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Influence of adding 0.5 or 1.0% of benzoic acid on growth performance and urinary parameters of fattening pigs

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ABSTRACT

An experiment was conducted to examine the effects of adding benzoic acid to diets on the pH, ammonia and urea of the urine and performance of growing-finishing pigs. The study was carried out with 60 crossbred gilts (32 to 112 kg body weight) distributed among three treatments with each 20 animals (4 pens containing each 5 animals) fed diets differing in addition of benzoic acid: (1) negative control (no addition), (2) 0.5 % benzoic acid, and (3) 1.0% benzoic acid. In the growing period (32 to 70 kg body weight), addition of benzoic acid increased daily weight gain ($p<0.05$) and daily feed intake. Addition of 1.0% dietary benzoic acid improved the feed conversion rate about 2% points and lowered the duration of the fattening period by about 3.4 days ($p<0.05$) compared to the control group. In the finisher period (70 to 112 kg body weight), 0.5% benzoic acid showed the highest daily weight gain (893 g) and the shortest duration of fattening (46.4 days). Increasing additions of benzoic acid reduced the mean urinary pH significantly from 7.96 (control) over 7.67 (0.5% benzoic acid) to 7.25 (1.0% benzoic acid). Urinary ammonia, however, was significantly increased by rising additions of benzoic acid from 0.9 up to 1.9 mmol per mmol of creatinine. No significant differences were found between the treatments regarding urinary urea content. In conclusion, benzoic acid improved growth performance and lowered the pH in the urine which may contribute to reduction of ammonia emissions from excrements.

Keywords: benzoic acid, growing pigs, growth performance, urinary pH, urinary urea, urinary ammonia

INTRODUCTION

In context with the ban of antibiotic feed additives since 2006, organic acids are candidates to substitute the nutritive use of antibiotics and to compensate at least for a part of losses in pig production, which are expected to arise in the future. Benzoic acid might be one of the promising candidates of those organic acids, although its growth promoting potential has not been investigated in detail as for example formic acid formulations. This applies especially for the use in pigs for fattening. However, the addition of benzoic acid does not only influence the growth performance but should also reduce the ammonia emissions from excrements. Therefore, the objective of this study was to determine the effect of a benzoic acid formulation on growth performance in fattening pigs from modern crossbred Austrian breed (ÖHYB) under common feeding and housing conditions. Furthermore, the effect of benzoic acid on urinary parameter was to be examined.

MATERIAL AND METHODS

The study employed a total of 60 Austrian growing crossbred gilts (OEHYB). The animals arrived at the experimental station (Austrian Pig Testing Facility) with an average body weight of 32 kg and were distributed equally among 12 boxes (4 boxes of 5 gilts per treatment group) considering litter and initial body weight. Each box was equipped with an automatic dry-feeder and a nipple drinking systems. During the experiment, four casualties occurred, three in the control group and one in the group with 1.0% benzoic acid. One casualty in the control group had a fracture of the leg and the other three animals had to be removed due to insufficient growth during further course of fattening.

The animals received a grower and finisher feed. At an average body weight of the animals of 70 kg within one box, the feed was switched to the finisher diet. The grower and finisher diets were based on corn, soybean

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extracts, barley and wheat, providing nutrients according to recommendations (GfE 1987) (Table 1). The diets differed with respect to addition of benzoic acid: (1) negative control (no addition), (2) 0.5 % benzoic acid, and (3) 1.0% benzoic acid

The analysed nutrient concentrations of the grower and finisher diets are given in Table 1. The three grower and finisher diets were equally distributed among the twelve animal boxes (four boxes per diet) considering possible environmental influences (e.g. edge box). During the experiment, feed intake of each animal was recorded daily by a transponder system. Individual body weights were determined weekly. Pigs were allowed to consume pelleted feed and water ad libitum. All diets were analysed for dry matter (DM), crude protein (CP), crude fiber (CF), crude lipids (CL), crude ash (CA), starch and sugar according to standard methods (Naumann and Bassler, 1976). Concentration of metabolizable energy (ME) was calculated according to GfE (1987).

