EFFECTS OF ORGANIC ACID BLEND ON GROWTH PERFORMANCE, NUTRIENT DIGESTIBILITY AND CONCENTRATION OF VOLATILE FATTY ACIDS IN THE FAECES OF YOUNG PIGS

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ABSTRACT

The objective of this experiment was to evaluate the effects of a feeding diet containing a dry organic acid blend (lactic acid—ammonium formate—ammonium propionate—citrate—sorbate) in young pigs on their: performance, the apparent total tract digestibility of nutrients and the concentration of volatile fatty acids in their faeces. A total of 12 crossbred pigs (Slovakian White × Landrace) with an initial live weight of 12.78 ± 1.86 kg were divided into two dietary treatments. The experimental period lasted 28 days. Pigs were fed a control diet (control group) or a diet supplemented with a dry organic acid (OA) blend, 0.6 g per 100 g feed (experimental group). Compared with the control group, the average daily gain (ADG) was improved ($P < 0.05$) by OA blend over the period of the investigation (0–28 days). For the apparent total tract digestibility determination, ash which is insoluble in hydrochloric acid was used as a marker. The apparent total tract digestibility of crude protein and total ash was improved ($P < 0.05$) by the OA blend in the experiment. Compared with the control

group, the concentration of the total volatile fatty acid in the faeces increased ($P < 0.05$) in pigs supplemented with the OA blend. The concentration of butyric acid in the faeces tended to be higher ($P < 0.01$) in pigs supplemented with the OA blend compared with the control group. In conclusion, the addition of 0.6 g per 100 g feed had a positive effect on: growth performance, total tract digestibility of crude protein and the concentration of volatile fatty acids in the faeces of young pigs.

Key words: digestibility; growth performance; organic acids; pigs; volatile fatty acids

INTRODUCTION

Young pigs, especially after weaning are exposed to various multiple stressors, including changes in diet composition, surrounding environment, and microbial challenges [6]. In-feed antibiotic growth promoters have been widely used for reducing harmful microbial activity and gastrointestinal disease in pigs after weaning [8, 27]. In

January 2006, antibiotic growth promoters were prohibited for use in animal feeds in the European Union. Due to the increasing safety concerns about the risk of spreading antibiotic resistance in the environment, and the presence of chemical residues in animal products, using organic acids to replace antibiotic in the diet of farm animals has increased considerably in recent years [19]. The inclusion of dietary organic acids as an alternative to antibiotic addition was evaluated in several studies using weaned pigs and in growing and finishing swine [1, 5, 24]. A number of studies have highlighted the potential effects of organic acids in improving digestion, nutrient digestibility and the promotion of growth performance in pigs [13, 14, 17].

The most commonly used organic acids include formic acid, fumaric acid, lactic acid, propionic and citric acids. Lactic acid has been reported to reduce gastric pH and to be more effective than other organic acid in improving the growth performance of pigs [25].

The results of organic acids blends are not always consistent, and the response to dietary organic acid blend could be affected by: the type of organic acids, dosage, feed formula, and the age of the animals [19]. The inconsistent responses to dietary acidifiers could be explained by: feed palatability, sources and composition of the diet, supplementation level of acidifier and the age of the animals [11].

This fact motivated us to determine the effects of feeding a diet containing dry organic acid blend in young pigs on: performance, total tract digestibility of nutrients and concentration of volatile fatty acids in the faeces.

MATERIALS AND METHODS

Animals, diets and experimental design

A total of 12 crossbred pigs (Slovakian White × Landrace) with an average body weight (BW) of 12.78 ± 1.86 kg were used for a 4-week trial (28 days). Pigs were divided into two groups; the control group (CG) and the experimental group (EG) with 6 pigs in each group. Both groups contained equal numbers of females (2) and castrated males (4).

The same feed components for the control and the experimental groups were used in the experiment: corn, wheat, barley, soybean meal, whey derivative, rapeseed oil and premix of minerals and vitamins. The diets used in this experiment were formulated to meet the requirements of

the NRC [18]. The experimental group diet was supplemented with dry organic acid (OA) blended in an amount of 0.6 g per 100 g diet. The characteristics of the supplemented OA blend were as follows: lactic acid, ammonium formate, ammonium propionate, citrate, and sorbate (ash 39.0 %).

Diet analysis

The diets were analysed for their dry matter (DM), crude protein (CP), crude fibre (CF), ether extract (EE) ash as well as ash which is insoluble in hydrochloric acid according to the EC Commission Regulation [4]. The nitrogen free extract (NFE) was mathematically calculated according to the formula $NFE = DM - CP - EE - CF - Ash$. The concentrations of dietary metabolizable energy were calculated according to Š i m e č e k et al. [23]. The results of the diet analyses are shown in Table 1.

