Ralf Kosch and Herman Van den Weghe, Vechta, as well as Jiri Broz, Basel/CH

Mitgation of Ammonia Emissions through the use of Benzoic Acid in the Diet of Pigs

Metabolising benzoic acid to hippuric acid through fattening pig feed reduces the pH value in their liquid manure. In a comparative investigation with two groups, the ammonia emission reduction by using benzoic acid in pig fattening was quantified. Besides increasing fattening performance, the positive effect on ammonia emissions attained resulted in only one of four fattening batches having a consistent reduction (19 %). The emission-reductive effect of benzoic acid is closely correlated with the nutrient utilization by the animals and the buffer feature of the slurry.

For the reduction of ammonia emissions from pig fattening units, there are various process-integrated measures, which in contrast to “end of pipe solutions“ have the advantage of preventing the formation of ammonia and therefore improving the air quality of the unit. As a process-integrated measure to reduce emissions, benzoic acid can be added to the feed of fattening pigs. The use of benzoic acid can reduce the pH value of the slurry, as it is taken up in the gut and in the presence of glycine from the liver, is detoxified to hippuric acid. Through the excretion of hippuric acid, the pH value of the urine is reduced [1].

[2] carried out a feeding experiment in which an acidic mix with 70% benzoic acid was used. In three fattening periods which were investigated, they found variations in emission reductions between 13% and 50%. The investigations of [3] and [4] were carried out over a fattening period with discontinuous measurements. [3] established a reduction in NH_3 emissions of about 40%, while [4] found a NH_3 reduction of 24%.

In the investigation presented here, the intention is to establish whether the desired reductions in emissions can be reproduced at operational changes in the keeping conditions, and in particular whether the addition of benzoic acid as a means of reducing emissions is applicable within the framework of legally acceptable standards in authorisation procedures for new units.

Animals, Materials and Methods

The investigation was carried out in a fattening pig farm with four similar compartments each containing 120 pigs. Two of the compartments were used for the comparative study. In four fattening batches, the compartments for the benzoic acid (BA) and the reference group (R) were alternated. The feed was offered ad libitum with automatic mash feeders. The feedstuff was identical for both groups, with the exception that the test group received a benzoic acid supplement of 1%. The feed consumption level was measured through separate feed silos.

The energy and crude protein in the feed was adapted to the growth development of the animals within the framework of a RAM feeding programme. The energy content was reduced from 13.4 MJ at the beginning of the fattening period to 12.6 MJ at the end of the fattening period, and in the same way the crude protein content was reduced from 17% to 14%. In the first fattening period, protein-reduced phase feeding was not applied because of the poor live weight gain.

The measurement of gas concentrations was carried out continuously by a photoacoustic spectrometer (Innova Air Tech Instrument, DK). In order to be able to carry out parallel measurements in both compartments, a multi sampler was used. The air samples were taken from the exhaust ducts behind the measuring fan. To conduct the

Dr. Ralf Kosch is member of the scientific staff and Prof. Dr. Ir. Herman Van den Weghe is head of the chair Process Technology in Animal Production of the University Göttingen, Universitätsstr. 7, 49377 Vechta; e-mail: *ralf.kosch@agr.uni-goettingen.de*. Jiri Broz is member of the staff of DSM Nutritional Products Company, Animal Nutrition and Health R&D, Basel/CH.

Keywords

Ammonia, emission, feeding, pig, benzoic acid

Table 1: Effect of benzoic acid on the performance of pigs in the fattening periods (M1-M4)

	M1		M2		M3		M4	
	R	BA	R	BA	R	BA	R	BA
Starting weight [kg/animal]	47.2	44.2	34.7	34.9	31.7	31.3	35	35.6
Feeding day	29		11		6		5	
End weight [kg/animal]	92.8	95.8	101.3	103.2	97.9	102.2	108.1	111.9
Feeding day	99		88		90		90	
Daily gain [g/d]	651	738	865	887	788	844	860	898
Increase [%]		13		2.5		7.0		4.4
Feed conversion [kg / kg]	2.86	2.83	2.55	2.48	2.64	2.58	2.64	2.61

R: Reference; BA: Benzoic acid

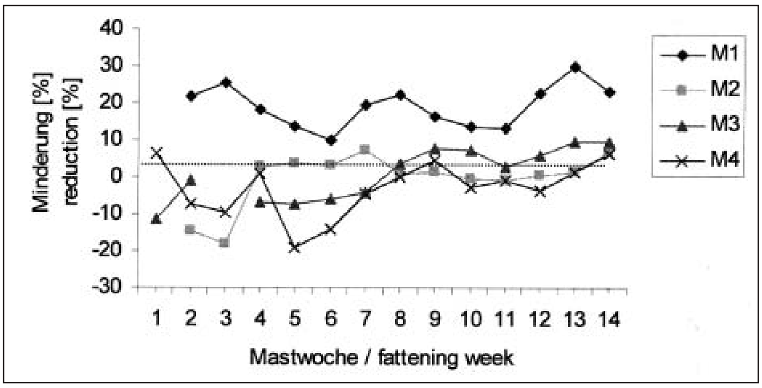

Fig. 1: Course of ammonia reduction in the four fattening periods (average weekly values)

Conclusion

With the addition of benzoic acid to the diet of fattening pigs, ammonia emissions can be positively affected. The reductions in emissions increase during the course of the fattening cycle and are affected by a number of factors. With a diet adapted to nutrient content with low nitrogen excesses (RAM), the effects of the benzoic acid are not as strong, compared with a high nutrient supply and a low live weight gain. As a procedure for a calculable reduction in emissions, no reproducible rate of reduction could be determined.

sample to the gas analyser, Teflon tubes (PTFE), which were heated to 45 °C, were used.