Spontaneous urine samples were retrieved from each pig at experimental week 3, 6, and 8. Each urine collection period lasted three days and was accomplished at 05:00 AM to 9:00 AM o'clock. Urine was analysed for pH value, urea, ammonia and creatinine using commercial test kits (urea and ammonia: R-Biopharm, Darmstadt, Germany; creatinine: Dia Team-Diagnostika und Arzneimittel, Germany).

The GLM procedure of SAS (SAS Inst., Inc., Cary, NC) was used to determine treatment effects by analysis of variance (ANOVA) using a randomized complete block design. The treatments were included in a 2 factorial arrangement to test the dietary concentration of benzoic acid, litter and interactions of benzoic acid x litter. The initial body weights were used as covariates for statistical analysis of growth performance. LSMeans of each treatment were compared using the Tukey test for each variable. The following tables present the mean values of the different feeding groups and the pooled standard error (S.E.) derived from the analysis of variance. Significant differences among means ($p<0.05$) are indicated by superscripts.

Table 1: Composition of the grower and finisher diets

	Grower period			Finisher Period		
Benzoic acid (%)	0	0.5	1.0	0	0.5	1.0
Treatment	1	2	3	1	2	3
			Ingredients (%)			
Corn	30.6	29.6	28.6	29.0	28.0	27.0
Wheat	17.0	17.0	17.0	33.0	33.0	33.0
Barley	20.0	20.0	20.0	11.0	11.0	11.0
Wheat bran	4.0	4.0	4.0	4.0	4.0	4.0
Soybean extracts (48/49 HP)	22.5	22.7	22.8	17.3	17.5	17.7
Food oil	1.0	1.34	1.67	0.50	0.84	1.17
Molasses	1.0	1.0	1.0	1.53	1.53	1.53
Mineral and vitamin supplement [1)]	3.33	3.33	3.33	3.15	3.15	3.15
Benzoic acid (%)	-	0.5	1.0	-	0.5	1.0
			Analyzed nutrients			
Dry matter, g/kg	902	899	896	882	884	890
Crude protein, g/kg	191	197	196	169	167	169
Crude lipids, g/kg	35	33	33	29	28	30
Crude fiber, g/kg	46	33	36	25	27	27
Crude ash, g/kg	64	59	57	53	53	71
Starch, g/kg	403	410	415	461	452	442
Sugar, g/kg	38	46	50	46	48	45
Benzoic acid, g/kg	1.0	5.1	10.2	0.0	4.9	10.0
ME, MJ/kg	13.32	13.70	13.73	13.74	13.60	13.47

[1)]Supplied per kg of grower (finisher) diet: 8.5 (8.5) g Ca, 6.6 (6.0) g P, 2.31 (2.01) g Na, 2.12 (2.11) g Mg, 16 (16) mg Cu, 105 (96) mg Fe, 3.7 (3.6) mg J, 58 (61) mg Mn, 0.54 (0.58) mg Se, 76 (77) mg Zn, 8000 (8000) IU vitamin A, 1500 (15009 IU vitamin D3, 99.5 (99.5) mg vitamin E, 2.0 (2.0) mg vitamin K3, 1.0 (1.0) mg vitamin B1, 3.0 (3.0) mg vitamin B2, 3.0 (3.0) mg vitamin B6, 20 (20) ěg vitamin B12, 20 (20) mg nicotinic acid, 10 (10) mg pantothenic acid, 1000 (1000) ěg folic acid, 161 (161) mg choline chloride, 75 (75) µg biotin

RESULTS AND DISCUSSION

Diets

The chemical composition of the grower and the finisher diets was comparable for all treatment groups (Table 1), but metabolizable energy (ME) content calculated according to GfE (1987) showed some variations. Analyzed dietary crude protein concentration was generally slightly higher than the calculated concentrations, but treatment differences were marginal. Analyzed benzoic acid contents of 0.1%, 0.5% and 1.0% in the grower diets and of 0.0%, 0.5% and 1.0% in the finisher diets agree very well with pre-planned dietary benzoic acid concentrations.

