Effect of Litter Type on Ammonia Emission in Turkey Housing

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Abstract

Litter material may affect ammonia emission in livestock buildings due to differences in NH_3 and water adsorption capacity, the rate of their further release as well as the ongoing biochemical processes. There is very few research data on ammonia emission for chicken buildings and even less for turkey production. In growing/finishing turkey barns birds remain much longer than in broiler houses. As a result the biochemical processes taking place in the litter and ammonia volatilization can be affected. The research was carried out in two identical barns, 550 m^2 each for two successive flocks. Birds remained in the barns for three consecutive stages (from brooding until finishing). For the first flock long rye straw versus softwood shavings litters were compared. For the second, 40 – 70 cm long rye straw and the same type of straw chopped to 5 – 8 cm pieces were investigated.
Once a week on Fridays from 7:00 to 9:00 A.M. the measurements of inside and outside air temperature and humidity, litter temperature, moisture and pH were carried out. Also average ammonia emission for the time of measurements was calculated by multiplying values of its concentration at the exhausting fans by ventilation air exchange.
The research did not show any significant effect of litter type on ammonia emission in turkey house. The ammonia emission at the end of week 5th (the end of typical broiler growing) corresponded well to ammonia emission obtained for broiler houses in other investigations. For long straw litter ammonia emission reached its maximum in week 6 – 7; for chopped straw and wood shavings maximum ammonia emission took place at approximately week 10. There was significant seasonal effect on ammonia emission from long straw litter.

Key words: turkey housing, ammonia emission, litter

Introduction

Most commonly used type of litter in poultry buildings in Poland is straw, probably since its high accessibility and low price. Most frequently long straw is used, and almost no chopped straw is being applied. In some areas with straw shortages growers use soft wood shavings as litter material.
Quite numerous research has been done on physical and chemical properties of various bedding materials for poultry. (Smith, 1956; Andrews and McPherson, 1963; Ruszler and Carson, 1974; Brake et al., 1992). Since most of the research was performed in U.S. where straw is rather rarely used as a bedding material, they typically did not deal with straw.

Most frequently, litter moisture as well as its uptake and release characteristics were measured (Ruszler and Carson, 1974; Brake et al., 1992).
The interest in ammonia emission from poultry litter came in early 80-ties and was mainly connected with litter re-use and its effects on high ammonia concentrations in brooding phase (Carr and Nicholson, 1980; Elliot and Collins, 1982) and excessive heat requirements necessary for providing suitable ventilation rate (Xin et al, 1996). Ammonia emission levels from fresh and reused litter were compared by Brewer and Costello (1999).
The other researches on ammonia emission from poultry houses concerned particularly effects of such factors as:

- air temperature and humidity, litter moisture and pH, ventilation rate and air velocity at litter surface (Carr et al, 1990; Weaver and Meijerhof, 1991; Groot Koerkamp and Elzing, 1996),
- providing for litter drying up (Dobrzański and Białas, 1993; Macke and Van Den Veghe, 1997; Groenestein, 1993; Souloumiac, 1994),
- optimizing of dietary protein level (Ferguson et al, 1998a; Ferguson et al, 1998b)
- using various additives to litter (Dobrzański and Mazurkiewicz, 1991; Moore et al, 1996)

Research on ammonia emission from various bedding materials were carried out for pig and cattle houses (Nicks et al, 1997; Kaiser and Van den Weghe, 1997; Jeppsson, 1999)
Chopped straw was measured to emit considerably less ammonia than long straw in a building for young cattle (Jeppsson, 1999). The ammonia concentrations measured in deep litter building for fattening pigs were significantly (by 49 %) higher for straw than sawdust used as bedding material (Kaiser and Van den Weghe, 1997)
The purpose of this research was to compare ammonia emission for three types of litter material, i.e. long and chopped rye straw and soft wood shavings in building for turkey through all three cycles of production: brooding, growing and finishing.
The working hypothesis based on some other researches dealing directly with ammonia emission (Kaiser and Van den Weghe, 1997; Nicks et al, 1997; Jeppsson, 1999) or on relations between litter material and its moisture dynamics (Andrews and McPherson, 1963) was that the highest emission should occur for long straw with lower ammonia emission expected for chopped straw and soft wood shavings.

