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Effects of carbadox or formic acid and diet type on ileal digestion of amino acids by pigs

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ABSTRACT

Endogenous flows and true ileal digestibilities of amino acids were determined with the homoarginine method in growing pigs fed barley-soyabean meal or by-product-soyabean meal diets plus 50 mg/kg carbadox, or 8 g/kg formic acid (85% v/w) or without either of these additives. Seven barrows (one reserve) equipped with T-cannulae according to the steered-ileo-caecal-valve method were fed these diets in a 6 x 4 cyclic change-over design from 39 to 83 kg live weight. Both carbadox and formic acid improved the apparent ileal digestibilities of several essential amino acids in the by-product-based diet but not in the barley-based diet. The improvements were due to reduced endogenous amino acid losses. Neither carbadox nor formic acid affected the true ileal digestibility of lysine.

KEY WORDS: amino acids, ileal digestion, pigs

INTRODUCTION

Antimicrobial feed additives are commonly used in grower diets in order to promote the performance of pigs and prevent diseases. However, concern over increased bacterial resistance to drugs caused by the routine use of antimicrobials has led to a search for alternatives, such as organic acids. Organic acids have been shown to enhance the performance of growing pigs (Baustad, 1993; Øverland and Lysø, 1997), but information about their modes of action is scarce. It has been suggested that dietary acidification limits microbial growth, increases enzyme activities and improves protein digestion (Kirchgessner and Roth, 1988). Mosenthin et al. (1992) and Kemme et al. (1995) have reported improved apparent ileal digestibilities (AID) of amino acids, by 2 to 7 %-units, in growing pigs fed acidified

diets. The observed variation in the digestibility responses may be due to differences in the dose and type of acid used, as well as in the diet composition. Whether the improved AID are due to decreased endogenous nitrogen losses (ENL) or increased true ileal digestibilities (TID) is not known. Thus, we studied the effects of carbadox and formic acid on the AID and TID of amino acids in growing pigs fed simple barley-based or complex by-product-based diets.

MATERIAL AND METHODS

A barley-based (765 g/kg barley, 211 g/kg soyabean meal) and a by-product-based diet (566 g/kg barley, 199 g/kg soyabean meal, 180 g/kg wheat bran-middlings, 20 g/kg wheat syrup, 12 g/kg rape seed oil) were formulated to be similar in energy (9.1 MJ NE/kg) and lysine content (7.8 g/kg) and to meet the vitamin and mineral requirements of growing pigs. Either 50 mg/kg carbadox, or 8 g/kg formic acid (85 %, v/w) or no additives were included in these diets. Seven barrows (one reserve) equipped with T-cannulae according to the steered-ileo-caecal-valve method (Mroz et al., 1996) were fed these diets in a 6 x 4 cyclic change-over design from 39 to 83 kg liveweight. The feeds were given twice daily by liveweight (90 g feed/kg $W^{0.75}$/d) in the form of wet mash (water to feed = 1.5:1). Chromium-mordanted straw (71 g Cr/kg) was used as marker (1.6 g/kg feed).

Ileal digesta were collected on d 10 and d 14 for 12 h to determine the AID and TID, respectively. To determine the TID and endogenous flow of lysine, the pigs were fed diets in which 50% of soyabean meal was replaced with guanidinated soyabean meal prepared in a 0.6 M *O*-methylisourea solution at pH 10.5 for 6 d (Imbeah et al., 1996). Prior to the homoarginine feeding, the pigs were fed three protein-free meals. Endogenous flows of other amino acids were calculated in relation to lysine by using the endogenous amino acid profile determined by de Lange et al. (1990).

Amino acids and homoarginine were analysed by Biochrom 20 Amino Acid Analyser after hydrolysis in 6 M HCl at 110°C for 23 h. For methionine and cystine analysis, the performic acid oxidation (at 0°C for 16 h) was performed prior to the hydrolysis. The data were subjected to a least-squares analysis of variance with the effects of animal, period, diet and additive and diet x additive interaction in the model. The differences between the additives were compared by the orthogonal contrasts: no additives vs carbadox/formic acid and carbadox vs formic acid.