Growth performance

Data of growth performance in the grower and the finisher period are given in Table 2. In the grower period (32 to 70 kg BW), addition of benzoic acid reduced ($p<0.05$) length of time span to reach 70 kg BW in a dose-related manner from 44.8 to 41.4 days, but increased daily weight gain significantly ($p<0.05$) from 867 to 928 g/day. Feed Conversion Ratio (FCR) was numerically reduced in benzoic acid supplemented groups, but treatment differences were not significant. During the finisher period (70 to 112 kg BW), growth rate in animals fed the 0.5% benzoic acid supplemented diet (893 g/day) was numerically higher than in the unsupplemented control group (879 g/d), but highest benzoic acid concentration of 1.0% tended to decrease daily gains to 838 g. The FCR of 2.72 in the unsupplemented control group and the 0.5% benzoic acid group, however, was lower ($p<0.05$) than observed in animals fed the 1.0% benzoic acid diet (2.87). Nevertheless, this observation may not be interpreted in terms of a growth depressive effect of 1.0% benzoic acid for finishing pigs. It is more likely the consequence of the more intensive weight gain during the grower phase, which might have resulted in an earlier decline of final growth capacity at the end of the finisher phase.

Improvement in growth due to addition of benzoic acid observed in the growing pigs in the present experiment is comparable to literature data. Van der Peet-Schwering et al. (1999) observed significant improvements of daily weight gain, feed intake and FCR in 43 to 109 kg pigs due to the inclusion of 1.0% benzoic acid in the diet. Similarly, over the whole fattening period, daily gains were numerically increased by 1.9 % and FCR was significantly reduced from 2.72 to 2.64 when pigs were fed a 0.7% benzoic acid diet in the grower stage (26 to 42 kg) and a 1.4% benzoic acid diet in the finisher stage (42 to 108 kg), respectively (Den Brok et al. 1999). Also in an experiment reported by Guingand et al. (2005), growth performance in growing to finishing pigs (30 to 115 kg BW) was positively affected by addition of 0.5% benzoic acid to the diet. The average daily weight gain increased by about 6% points and the FCR improved by about 5% points, respectively. In agreement with the positive effects on growth performance in growing pigs of the present study, those results clearly confirm the potential of dietary additions of benzoic acid to enhance performance of fattening pigs.

pH, urea, ammonia and creatinine in the urine

Ammonia (NH3) in pig slurry originates predominantly from urea, whereby urea in the urine is quite persistent. However, when urea comes in contact with the enzyme urease, volatile NH3 is produced. Urease is ubiquitous in faeces and consequently contact between urea and urease occurs easily in commercial pig farms (Aarnink et al., 1993). Urease oxidises free ammonia only at high pH values (Pommerening-Röser and Koops, 2005). Thus, a low pH-value in slurry is important in order to reduce ammonia emission.