Material and methods

The research was carried out in two identical turkey barns, 550 m^2 each for two flocks.
Ventilation system of each barn consisted of 7 x 4760 m^3/h at 20 Pa exhaust fans.
Two fans were running continuously as 1st step ventilation with thermostatically controlled variable speed. Remaining 5 fans were also thermostatically controlled. When inside temperature exceeded maximum value assumed for 1st step ventilation, successively 2 and 3 additional fans were switched on as 2nd and 3rd stage respectively. All fans were located in vertical chimneys uniformly distributed along the building ridge.
Birds remained in the barns for three consecutive stages (from brooding until finishing).
The only difference between barns was type of material used for litter.
For the first flock, long rye straw versus softwood shavings litter were compared. 5660 turkey poults were put into 2 barns resulting in density 10,29 poults/m^2. At the end of 5th week only females were left in both barns, 2700 in each, resulting in density 4,91 turkeys/m^2. The amount of wood shavings was 41,82 kg/m^2, the amount of long straw 15,84 kg//m^2.

For the second flock, long rye straw and the same type of straw chopped to 5 – 8 cm pieces were investigated. 6200 poults were put to the barn with chopped straw and 5980 to the barn with soft wood shavings, resulting in respective densities 11,27 poults/m^2 and 10,87 poults/m^2. At the end of 5th week the female turkeys were only left in both barns, 2915 in each, resulting in density 5,30 turkeys/m^2. The amount of chopped straw was 11,60 kg/m^2, the amount of long straw 13,90 kg//m^2.
In both barns 1 day old BIG 6 type turkeys were brought from commercial hatchery. The birds in both barns were on identical diets for all experiment time.
The measurements were carried out every week on Fridays from 7:00 to 9:00 A.M. to avoid any effect of breeding procedures, like feeding, adding fresh litter, etc. Measurements started approximately at the end of the 2nd week, in 17th day for the first flock which was started on Wednesday and in 14th day for the second flock which was started on Saturday.
Inside and outside air temperature and humidity were continuously recorded in 1 hour intervals, at a center of each barn, 60 cm above the litter. Since all the other data used for analysis of data on ammonia emission were obtained once a week in morning hours, air temperature and humidity values were taken as the average of 3 measurements carried out in 1 hour intervals between 7:00 – 9:00.
All temperature measurements were performed by using German logging system ALMEMO with PT 100 temperature sensors with accuracy ± 0,3 K and RH capacity sensors with accuracy ± 3%.
Ammonia concentrations in the inside air were measured once a week using Draeger Chip Measurement System, consisting of a substance-specific chips and an analyzer which is quantifying the measurement and providing a digital display of the results. The accuracy of measurements for chips was according to producer ±8 %. Ammonia emission was evaluated on the basis of values of its average concentration measured momentarily at 2 exhaust fans of first stage ventilation and air exchange taken from number and capacity of running fans. Before the measurements of ammonia concentration were performed, the automatic ventilation control was switched off and the fans were put at full speed for 15 minutes period. It allowed for stabilization of ammonia concentration and precise evaluation possibilities for air exchange. The number of fans operating at full speed was being adjusted as close as possible to actual ventilation level. The minimum number of fans running at full capacity was 2, whereas the maximum was 7. The capacity of the fans was checked additionally with calibrated fan wheel anemometer for 4 fans running at full speed to get the value 4650 m^3/h which was used for all ventilation air exchange.

Table. 1. Number of continuously working fans for Summer-Autumn and Winter-Spring flock for all measurements of ventilation exchange.

