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Effect of Fat Type and Calcium Level Supplementary on Growth Performance, Fat Digestibility, and Ca and P Absorption and Balance in Growing-Finishing Pigs

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ABSTRACT

The study was carried out to investigate the effect of two different fat types (beef tallow and sunflower oil) and level of dietary calcium (high and low) on growth performance, nutrient digestibility, calcium – phosphorus absorption and balance in growing-finishing pigs. Four castrated male pigs were designed in 4 × 4 Latin square with two weeks a period. The results showed that the supplementation of calcium tended to increase the apparent fat digestibility and increased significantly ($p<0.05$) the absorption and balance of calcium, but it was no influence on absorption and balance of phosphorus. It could be concluded that supplementation of vegetable oil with calcium at low level (minimal requirements) are suitable and adequate, respectively, for growing-finishing pigs.

Key words: fat type, digestibility, absorption, calcium and phosphorus

INTRODUCTION

Presently, the consumer increasingly prefers animal products with a higher unsaturated fatty acid composition because of beneficial effect in preventing cardiovascular diseases (Monique *et al.*, 1996). Vegetable oils, higher in unsaturated fatty acids, have a higher digestibility than animal fats during the first week post weaning (Dove, 1993) and the fat digestibility was increased with the age of growing pigs (Cera *et al.*, 1988). However, extra calcium intake may lower fat digestibility by reducing the solubility of bile acids in the intestinal lumen. As previous researches, extra calcium in the diets of rats increased the amount of insoluble calcium phosphate sediment in the digesta (Brink *et al.*, 1992). Increased calcium intake generates more binding sites for bile acids on the calcium phosphate sediment, which decreases the solubility of bile acids in the digesta as has been shown in rats (Govers *et al.*, 1994). In veal calves, fat digestion was decreased and fecal bile acid excretion was increased when veal calves fed high calcium in dietary because of

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the formation of extra calcium phosphate sediment (Xu *et al*., 1998; Yuangklang *et al*., 2004). Additionally, the interaction between fat type and calcium level might affect the apparent digestibility of fat. Thus, this experiment was carried out to investigate the effect of two different fat types (animal fat and vegetable oil) and extra calcium level in diet on growth performance, nutrient digestibility especially fat digestibility, calcium and phosphorus absorption and balance in growing-finishing pigs. The authors hypothesized that the higher calcium intake would increase the effect of calcium on fat digestion and alleviate effect of fat on calcium absorption.

MATERIALS AND METHODS

Animals and experimental treatments

Four castrated-male pigs (Landrace × Large White × Duroc) with an average 55.0 kg BW was kept individually in metabolism cages and were used in 2 × 2 factorial in 4 × 4 Latin square design. Each period were lasted for 14 days; 5 days were used to measure feed intake and last 7 days were used to measure digestibility by using total collection method (Schnieder and Flatt, 1977). Experimental diet were; BT (Beef tallow) low Ca (minimal requirements); BT (Beef tallow) high Ca; SFO (Sunflower oil) low Ca (minimal requirements); SFO (Sunflower oil) high Ca and all dietary fat types and levels of calcium were mixed with constant composition as shown in Table 1. Animals were offered the diet *ad libitum* and feed refusals being measured twice daily. During total collection period, feces and urine samples were collected in the last five consecutive days. Feed samples were collected weekly and pooled for analysis.

Feed and feces samples were dried at 60 °C for 72 hr; ground and analyzed for dry matter (DM), crude protein (CP), crude fat, crude fiber (CF), ash, calcium (Ca) and phosphorus (P) in Table 1 and urine samples were analyzed for calcium and phosphorus according to standard method (AOAC, 1990). Digestibility of nutrient was calculated as nutrient intake - nutrient in feces

Table 1 Composition of the experimental diets.

