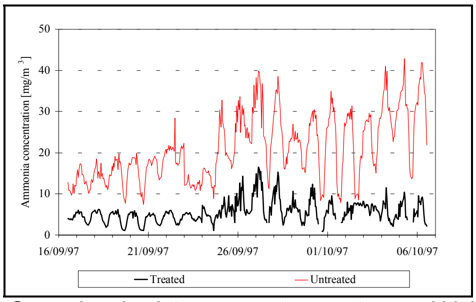
Figure 2
Monitoring data trend during second experimental period: outside, inside and litter temperature, inside relative humidity and ventilation rate.

To eliminate the environmental differences of the two housings, the values found were submitted to statistical analysis and the linear interpolation function was identified on the basis of the parameters of outside temperature, inside temperature, litter, relative humidity, live weight present, and ventilation (the latter parameter was used only for the second cycle).

Figure 3 shows the values of ammonia concentration recalculated on the basis of identical environmental conditions. In this case, the average concentration calculated resulted as: 30.4 mg/m^3 for the control housing, and 16.8 mg/m^3 for the treated housing, with an average reduction of 45% for the first cycle, and 21 mg/m^3 and 5.6 mg/m^3, for the second cycle, with an average reduction of 73%. The difference found in the second cycle between the values of ammonia concentration reduction is due to the different inside temperatue conditions of the housings and the litter.



First cycle : low outside temperature and minimum ventilation rate during starting cycle induced high ammonia concentration in untreated house. During this fase it has been monitored significative additive effect.



Second cycle : late summer temperature and high ventilation rate induced low ammonia concentration in both broilers houses. It has been monitored high additive effect also in this period.

Figure 3
Inside ammonia concentration (mg/m^3) trend during monitoring periods. Graphs reports elaborated data: multiple linear regression based on temperature (inside and outside), live weight, relative humidity and ventilation rate (only for second period).

The characteristics of the outgoing litter of the housings (Tables 4 and 5) lead to a number of observations :

- the moisture level of the product is only affected by the treatment in a limited way: 31.5% in the treated housing against 28.2% in the control housing during the first cycle, and 20% vs. 28%, respectively, in the second cycle;
- a higher quantity of nitrogen remains in the treated litter with respect to the untreated litter, 37,600 vs. 37,060 mg/kg for the first cycle, and 48,280 vs. 39,730 mg/kg in the second cycle. In quantitative terms, this is equivalent to 1480 vs. 1409 kg nitrogen content in the first cycle, and 1777 vs. 1557 kg in the second cycle;
- the different quantity of nitrogen that remained bound to the organic substance is clearly shown by the C/N ratio: the analysis showed that it was significantly lower in the treated litter with respect to the control litter: 8.46 vs. 9.56 in the first cycle, and 7.34 vs. 7.6 in the second cycle;
- considering the quantities of nitrogen administered with the feed and those excreted, some evaluations were made regarding the ammonia emissions of the housing: for the control housing, an estimate of 0.30 kg/head/year was made, and 0.24 kg/head/year for the treated housing, with an average reduction of 20%;
- the differences in ammonia emission between the two cycles (-15% for the first and -25% for the second) are in line with the different level of the ammonia concentration reduction found inside the housings, though it was not possible to indicate an exact correspondence.

Parameters		Untreated litter		Treated litter	
		1st cycle	2nd cycle	1st cycle	2nd cycle
pH		8.48	9.18	8.74	8.26
TS	[g/kg]	718.59	719.12	685.43	799.66
VS	[g/kg]	601.8	587.13	569.1	674.02
	[% TS]	*83.74*	*81.65*	*83.02*	*84.29*
NTK	[mg/kg w.b.]	37060	39730	37600	48280
	[% TS]	*5.16*	*5.52*	*5.49*	*6.04*
N-NH4	[mg/kg w.b.]	4860	5320	4530	3250
	[% NTK]	*13.11*	*13.39*	*12.05*	*6.73*
TOC	[% ST]	49.3	41.97	46.06	44.33
C/N		*9.56*	*7.60*	*8.46*	*7.34*

Table 4
Litter composition at the end of the cycles

Parameters		Untreated litter		Treated litter	
		1st cycle	2nd cycle	1st cycle	2nd cycle
N intake	[kg] (1)	4906	4630	4530	4383
N excretion	[kg]	2876	2772	2656	2624
	[kg/head.y] (2)	0.52	0.53	0.53	0.52
Litter	[t]	38.0	39.2	39.4	36.8
	[kg/head.cycle]	1.35	1.41	1.49	1.42
	[SS %]	71.91	71.86	79.97	68.54
N into litter	[kg]	1409	1557	1480	1777
Housing N emission	[kg]	1467	*1215*	1176	*847*
	[kg/head.y] (2)	0.27	*0.23*	0.23	*0.17*

Note: (1) average protein content: 21,7%; (2) based on 5 cycles/year

Table 5
Nitrogen balance

4. Discussion and conclusions

The inside temperatures were lower on average in the treated housing than those in the untreated housing, with more accentuated differences in the late summer cycle (2nd cycle) with respect to the autumn cycle (1st cycle). Analogous temperature differences were found on the surface of the litter, with higher average values in the litter of the untreated housing (+1.7 °C in the late summer cycle). Only in the first cycle (autumn) did the difference diminish and then disappear completely in the final phases (Fig. 1).

The trend of nitrogen concentration in the litter clearly reflects the thermal trend of the litter. Nitrogen concentration was always higher in the untreated housing in the presence of higher temperatures of the litter, while the difference in concentration between the treated and untreated housing tended to disappear as the temperature differences between the litters disappeared (Fig. 1).

The reasons for the untreated litter having a higher temperature than the treated litter are not easy to interpret. The effectiveness of the product used to reduce ammonia emission is confirmed by the data resulting from the chemical analysis made on the outgoing litter (Table 4), which show higher quantities of nitrogen in the treated situation. An attempt to balance the nitrogen which accounts for the amount ingested by the animals, that which is excreted and that which is found in the litter, makes it possible to estimate the ammonia emission and to confirm, also by this means, an appreciable effectiveness of the additive used.

Given the limited number of trials, this result cannot yet be considered conclusive. Nonetheless, further testing would be in order and, if further confirmation is found, the research should be developed in order to better understand the mechanisms that govern the action of this and other biological additives currently on the market.

5. References

1 - **Hendriks J., Berckmans D., Vinckier C**., 1997 - Field tests of bio-additives to reduce ammonia emission from pig houses. Proceedings of the International Symposium, Vinkeloord, The Netherlands, October 6-10.

2 - **Martinez J., Jolivet J., Guiziou F., Langeoire G**., 1997 - Ammonia emissions from pig slurries: evaluation of acidification and the use of additives in reducing losses. Proceedings of the International Symposium, Vinkeloord, The Netherlands, October 6-10 1997. Voermans J.A.M. and Monteny G. (eds), Vinkelord, NLD, 485-492.