Week		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Flock I	A	2	3	5	5	6	6	7	7	7	7	7	7	7	-	-
	B	2	3	5	5	6	6	7	7	7	7	7	6	7	-	-
Flock II	A	2	2	2	3	4	4	4	4	5	5	5	5	5	6	6
	B	2	2	2	3	4	5	6	6	6	6	6	6	6	6	6

The samples of the litter were taken once a week from three locations uniformly distributed at the long axis of the building. In each of three locations the areas of approximately 0,5 m x 0,5 m were preliminarily designated for each week sample to be taken. First, the surface 3 cm

layer was taken away, than the other 2 cm layer, in total amount of approximately 1 kg from each location, was loaded to tight plastic container. The samples from one barn were mixed thoroughly and tested in the laboratory for its pH and dry matter content. Litter temperature was measured in direct neighborhood of locations from which its samples were taken. Its final value was taken as average of two measurements in each of the three positions taken at a beginning and end of each series of research carried out once a week.
The research started at the end of the 2nd week since during the first two weeks ammonia emission was expected to be negligible (Weaver and Meijerhof, 1991).

Table 2. The overview of the treatments

Flock \ House	A	B
I	wood shavings	long straw
II	chopped straw	long straw

Results and their analysis

The results of the research has been summarized in tab. 3 and 4. for flock I and II respectively.

Table. 3. Ammonia emission and some factors potentially affecting its rate for soft wood shavings (House A) versus long rye straw (House B) at breeding/growing/finishing turkey barns for Summer-Autumn flock.

Week	T_o (°C)	pH		T_i (°C)		φ_i (%)		T_{litter} (°C)		φ_{litter} (%)		NH_3 emission ($mg\ m^{-2}\ h^{-1}$)	
		A	B	A	B	A	B	A	B	A	B	A	B
2	14,5	5,9	6,2	26,7	24,8	57,7	58,9	25,4	22,3	17,9	16,6	2,7	6,3
3	10,0	6,2	6,5	26,7	23,4	60,9	62,5	31,9	24,3	21,8	25,4	17,2	28,7
4	13,1	6,9	7,2	24,0	24,4	69,6	73,5	35,5	28,5	24,9	31,2	84,4	136,5
5	15,2	7,6	7,8	21,0	21,5	69,6	70,8	29,5	26,0	26,8	37,1	212,9	345,3
6	12,5	8,4	8,3	20,0	20,6	75,8	79,1	29,7	25,4	30,1	42,8	224,4	515,8
7	11,0	8,7	8,5	19,0	19,0	73,2	78,8	30,5	25,2	32,9	41,1	266,2	362,3
8	13,3	9,0	8,9	21,3	20,8	71,5	75,0	28,3	29,1	35,6	42,3	380,5	285,6
9	7,0	9,0	9,0	17,5	18,5	70,0	73,3	23,8	24,3	37,1	43,1	422,3	341,0
10	13,6	8,8	8,8	21,7	21,3	72,1	75,2	27,9	27,2	35,9	46,8	491,0	445,0
11	13,8	8,8	8,7	22,1	22,2	75,2	74,7	28,1	27,3	36,1	47,3	546,4	503,8
12	10,8	8,7	8,7	20,9	20,3	72,4	77,3	27,4	26,8	35,9	44,7	509,4	377,2
13	11,2	8,7	9,0	20,7	21,2	74,8	75,2	26,6	27,5	36,3	46,9	584,0	460,4
14	12,6	8,8	9,0	21,5	20,8	73,6	74,5	27,3	27,5	34,8	45,1	562,2	386,2
Ave	**12,2**	**8,1**	**8,2**	**21,8**	**21,4**	**70,5**	**73,0**	**28,6**	**26,3**	**31,2**	**39,3**	**331,0**	**322,6**

A – wood shavings; B – long straw

To – Outside temperature (^oC)
T_i – Inside temperature (^oC)
φ_i – Inside air relative humidity (%)
T_{litter} – Litter temperature (^oC)
φ_{litter} – Litter moisture (%)

Table. 4. Ammonia emission and some factors potentially affecting its rate for chopped (House A) versus long rye straw (House B) at breeding/growing/finishing turkey barns for Winter-Spring flock.