	BT		SFO	
	Low Ca	High Ca	Low Ca	High Ca
Ingredients (g/100g)				
Beef tallow	5.0	5.0	-	-
Sunflower oil	-	-	5.0	5.0
Calcium carbonate	1.0	2.5	1.0	2.5
Constant components[1]	94.0	94.0	94.0	94.0
Chemical analysis (g/100g)				
DM	88.63	88.55	88.05	87.73
CP	21.73	20.94	19.17	21.55
Crude fat	5.36	5.88	5.47	5.54
CF	6.65	6.21	6.26	6.07
Ash	8.37	8.74	8.36	8.94
Ca	1.32	1.48	1.19	1.48
P	0.47	0.36	0.40	0.34
Ca : P	2.85	4.20	2.83	4.39

[1] The constant components consist of 45.53 g cassava chip, 34 g soybean meal, 7 g extruded soybean, 4 g molasses, 2.7 g di-calcium phosphate, 0.35 g salt, 0.17 g DL-methionine, and 0.25 g premix.

× nutrient intake-1 × 100 (Schnieder and Flatt, 1977). Balance of mineral (calcium or phosphorus) was calculated as mineral intake – mineral in feces – mineral in urine.

Data were subjected to analysis of variance using GLM procedure (SAS, 1996). Treatment means were compared using Duncan's new multiple range test (Steel and Torries, 1960). The statistical significant was considered at $p < 0.05$.

RESULTS

Growth performance

The average body weights of the pigs were 55.0 kg at the start and 95.3 kg at the end of the experiment. Average daily feed intake (ADFI) and average daily gain (ADG), were not different ($p > 0.05$) between the treatment (Table 2). These results agree with previous reports (Cera *et al*., 1990; Kouba *et al*., 2003). However, the feed conversion ratio (FCR) was statistically different between BT low Ca and SFO low Ca.

Nutrient digestibility and Ca and P absorption and balance

There were no statistically difference in apparent digestibilities of dry matter (DM) and ash among all treatment groups. The apparent fat and crude protein digestibility of SFO high Ca was highest among those treatment diets with statistical difference ($p<0.05$) (Table 2). The calcium and phosphorus intake were different among those treatments, but the excretion of calcium in feces was not different while that of phosphorus was different. Conversely, the excretion of calcium was different but the excretion of phosphorus was not different (Table 3). The absorption of calcium in the absolute, per live and metabolic body weight (BW and MBW, respectively) of intake value was highest in the SFO high Ca diet and this diet gave statistical difference ($p<0.05$) from the BT low Ca and SFO low Ca diet but not different from BT high Ca. The balance of calcium in the absolute, per BW and per MBW values was highest in SFO high Ca diet and was statistically different from other three treatment diets ($p<0.05$). Both absorption and balance of phosphorus in the absolute, per BW and per MBM were not different among these four experiment diets.

DISCUSSION

The treatment diets have no effect on the ADFI and the ADG agree with the previous reports (Cera *et al*., 1990; Kouba *et al*., 2003). that the

Table 2 Effect of fat type and calcium level on growth performance and nutrient digestibility.

	BT		SFO		Pooled SE
	Low Ca	High Ca	Low Ca	High Ca	
ADFI, kg/d	2.31	1.88	2.28	1.85	0.40
ADFI DM, kg/d	2.05	1.67	2.01	1.62	0.35
ADG, g/d	683.04	752.98	720.24	723.21	185.07
FCR (feed:gain)	3.06^{a}	2.86^{ab}	2.65^{b}	2.94^{ab}	0.23
Apparent digestibility, % of intake					
Dry matter (DM)	90.91	90.10	89.13	91.14	1.21
Crude protein (CP)	91.79^{ab}	91.84^{ab}	88.85^{b}	92.81^{a}	1.97
Crude fat	77.38^{b}	79.06^{ab}	80.09^{ab}	81.51^{a}	2.08
Ash	73.69	72.93	68.66	72.97	5.68

^{ab} Values in the same row with the different superscripts are different ($p<0.05$)

palatability of each diet was not different. However, FCR was highest in BT low Ca and lowest in SFO low Ca, this might explain that the different of fat type in diet with SFO low Ca gave higher apparent fat digestibility although there was not different. The apparent digestibility of fat of SFO (high unsaturated fatty acid) tends to be higher than that of BT (high saturated fatty acid) in agreement with previous results (Cera *et al*., 1990; Yacowitz *et al*., 1967). However, adding calcium in the diet for pigs did not decrease the digestibility of fat and the absorption and balance of calcium increased with the higher contents of calcium in the diets for both types of fat source. These finding are not in agreement with the previous results (Yacowitz *et al*., 1967; Xu *et al*., 1998; Yuangklang *et al*., 2004). The apparent fat digestibility based on the current study increased with an increasing of age in accordance with the result of Guilloteau *et al*. (1983) who found that the activity of pancreatic lipase increased with age. The possible explanation for higher fat digestibility in high Ca group might be that the increasing age might masks the effect of calcium level on the apparent fat digestibility by rendering unequally values of the digestibility at the start of each period. The absorption and balance of calcium increased with the higher contents of calcium in the diets for both types of fat source. Interestingly, the amount of the calcium balance per either live body weight or metabolic body weight gave the higher level of significance. Thus, both parameters should be used for the higher accuracy measurement. For the pigs in SFO high Ca treatment, the sum of