In the present study, addition of 0.5 and 1.0% benzoic acid reduced mean urinary pH significantly from 7.96 in the negative control group to 7.67 and 7.25, respectively (Table 3). This effect was consistent in all 3 collection periods. Urinary creatinine concentration increased with rising body weight of animals from 8 to 12 mmol/L, but did not differ between treatments. Using creatinine for reference, benzoic acid did not affect urinary urea (on average 19 mmol per mmol creatinine). Urinary ammonia, however, was significantly increased ($p<0.05$) by rising additions of benzoic acid from 0.9 up to 1.9 mmol per mmol of creatinine. Comparable to pH-values, this effect was consistent for all 3 collection periods. The reduction of urinary pH in the present study is in agreement to other authors dealing with effects of benzoic acid in fattening pigs. Urinary pH was decreased about 1.8 points in starting pigs (26 to 42 kg BW) fed a 0.7% benzoic acid diet and about 2.5 points in finishing pigs (43 to 109 kg BW) fed a 1.4% benzoic acid diet, respectively (den Brok et al., 1999). Congruently, van der Peet-Schwering et al. (1999) demonstrated a dietary supplementation of benzoic acid to lower urinary pH significantly from 7.52 (control) to 6.45 and to 5.59 at inclusion levels of 1 and 2% benzoic acid, respectively. A significant reduction of urinary pH of about 0.9 points as a result of adding 1% benzoic acid to the feed was also found in a study from Guingand et al. (2005). Therefore, benzoic acid is demonstrated to be an effective tool to reduce urinary pH, what, in turn, is considered to effectively reduce ammonia emissions from excrements. Besides positive effects on environment, reduced gaseous NH3 exposure of the pigs may also positively affect health of the animals. This effect is also confirmed by the higher NH3 contents in urine of animals treated with benzoic acid because higher urinary NH3 concentrations result in gaseous losses.

Table 2: Growth performance during the grower and finishing period

Benzoic acid (%)	0	0.5	1.0	
Treatment	1	2	3	S.E.
		Grower period (32 to 70 kg of body weight)		
Number of pigs	17	20	19	-
Days on experiment	44.8a	43.4a	41.4b	2.4
Initial weight, kg	30.9	31.9	33.3	4.3
Final weight, kg	69.8	71.1	71.6	4.0
Daily weight gain, g/d	867b	903ab	928a	69
Daily feed intake, g/d	1796	1828	1881	144
Feed conversion, (feed/gain), g/g	2.07	2.02	2.03	0.11
		Finisher period (70 to 112 kg of body weight)		
Number of pigs, n	17	20	19	
Days on experiment	48.7	46.4	49.1	8.4
Initial weight, kg	69.8	71.1	71.6	4.0
Final weight, kg	112.1	111.3	112.3	2.4
Daily weight gain, g/d	879	893	838	101
Daily feed intake, g/d	2388	2405	2401	246
Feed conversion (feed/gain), g/g	2.72b	2.72b	2.87a	0.18

a, b) Means of the same parameter without common superscripts are statistically different ($p < 0.05$)

Table 3: Urinary pH; urinary urea/creatinine1) ratio, urinary ammonia/creatinine ratio and contents of urea and ammonia in the blood plasma

Benzoic acid (%)		0	0.5	1.0	
Treatment		1	2	3	S.E.
Urinary pH					
Week 3		8.11a	7.90a	7.48b	0.45
Week 6		7.98a	7.75a	7.12b	0.39
Week 8		7.81a	7.37b	7.13b	0.46
Average		7.96a	7.67b	7.25c	0.46
Urinary urea content relative to creatinine					
Week 3	mmol/mmol	17.8	18.9	20.5	8.0
Week 6	mmol/mmol	19.1	17.1	20.6	6.4
Week 8	mmol/mmol	23.5	19.5	17.5	11.2
Average	mmol/mmol	20.3	18.5	19.5	8.8
Urinary ammonia content relative to creatinine					
Week 3	mmol/mmol	0.73b	1.58ab	2.67a	1.89
Week 6	mmol/mmol	0.57b	0.80ab	1.30a	0.79
Week 8	mmol/mmol	1.37	1.26	1.77	1.47
Average	mmol/mmol	0.90b	1.21b	1.94a	1.49

[a, b, c)] Means of the same parameter without common superscripts are statistically different ($p < 0.05$)

[1)] Urinary creatinine content as an average of all feeding groups was 8.0 mmol/L, 11.9 mmol/L and 12.1 mmol/L for measurements 1 to 3.

CONCLUSION

Benzoic acid has been approved as a new feed additive for growing pigs. Dietary supplementation results in higher growth performance and in a decrease of urinary pH, accompanied by a reduction in ammonia emission.

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