Week	T_o (^oC)	pH		T_i (^oC)		φ_i (%)		T_{litter} (^oC)		φ_{litter} (%)		NH_3 emission (mg m^{-2} h^{-1})	
		A	B	A	B	A	B	A	B	A	B	A	B
2	3,3	6,0	6,1	29,1	29,2	44,6	45,4	25,4	23,9	15,5	15,3	8,1	19,0
3	5,8	6,0	6,5	28,3	27,4	53,5	52,2	28,4	24,3	19,2	20,4	36,4	41,7
4	-7,0	7,3	6,9	24,9	25,8	56,8	60,7	30,5	25,0	21,3	23,2	32,3	84,2
5	-2,6	8,1	7,6	21,5	21,4	66,7	68,8	32,7	26,0	24,8	25,9	126,7	154,4
6	2,7	8,4	8,8	19,4	18,3	60,3	61,8	23,1	23,9	26,3	28,2	167,1	244,2
7	-0,6	8,7	8,6	17,8	16,3	56,3	60,3	24,9	21,6	28,2	27,3	245,5	256,2
8	-4,2	8,9	8,7	17,1	14,7	61,2	67,1	24,9	21,6	30,3	29,7	211,4	235,6
9	1,9	8,6	8,9	17,1	13,1	66,2	74,3	21,6	22,5	30,9	32,9	281,3	259,6
10	-2,2	8,6	8,7	15,0	14,3	66,5	70,2	26,4	20,8	31,2	33,1	336,7	247,2
11	6,9	8,8	8,7	17,5	15,0	67,8	75,7	27,3	21,9	34,9	37,1	304,8	305,2
12	-4,6	8,8	9,0	14,5	14,2	70,4	71,6	25,9	20,3	36,2	36,2	382,7	247,2
13	-2,0	8,7	8,8	13,8	13,9	70,4	72,0	26,2	18,7	33,1	37,9	325,6	273,0
14	1,2	9,0	9,0	15,6	14,8	68,9	70,2	25,7	18,8	34,5	39,1	308,8	188,3
15	5,0	9,0	9,0	16,1	15,6	70,3	73,3	23,0	17,6	37,7	42,4	287,7	208,9
16	2,3	8,9	8,8	14,8	14,2	71,1	72,5	22,2	19,4	37,0	40,4	348,4	216,6
Ave	**0,4**	**8,3**	**8,3**	**18,8**	**17,9**	**63,4**	**66,4**	**25,9**	**21,8**	**29,4**	**31,3**	**226,9**	**198,8**

A – chopped straw; B – long straw

Average ammonia emission from the end of week 2 to the end of week 14 for Summer-Autumn flock was 331,0 mg m^{-2} h^{-1} for wood shavings and 322,6 mg m^{-2} h^{-1} for long straw litter. The difference between the means for the two materials was not statistically significant. There was also no significant difference between chopped and long straw from the end of week 2 to the end of week 16 for Winter-Spring flock. Respective ammonia emission values were 226,9 0 mg m^{-2} h^{-1} and 198,8 0 mg m^{-2} h^{-1}.

The analysis of weekly data on ammonia emission given in table 3 shows that ammonia emission from the end of week 2 to the end of week 7 was higher for long straw than for wood shavings. From week 8 to week 14 the tendency was totally different with significantly higher ammonia emission for wood shavings.
Similar analysis of weekly data on ammonia emission given in table 3 shows that from the end of week 2 to the end of week 8 it was higher for long than for chopped straw. From week 9 to week 16 considerably higher ammonia emission was for chopped straw.

The change in emission tendency (week 7/8 for Summer-Autumn flock and week 8/9 for Winter-Spring flock) was connected with strong tendency to litter caking forming observed in long straw litter. These weeks the area of litter caking for long straw litter rapidly grew, exceeding 90 % of all flooring area, whereas for wood shavings it was less than 40 % and for chopped straw less than 50 - 60 % (Słobodzian – Ksenicz, 2002). The three types of litter seemed to have different physical structure.
To account for the changes in physical properties of the litter additional grouping variable – housing period (week 2 – 7 and 8 – 14 for Summer-Autumn flock and week 2 – 8 and 9 – 16 for Winter-Spring flock) were introduced.
The analysis of two way repeated measures ANOVA was performed with grouping variables: housing period and litter type. Its results have been illustrated at fig. 1. for Summer-Autumn flock and at fig. 2. for Winter-Spring flock.