Table 3 Effect of fat type and calcium level on calcium and phosphorus absorption and balance.

	BT		SFO		Pooled	p-value		
	Low Ca	High Ca	Low Ca	High Ca	SE	Fat	Ca	Ca × Fat
Calcium								
Intake, g/d	23.02^{b}	27.14^{ab}	26.30^{b}	32.87^{a}	3.44	0.04	0.02	0.54
Feces, g/d	2.63	2.46	2.75	2.93	0.44	0.36	0.99	0.58
Urine, g/d	3.81^{ab}	4.70^{a}	4.35^{a}	2.93^{b}	0.81	0.25	0.61	0.05
Absorption								
- g/d	20.39^{b}	24.69^{ab}	23.55^{b}	29.94^{a}	3.21	0.05	0.02	0.59
- % of intake	88.21^{b}	90.66^{ab}	89.60^{b}	90.83^{a}	1.27	0.54	0.17	0.63
Balance, g/d	16.57^{b}	19.98^{b}	19.20^{b}	27.01^{a}	2.74	0.01	0.01	0.19
Balance/BW $^{\alpha}$	0.21^{b}	0.24^{b}	0.24^{b}	0.34^{a}	0.04	< 0.01	< 0.01	0.06
Balance/BW0.75 $^{\beta}$	0.62^{b}	0.73^{b}	0.71^{b}	1.01^{a}	0.10	< 0.01	0.01	0.07
Phosphorus								
Intake, g/d	7.44^{b}	6.67^{b}	8.70^{a}	7.50^{ab}	1.02	0.07	0.09	0.68
Feces, g/d	2.47^{ab}	1.92^{b}	2.86^{a}	2.58^{a}	0.32	0.03	0.07	0.52
Urine, g/d	0.39	0.35	0.54	0.41	0.10	0.31	0.40	0.64
Absorption								
- g/d	4.97	4.75	5.83	4.91	1.03	0.35	0.31	0.52
- % of intake	66.68	68.94	66.16	64.82	5.93	0.51	0.85	0.60
Balance, g/d	4.58	4.40	5.29	4.50	0.96	0.47	0.40	0.59
Balance/BW $^{\alpha}$	0.06	0.05	0.07	0.06	0.01	0.42	0.26	0.78
Balance/BW0.75 $^{\beta}$	0.17	0.16	0.20	0.17	0.04	0.42	0.30	0.72

^{ab} Values in the same row with the different superscripts are significantly different ($p<0.05$)

α and β are in the unit of mg/kg and mg/kg$^{0.75}$, respectively

calcium in feces and urine is rather low implying the pigs used calcium for a specific purpose. Scott *et al*. (1982) explained that the fat-soluble vitamins are absorbed along with the dietary fat. Thus, the authors hypothesized that more fat-soluble vitamins dissolved in SFO resulting in higher calcium absorption. This hypothesis warrants further investigation. In contrast, both dietary fat type and calcium level have no effect on the absorption and balance of phosphorus was not influenced by calcium level in this experiment, although there was different in phosphorus intake. These might explain by no difference in the amount of phosphorus absorption and balance in all treatment diets. Therefore, supplementation of calcium at low level (minimal requirements) is enough for growing-finishing pigs and adding vegetable oil in diet could be beneficial effect leading higher fat digestibility and probably increase of unsaturated fatty acid in pork improving health of consumers.

CONCLUSION

In this investigation, sunflower oil (vegetable origin) tends to give the higher digestibility when compare with beef tallow (animal source). The supplement of calcium at low level in diet is adequate for pig requirements.

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