Table 1. Chemical composition (g.kg⁻¹, as fed basis) of diets

	Control diet	Experimental diet
	Analysed content [g.kg ⁻¹]	
DM	894.8	892.5
CP	185.5	188.5
EE	34.7	34.6
CF	32.7	33.0
Ash	49.5	56.9
NFE	592.4	579.5
ME [MJ.kg ⁻¹]	13.65	13.60

DM—dry matter; CP—crude protein; EE—etheric extract; CF— crude fibre; NFE— nitrogen free extract; ME—metabolizable energy

Both groups (CG and EG) were fed twice per day. The pigs had free access to water *ad libitum*. Water was also provided directly in the trough during meals. Feed consumption and pigs' weight were recorded weekly to determine the average daily gain (ADG) and the feed conversion ratio (FCR) which were calculated at the end of the experiment. The investigation was carried out in the animal quarters of the Department of Animal Nutrition and Husbandry at the University of Veterinary Medicine in Košice.

Nutrient digestibility

For the apparent total tract digestibility determination, acid-insoluble ash was used as a marker. The faeces were taken directly from the rectum at the end of the investigation individually from each animal. The samples were immediately frozen at -20°C until analysis. Each sample of faeces was pre-dried at 60°C . All samples were ground to pass through a 1-mm sieve before analysis. Faecal samples were analysed in the same way as for diets.

Volatile fatty acid concentration

Fresh faecal samples collected on day 28 were used for the analysis of volatile fatty acids (VFA). The quantitative determination of the main volatile fatty acids (VFA): acetate, propionate, and butyrate, were done by the method of isotachopheresis employing a two-capillary analyser EA100 (VILLA LABECO, Slovakia). The total volatile fatty acid (TVFA) concentration in the faeces was calculated as a sum of acetate, propionate and butyrate concentrations.

Statistical methods

All data were reported as the mean $\pm$ SD (standard deviation). The differences between means were determined according to the unpaired t-test using Graph-Pad Prism software, USA). By conventional criteria, the differences $P < 0.05$ were considered to be of statistical significance.

Ethical statement

The research was approved by the UVLF Ethics Committee in accordance with applicable national and international animal welfare legislation.

The authors declare that there was no conflict of interest.

RESULTS

Growth performance

The means and standard deviations for growth performance, initial live weight of animals (day 0) and live weight at the end of the experiment (day 28) are given in Table 2. Compared with the control group, the pigs fed the experimental diet supplemented with a dry organic acid blend had greater ($P < 0.05$) average daily gains (ADG) ($+45\text{ g}\cdot\text{day}^{-1}$). The feed efficiency in pigs was measured via feed consumed per unit of gain. The feed conversion ratio (FCR) which was measured as the feed intake over a period divid-

ed by the average daily gain (ADG). The FCR was a little higher in pigs fed the control diet ($+0.02\text{ kg feed}\cdot\text{kg}^{-1}\text{ gain}$) compared to the experimental group.

Table 2. Effects of organic acid blend supplementation on the performance of the pigs (means $\pm$ SD)

Diet	Control (CG) n = 6	Experimental (EG) n = 6
	Live weight [kg]	
Initial (day 0)	12.83 $\pm$ 1.82	12.72 $\pm$ 1.89
Final (day 28)	30.20 $\pm$ 2.87	31.35 $\pm$ 2.90
ADG [g]	620.4 ^A $\pm$ 35.2	665.3 ^B $\pm$ 34.3
FCR gain [kg feed $\cdot$ kg ⁻¹]	1.79	1.77

ADG—Average daily gain; FCR—Feed conversion ratio;
SD—Standard deviation; A, B—significant at $P < 0.05$

Apparent nutrient digestibility

Our findings showed a tendency for an improvement of the apparent total tract digestibility of nutrients after supplementation of the diet with the mixed organic acids in young pigs (12 to 30 kg of live weight). Compared with the control group, pigs fed with the dry organic acid blend increased ($P < 0.05$) the apparent total tract digestibility of crude protein and ash, by approximately 2.9 % and 4.6 % respectively (Table 3). It is generally considered that dietary organic acids lower the gastric pH, resulting in increased activity of proteolytic enzymes and thus improved the protein digestion. As regard to ash, it may be also due to the higher content of ash in the experimental diet after the dry organic acid blend administration.

The apparent total tract digestibility of fat, crude fibre

Table 3. Coefficients of digestibility (CD) in pigs (Mean $\pm$ SD)

Parameter [%]	Control group	Experimental group
CP	78.50 ^A $\pm$ 2.02	81.40 ^B $\pm$ 1.77
Fat	65.70 $\pm$ 2.83	67.20 $\pm$ 2.92
CF [%]	33.50 $\pm$ 2.88	34.50 $\pm$ 2.62
Ash [%]	39.30 ^A $\pm$ 2.98	43.90 ^B $\pm$ 2.77
NFE [%]	85.20 $\pm$ 2.06	87.50 $\pm$ 1.80

CP—crude protein; CF—crude fibre; NFE—nitrogen free extract
A, B—significant at $P < 0.05$

and nitrogen free extract were also improved (fat +1.5 %, crude fibre +1 % and nitrogen-free extract +2.3 %) in pigs supplemented with a diet containing a mixed of organic acids compared to the control group; but these differences were not statistically significant. The NFE represents soluble carbohydrates and other digestibles and easily utilizable non-nitrogenous substances in the feed.