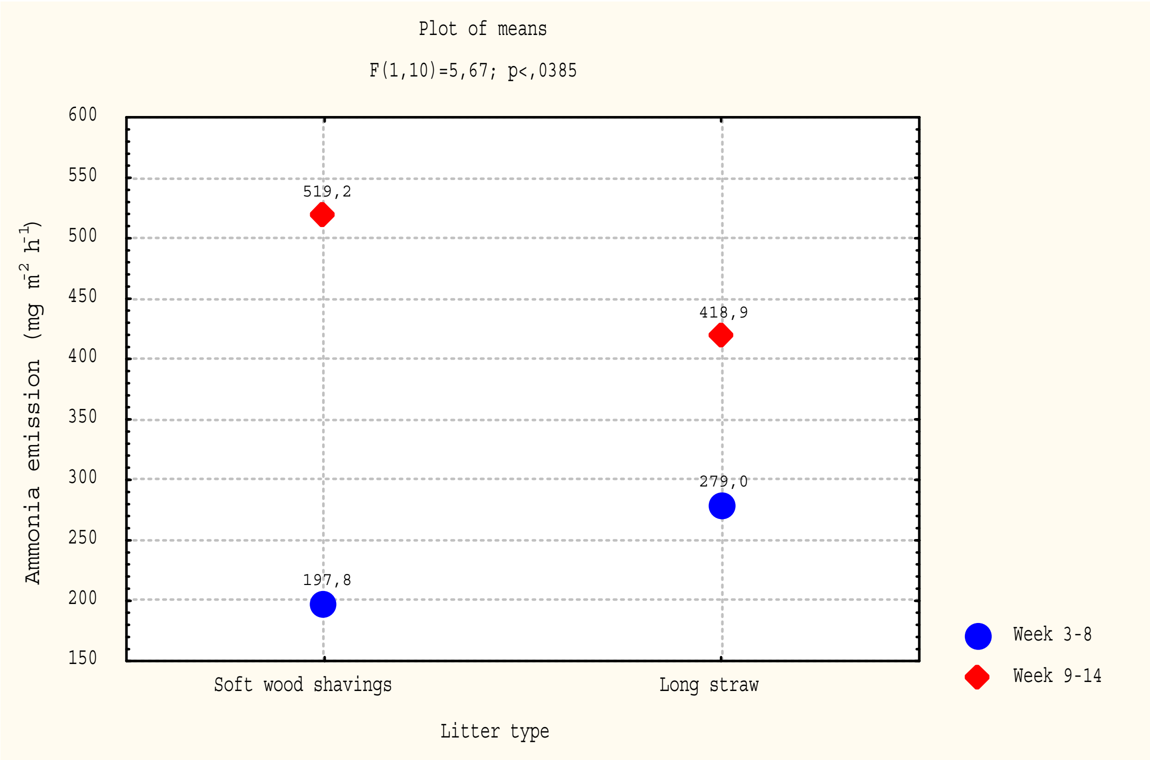

Fig. 1. Average ammonia emissions in brooding/growing/finishing turkey house with soft wood shavings and alternatively long straw litter for 3 to 14 week old turkeys (Flock I)

From the end of week 3rd to week 7th there was considerable higher ammonia emission from long straw than from wood shaving 279,0, mg m^{-2} h^{-1} versus 197,8 mg m^{-2} h^{-1}. From week 8th to the end of fattening, the tendency was quite different with respective average emission values 519,2 mg m^{-2} h^{-1} for wood shaving and 418,9 mg m^{-2} h^{-1} for long rye straw.
The values of ammonia emission for both, soft wood shavings and long rye straw were positively correlated with litter moisture, with respective correlation coefficients $r = 0{,}93$, $p < ,05$ and $r = 0{,}93$, $p < ,05$. Litter moisture in turn was significantly correlated with air humidity Correlation coefficient for wood shavings was $r = 0{,}83$, $p < ,05$ and for long straw $r = 0{,}87$, $p < ,05$.