RESULTS AND DISCUSSION

Carbadox and formic acid improved the AID of several amino acids in the by-product-based diet, but not in the barley-based diet (Table 1). Similar improve-

TABLE 1

Apparent ileal amino acid digestibilities (%) and ileal flow (mg/kg dry matter intake) and true ileal digestibility (%) of lysine in barley or by-product-based diets fed without additives or with carbadox or formic acid

Diet	Barley-based			By-product-based				Significance		
Additive[1]	–	carbadox	formic acid	–	carbadox	formic acid	Root MSE	diet	additive	diet x additive
n	4	3	5	4	4	3				
Apparent digestibility										
arginine[b]	88.0	87.5	88.4	85.9	87.6	87.5	0.89	0.059	0.169	0.119
cystine[b,c]	76.1	76.4	77.5	75.0	75.4	78.0	1.10	0.334	**0.012**	0.404
histidine[b]	82.8	82.6	83.7	80.1	82.9	82.4	0.94	**0.027**	**0.025**	**0.045**
isoleucine[b]	82.8	82.5	83.5	80.2	82.7	82.5	1.20	0.097	0.098	0.148
leucine[b]	84.0	83.9	84.6	81.6	83.9	83.6	1.01	**0.043**	0.071	0.127
lysine[b]	82.1	82.1	83.6	78.5	82.0	81.5	1.34	**0.017**	**0.024**	0.106
methionine	80.3	79.5	80.6	77.4	78.5	79.5	1.71	0.075	0.437	0.509
phenylalanine[b]	84.7	83.9	84.8	82.6	84.6	83.8	1.03	0.165	0.467	0.095
threonine[b]	76.0	76.0	76.8	72.7	76.0	75.7	1.18	**0.034**	**0.028**	0.078
tyrosine[b]	79.7	79.0	81.2	76.5	80.1	78.3	1.38	**0.040**	0.099	**0.036**
valine	82.8	83.0	84.3	80.7	82.7	82.7	1.79	0.169	0.216	0.651
Ileal lysine flow										
Total[b]	1871	1815	1619	2010	1670	1711	131.8	0.664	**0.009**	0.165
Endogenous[a,b]	1301	1390	1067	1585	1200	1295	160.2	0.207	**0.038**	**0.049**
True lysine digestibility	94.5	95.8	94.4	95.5	94.9	95.6	1.48	0.581	0.911	0.416

[1] the analysed carbadox contents of the barley and by-product-based diets were 52 and 47 mg/kg respectively; formic acid decreased the dietary pH to 4.8 from 5.9 and 6.0 respectively

[a] denotes significant difference ($P<0.05$), carbadox vs. formic acid on the barley-based diet,

[b] denotes significant difference ($P<0.05$), no additive vs. carbadox or formic acid on the by-product based diet

[c] denotes significant difference ($P<0.05$), carbadox vs. formic acid on the by-product-based diet

ments in the AID of amino acids have been previously observed in growing pigs following dietary acidification (Mosenthin et al., 1992; Kemme et al., 1995). In those studies the digestion response was greater when a by-product-based diet (Mosenthin et al., 1992) was used rather than a maize-soyabean meal diet (Kemme et al., 1995). Carbadox improved (Yen et al., 1976) or had no effect on the apparent total tract digestibility of protein (Danielsen and Oksbjerg, 1990), whereas information about its effects on the AID of amino acids is limited.

The observed improvements in the AID of amino acids in the by-product-based diet were due to reduction in the ENL. The additives did not affect the TID of lysine or other amino acids. The ENL mainly consists of undigested pancreatic juice, bile, mucus and sloughed cells, but the contribution of bacterial protein can increase considerably with dietary fibre (Schulze et al., 1994). The higher neutral detergent fibre content in the by-product based diet (219 vs 188 g/kg dry matter (DM)) increased the endogenous lysine flow by 284 mg/kg DM intake. Because both antimicrobial feed additives and organic acids inhibit microbial growth (Kirchgessner and Roth, 1988), the decrease in the ENL in the by-product-based diet may reflect a decrease in bacteria-produced protein in the ileal digesta (Schulze et al., 1994).

In conclusion, carbadox and formic acid appear to improve the AID of amino acids by reducing ENL rather than by improving the TID of amino acids, although these effects seem to depend on diet composition. A reduction in ENL will not only contribute to a reduction in nitrogen excretion, but will also improve the efficiency of dietary amino acid utilisation for growth.

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