Liquid manure samples were taken from the slurry in regular intervals and analysed in the laboratory to establish the pH value. The sample was taken through the slatted floor at two sampling points. After sampling, the samples were frozen and analysed in the laboratory. At the end of the fattening period, the slurry was analysed for the factors which influence the ammonia emissions - DM, TN, C/N ratio, NH_4 and pH. Total carbon (TC) and Total nitrogen (TN) were analysed with the MACRO N from Elementar corp. Ammonia was digested with the Kjeldahl-method and measured with a photometer. The pH-influencing parameter as electrolyte content, with reference to the dietary electrolyte balance (dEB - mEq/l = Ca^{+}+K^{+}-Cl^{-}) and buffer capacity (titration with 1M HCL at pH 3) was investigated in the slurry.

The statistical evaluation was carried out with the Programme SPSS 14.0. The effects of the benzoic acid on ammonia emissions were calculated with a multivariate Analysis of Variance (GLM) on the basis of weekly average values. For the slurry analysis, two sampling times were used at the end of the fattening period. In both variance models, benzoic acid and fattening period are included as factors. The means of different slurry characteristics between the fattening periods were tested for statistical significance using Student-Newman-Keuls procedure.

Results

The increases in live weight were lowest in the first fattening period and consequently, the feed conversion was higher than in the following batches (*Table 1*). This is a result of an inferior state of health in the first fattening period. In the mean of the four fattening periods, higher daily gains could be attained with benzoic acid, amounting to 788 g d^{-1} in the reference compartment and 841 g d^{-1} in the compartment with benzoic acid. The average feed conversion was also improved in the group with benzoic acid, with values of 2.62 kg/kg and a shift of 0.05 kg/kg.

The reductions in ammonia levels turned out to be very different in the four fattening periods and are related to the observations for the fattening parameters. In the first fattening period, a large reduction was apparent, which produced an average 19 % reduction in emissions for the whole fattening period. However, the effects could not be reproduced in following fattening periods after the units were changed. The reduction rates were negative at the start of fattening; positive results occurred only later in the period (*Fig. 1*). Over the whole of the fattening period, no statistically significant reduction rate could be established.

The slurry analysis (*Table 2*) indicates significant differences for the factors C:N ratio, TN, NH_4, pH, dEB and buffer capacity between the fattening periods. In the analysis of variance, the benzoic acid did not significantly influence the pH value. The high emission reduction rate in the first fattening period can be referred back to the higher N concentrations (TN and NH_4) in the slurry. Similarly, the buffer capacity was lowest in the first fattening cycle, meaning that good conditions were present for the benzoic acid to reduce emissions. The parameters dEB, DM und C/N ratio have no significant relationship to ammonia emissions.

Literature

[1] *Kluge, H., J. Broz and K. Eder*: Effect of benzoic acid on growth performance, nutrient digestibility, nitrogen balance, gastrointestinal microflora and parameters of microbial metabolism in piglets. J Anim Physiol Anim Nutr. (Berl), 90 (2006), no. 7-8, pp. 316-324

[2] *Bridges, J. W., M.R. French, R.L. Smith and R.T. Williams*: The Fate of Benzoic Acid in Various Species. Biochem. J. 118, (1970), pp. 47-51

[3] *Brok, G.M.D., J.G.L. Hendriks, M.G.M. Vrielink and C.M.C.v.d. Peet-Schwering*: Urinary pH, ammonia emission and performance of fattening pigs after the addition of a mixture of organic acids, mainly benzoic acid to the feed. In: Praktijkonderzoek Varkenshouderij, 1997

[4] *Levrouw, L., and S. Godrie*: Fattening pigs experiment DSM Nutritional Products. Trial Report: 2003/18, Zoötechnisch Centrum, Faculteit der Landbouwkundige en Toegepaste Biologische wetenschappen, Belgie, 2003

[5] *Guingand, N., L. Demerson and J. Broz*: L'incidence de l'incorporation d'acide benzoïque dans l'alimentation des porcs charcutiers sur les performances zootechniques et l'émission d'ammoniac. 37èmes Journées de la Recherche Porcine, 2003

Table 2: Slurry characteristics in the four fattening periods (M1-M4)

FP	DM [%]	C/N	TN [%]	NH_4-N [%]	pH value	dEB[1] [mEq/l]	Buffer capacity[2] [ml/kg]
1	12.3	7.27^{b}	0.74^{c}	0.62^{c}	7.48^{a}	4377^{b}	694^{a}
2	11.0	7.38^{b}	0.68^{bc}	0.59^{bc}	7.54^{ab}	3994^{ab}	730^{ab}
3	11.1	8.42^{c}	0.60^{a}	0.56^{b}	7.76^{b}	3986^{ab}	732^{ab}
4	10.2	6.32^{a}	0.62^{ab}	0.52^{a}	7.74^{b}	3665^{a}	804^{b}

FP = Fattening Period
[1] deB = Ca^{+} K^{+}-Cl^{-} [2] Quantity of 1M HCl for a titration at pH 3