There was no statistically significant correlation between ammonia emission and litter temperature. Respective correlation coefficients for shavings and straw were r = - 0,5 at p = 0,083 and r = 0,42 at p = 0,149.
There was very strong correlation between the ammonia emission and week of housing for wood shaving litter, r = 0,98, p < ,05 and apparently weaker, although statistically significant correlation for long straw, r = 0,73, p < ,05.
The values of pH were remaining at relatively low level for both wood shavings and straw until approximately the end of week 4 when they reached a level of 6,9 and 7,2 respectively. Associated by very low litter moisture until the end of 3rd week, they resulted in very low actually insignificant ammonia emission values for 2nd and 3rd week..

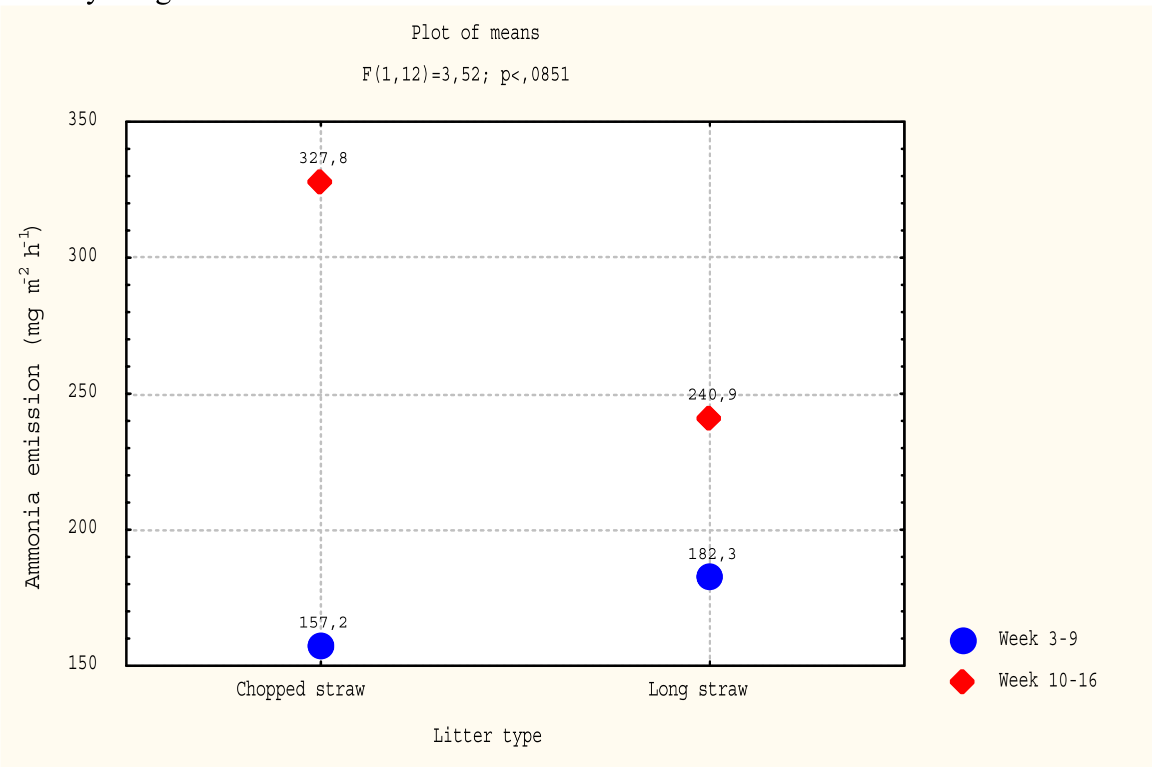

Fig. 2. Average ammonia emissions in brooding/growing/finishing turkey house with chopped rye straw and alternatively long straw litter for 3 to 16 week old turkeys (Flock II)