Volatile fatty acids in the faeces

Compared with the control group, the concentration of the total volatile fatty acids (TVFA) in the faeces was improved ($P < 0.05$) in pigs supplemented with the organic acid blend (Table 4). The content of acetic and propionic in the faeces were also increased by the supplement of the organic acids blend compared with the control group, but these differences were not statistically significant. We observed higher ($P < 0.01$) concentration of butyric acid in the faeces of pigs from the experimental group compared with the control group.

Table 4. Effects of organic acid blend on the volatile fatty acids concentration in the faeces (g.kg^{-1}) (means $\pm$ SD)

	Control group	Experimental group
Acetic acid	3.73 ± 0.38	4.15 ± 0.40
Propionic acid	2.46 ± 0.21	2.76 ± 0.30
Butyric acid	$1.22^A \pm 0.10$	$1.46^C \pm 0.09$
TVFA	$7.41^A \pm 0.69$	$8.37^B \pm 0.79$

TVFA—Total volatile fatty acids;

A, B—significant at $P < 0.05$; A, C—significant at $P < 0.01$

DISCUSSION

Acidifiers are often used as alternatives to antibiotic growth promoters because of their ability to create a favourable intestinal environment for the beneficial microbes which may result in increased nutrient digestibility and increased growth performance [12]. Dietary acidifiers may be organic or inorganic acids or salts of acids [21, 22]. In our study, we reported the effects of feeding a diet containing a dry organic acid blend on the: performance, total tract digestibility of nutrients and concentration of volatile fatty acids in the faeces of young Slovakian White x Lan-

drace pigs (12 to 30 kg of live weight). The applied organic acid (OA) blend consisted of a mix of: lactic acid, ammonium formate, ammonium propionate, citrate, and sorbate.

In the results of the current study, ADG was positively significantly affected by dietary inclusion of dry organic acid blend in the experimental diet (0.6 g OA blend in 100 g diet). Also the FCR parameter was improved in pigs fed the experimental diet.

This is in agreement with Grili et al. [7], who reported that the addition of a mixture of citric acids and sorbic acids resulted in improved growth performance of pigs. Likewise, the addition of a blend of organic acids (fumaric, lactate, citric, propionic, and benzoic acids) followed by a blend of phosphoric, fumaric, lactic, and citric acid improved the growth performance of newly weaned pigs in the study of Walsh et al. [26].

Similarly, Øverland et al. [20] also reported that weaned pigs fed with a diet containing formic acid had a significantly improved ADG and feed efficiency compared with pigs fed a diet without OA supplementation. The study of the Long et al. [13] demonstrated that organic acids supplementation, which contained butyrate, sorbic acid combined with other short and medium chain fatty acids significantly improved ADG and feed efficiency in weaned pigs compared with a control group during all periods of the experiment.

The improved performance in pigs fed diets containing OA blend in the present study could be associated with greater digestibility of the organic nutrients and total ash. The improvement in apparent total tract digestibility (ATTD) of nutrients for pigs fed with OA blend in this study compared with the control group is in agreement with the results of Mroz et al. [16], who reported that the ATTD of crude protein was increased by OA (especially formic acid) supplementation, likely because OA can improve the activity of pepsin and trypsin.

It is generally known that dietary acidifiers lower gastric pH, resulting in an increased activity of proteolytic enzymes and improved protein digestibility [11]. Although the organic acid supplementation was initially targeted for weaned piglets, there is growing evidence that dietary acidification may also be beneficial for the performance of fattening pigs [22]. Some previous results have indicated that in fattening pigs, organic acids improved the apparent ileal digestibility of protein and amino acids [10, 15, 16] and absorption of minerals [9].

The volatile fatty acids, produced by microbial fermentation of carbohydrates in the gastrointestinal tract, are beneficial to the animal [2]. In the current study, OA blend as a feed additive resulted in a significantly higher TVFA content in the faeces. Although the differences among the coefficients of digestibility of CF and NFE were not statistically significant, the higher apparent total tract digestibility of CF and NFE (+1 % and 2.3 % respectively) in pigs from the experimental group indicated that the OA blend promoted the microbes to utilize carbohydrates to produce volatile fatty acids.

The results of the Long et al. [13] study indicated that the concentration of TVFA in faeces was significantly improved in pigs supplemented with mixed OA and the content of acetic, propionic and butyric acid in faeces were also increased by the supplement of organic acids compared with the control group.

The volatile fatty acids, especially butyric acid, produced by fermentation of carbohydrates in the large intestine, had a positive effect on the epithelial cell growth and absorptive functions in pigs [2, 3], which partly agrees with our results.

CONCLUSIONS

The present study demonstrated that the overall growth performance was improved in pigs fed diets supplemented with mixed organic acids when compared with pigs fed with the control diet without organic acid blend. The results could be due to the improvement in apparent total tract digestibility of total proteins and ash by mixed organic acids supplementation. The results suggested that an organic acid blend can be used with positive effects on: the performance, protein digestibility and total volatile fatty acids content in the faeces in the category of young pigs (12 to 30 kg of live weight).

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