The same tendencies as for wood shavings and long straw were obtained for chopped and long rye straw. From the end of week 3rd to the end of week 9th considerable higher ammonia emission took place from long than from chopped straw, respectively 157,2 mg m^{-2} h^{-1} and 182,3 mg m^{-2} h^{-1}. From week 10th to the end of housing period the tendency was opposite with average emission values for chopped straw 327,8 mg m^{-2} h^{-1} and long straw 240,9 mg m^{-2} h^{-1}.
The values of ammonia emission for chopped and long rye straw were positively correlated with litter moisture, with respective correlation coefficients r = 0,94, p < ,05 and r = 0,74, p < ,05. Litter moisture was significantly correlated with air humidity for both types of litter Correlation coefficient for chopped straw was r = 0,82, p < ,05 and for long straw r = 0,79 p < ,05.
There was negative but no statistically significant correlation between ammonia emission and litter temperature for chopped straw. Correlation coefficient was - 0,47 at p = 0,076. For long straw this correlation was also negative and statistically significant with r = - 0,52, p < ,05.

Like for wood shavings in research carried out for the first flock, there was strong correlation between the ammonia emission and week of housing for chopped litter, $r = 0,89$, $p < ,05$ and considerably weaker correlation for long straw, $r = 0,65$ $p < ,05$.
For chopped and long straw litter ammonia emission remained actually insignificant respectively until the end of 4th week and 3rd week. This was apparently connected with low pH values, litter moisture and low input of Nitrogen as source of emission.
There was statistically lower ammonia emission for long straw litter for December – March flock than for the August – November one. Its respective values were 198,8 mg m^{-2} h^{-1} and 322,6 mg m^{-2} h^{-1}, at $p = 0,039$

Discussion

The results of research did not confirm preliminarily assumed thesis that there would be higher ammonia emission for turkeys kept on long rye straw comparing to chopped straw and soft wood shavings. The total ammonia emission for all period of brooding, growing and finishing birds was no significantly different neither for long compared to chopped straw nor for long straw compared to wood shavings. At the same time this research showed statistically significant difference between ammonia emission level for the analyzed litter materials when ammonia emission was considered in context of time passed from the beginning of the flock. The first weeks ammonia emissions was significantly higher from long straw and from 8th or 9th week it became higher for wood shavings or chopped straw respectively.
The probable reason was for lowering ammonia emission rate at later stage of housing could have been, as suggested by Brewer and Costello (1999), litter caking, which to much more extent was visible for long straw than for two other litter types. Caking developed with particular speed at week 6 and 7 for August – November flock and week 7 and 8 for December – March one. Under tight layers of caked litter lying on prevailing area of the building with long straw there was probably not enough oxygen and good conditions were developed for its anaerobic decomposition. At anaerobic conditions ammonia volatilization should be expected to be lower than at aerobic ones (Kirchmann and Witter, 1989). It could have been one of the reason of lower ammonia emission from long straw litter in a second phase of housing period. The momentarily ammonia concentration measurements taken occasionally below the caking layer showed however that highest ammonia concentrations were in the barn with long straw, what could suggest that long straw caking was also most impermeable for ammonia
There was considerable lower ammonia emission in first 6 weeks of housing for soft wood shaving (by 48 %) and for chopped straw (by 32 %) comparing to long straw litter. It could suggest that at broiler housing with 5 – 6 week period of housing, application of long straw as litter material should result in considerably higher ammonia emission than using soft wood shavings or just chopped litter.
For animal health, welfare and production efficiency long straw appeared to be the worst solution for all time of the housing. The birds on this kind of litter were found experimentally to have largest number of leg and breast abnormalities and gained significantly lower than turkeys kept on chopped straw or wood shavings (Słobodzian – Ksenicz, 2002).
The average ammonia emission for wood shavings at the end of week 5 for August – November flock was 212,9 mg m^{-2} h^{-1} (tab.2), which corresponds very well to approximately 250 mg m^{-2} h^{-1}, given by Brewer and Costello (1999) and the similar level reported for chopped straw by Macke and Van Den Veghe (1997). Much lower ammonia emission values

126,7 mg m^{-2} h^{-1} for chopped straw and 154,4 mg m^{-2} h^{-1} for long straw were observed at the end of week 5 at December – March flock (tab.3). It should be remembered however that January was rather cold and supplementary heating was on for all the time. Similar variability in results was confirmed by the research carried out in 33 broiler houses in Northern Europe (Groot Koerkamp et al, 1998). The average ammonia emissions were 8,9 mg h^{-1} per bird for Denmark, 11,2 mg h^{-1} per bird for the Netherlands, 18,5 mg h^{-1} per bird for Germany and 19,8 mg h^{-1} per bird for UK. Assuming 18 broilers per 1 m^2 it gives the emission range from 160,2 mg m^{-2} h^{-1} to 356,4 mg m^{-2} h^{-1}. The ammonia emission rates for long litter at Summer-Autumn flock 345,3 mg m^{-2} h^{-1} (tab.2) correspond very well to the results obtained for Germany and UK (Groot Koerkamp et al, 1998).

At the weeks 6-7 ammonia emission for long litter straw was reaching its maximum and it did not change considerably through the next weeks. The similar maximum of ammonia emission for wood shavings and chopped straw litter was taking place 3 – 4 weeks later.

It was impossible to reliably compare ammonia emission for soft wood shavings and chopped straw because of different period of housing with these two types of litter and associated differences in outside temperature, 12,2 ^oC and 0,4 ^oC respectively for August – November and December – March flock. Ammonia emission for chopped straw in December – March was by 31,5 % lower than for wood shavings in August – November. Even higher reduction in emission for December – March flock (by 38,5 %) was found for long straw itself.

There are proven positive correlations between air and litter temperature and ammonia emission (Carr et al, 1990; Groot Koerkamp and Elzing, 1996). The results of our research did not confirm this findings mainly because of the nature of research itself, which was weekly evaluation of ammonia emission rate for all (with exempt for 2 first weeks) housing period. During the first weeks of brooding when temperature have had to be kept at very high level, ammonia emission was very low, what totally changed the real relation between these two variables.

Research confirmed strong positive correlation between air humidity and litter moisture (Weaver and Meijerhof, 1991) and further, litter moisture and ammonia emission (Carr et al, 1990).

Very interesting could have been the results of multiple regression analysis for combined action of various factors affecting ammonia emission, unfortunately there was not enough data even for analysis with two independent variables.

There was significant effect of seasonality on ammonia emission from long straw. It should be mentioned that buildings at first flock were heated up only for first 4 weeks and at second flock for most of the time of housing, with exempt for last 3 weeks. Average outside temperature at a time of housing was 12,2 ^oC and 0,4 ^oC for first and second flock respectively. The other values of factors potentially affecting ammonia emission for two housing periods, respectively for August – November and December – March flocks, were lower air temperature and humidity, resulting in also lower litter temperature and moisture.

The methodology of evaluation how many fans should run continuously on the basis of observations proceeding their setting up was subjective. It has been particularly reflected in measurements performed in weeks 7, 8, 9 and 11 at Winter-Spring flock, when apparently too many fans have been switching on in barn B. As a result the temperatures at these days were significantly lower in barn B and so was the average temperature in this barn.

Conclusions

1. There was no significant effect of litter type on total ammonia emission in turkey house.
2. The litter which was supposed to give higher ammonia emission i.e. long straw emitted more ammonia than wood shavings or chopped straw only in first 7 – 8 weeks of housing. It may suggest that long straw should be particularly avoided for negative environmental impact in broiler housing where birds are being kept for relatively short time.
3. Ammonia emission at the end of week 5th (the end of typical broiler growing period) corresponded well to ammonia emission obtained for broiler houses in other investigations.
4. For long straw litter ammonia emission reached its maximum in week 6 – 7; for chopped straw and wood shavings maximum ammonia emission took place at approximately week 10.
5. In 6th to 8th week, depending on the flock, there was a strong tendency at long straw litter for caking with eventually close to 100 % of flooring being covered by almost impermeable layer of caking. The caking formed on long litter straw seemed to be the most tough and impermeable.
6. There was significant seasonal effect on ammonia emission for long litter straw with much lower ammonia emission in Winter than in early Autumn

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