BRIEF COMMUNICATION: Effect of lipid type, selenium and vitamin E on total tract nutrient digestibility in growing pigs

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INTRODUCTION

It has been shown that the fatty acid, selenium and vitamin E content of pork can be modified by dietary inclusion of different types of fat and/or supplementation with selenium and vitamin E (Morel *et al.,* 2008). These dietary manipulations result in pork with an enhanced nutritive value. It is generally assumed that fat digestibility increases as the ratio of unsaturated to saturated fatty acids increases (Wiseman *et al.,* 1998). However, it is not well documented how the addition of dietary antioxidants like selenium and vitamin E will affect nutrient digestibility.

In this paper the results of two experiments are presented. As part of an experiment aiming at changing the nutritive value of pork, the effects of lipid type, namely plant oil, animal fat, or fish oil, and selenium plus vitamin E supplementation on total gastrointestinal tract nutrient digestibility were investigated. A second experiment was then conducted to assess the repeatability of the effects of selenium and vitamin E supplementation on nutrient digestibility found in the first experiment.

MATERIAL AND METHODS

Experiment 1

Thirty two crossbred female pigs weighing 18.9 ± 1.7 (standard deviation) kg were randomly allocated to four dietary treatments. The animals were kept in pens of four with one pig of each treatment per pen, and individually fed twice daily for 35 days at the rate of one kg of feed daily during the first week, with this amount increasing weekly by 0.25 kg per pig. The un-supplemented diets were formulated to meet the National Research Council (1998) mineral and vitamin requirements. Diet compositions are given in Table 1. The diets were supplemented with either soybean oil plus linseed oil (SL), tallow (T) or fish oil (F) and a preparatory selenium (+0.024% organic selenium, Sel-Plex, Alltech Inc., Nicholasville, Kentucky, USA) and vitamin E (+0.04% vitamin E, Lutavit E50, BASF, Auckland, New Zealand) supplement (+). Fish oil was stored in a refrigerator at approximately 7°C and was added each day to the diet using a syringe. Titanium dioxide (TiO_2) was used as an indigestible marker. Water was available at all times. Faecal samples were collected by direct rectal sampling on Days 31 to 35, pooled for each animal and sub-sampled for analysis. All faecal samples were frozen, freeze-dried and finely ground before chemical analysis.

Experiment 2

Twenty four crossbred female pigs weight (12.0 ± 1.1 kg) were randomly allocated to four dietary treatments in a 2 x 2 factorial design with two levels fibre, low (LF) and high (HF), and with (+) or without a preparatory selenium and vitamin E supplement (Table 1). The diets used in Experiment 2 were based on soybean meal and soybean oil with the level of fibre adjusted by the proportion of wheat and wheat-middling. The pigs were kept in pens of 6 and fed the experimental diets *ad libitum* for 14 days. Faecal samples were collected by direct rectal sampling on Days 10 to 14, pooled for each animal and sub-sampled for analysis. All faecal samples were frozen, freeze-dried and finely ground before chemical analysis.

Chemical analysis

Feed and faecal samples were analysed in duplicate for dry matter (930.15, 925.10; AOAC 1990), ash (942.05; AOAC 1990), TiO_2 (Short *et al.,* 1996) and neutral detergent fibre (NDF), (Robertson & van Soest, 1981). The experiments were conducted in accordance with the Massey University Animal Ethics Committee.

RESULTS

In Experiment 1, dietary treatments had a significant effect on dry matter digestibility (DDM) ($P < 0.01$), organic matter digestibility (DOM) ($P < 0.01$) and ash digestibility (DA) ($P < 0.05$). Pigs fed the un-supplemented SL diet had the lowest digestibility for DDM, DOM and DA (Table 2), those fed the supplemented SL+ diet had the highest digestibility. Digestibility coefficients for pigs fed the T+ and F+ diets were in between. In Experiment 2, no significant interaction between supplementation and fibre levels was found. Pigs fed the diets LF and LF+ had a higher DDM ($P < 0.001$), DOM ($P < 0.001$) and DA ($P < 0.001$)

TABLE 1: Ingredient and chemical composition of the experimental diets on an "as-fed" basis). SL = Soybean and linseed oil added; T = Tallow added; F = Fish oil added; LF = Low fibre diet; HF= High fibre diet; + = Selenium and vitamin E supplement added; NDF = Neutral detergent fibre.

Component	Experiment 1				Experiment 2			
	SL	SL+	T+	F+	LF	LF+	HF	HF+
Ingredient (g/kg)								
Barley	673.7	673.7	673.7	673.7	-	-	-	-
Wheat	-	-	-	-	711	710.4	460.4	461
Broll	60	60	60	60	0	0	250	250
Soybean meal	160	160	160	160	200	200	200	200
Tallow	-	-	44	-	-	-	-	-
Soybean oil	33	33	-	-	40	40	40	40
Linseed oil	11	11	-	-	-	-	-	-
Fish oil	-	-	-	44	-	-	-	-
Lysine	3.7	3.7	3.7	3.7	5	5	5	5
Methionine	2.6	2.6	2.6	2.6	2	2	2	2
Threonine	2	2	2	2	2	2	2	2
Dicalcium phosphate	30	30	30	30	30	30	30	30
Limestone	16	16	16	16	-	-	-	-
Sodium chloride	1	1	1	1	1	1	1	1
Disodium phosphate	4	4	4	4	2	4	4	4
Vitamin-mineral	3	3	3	3	3	3	3	3
Selplex	-	0.24	0.24	0.24	-	0.24	-	0.24
Vitamin E	-	0.40	0.40	0.40	-	0.40	-	0.40
Titanium dioxide	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Analysed "as is" composition (g/kg)								
Dry matter	887	893	892	892	892	891	893	893
Organic matter	808	806	812	810	832	842	818	809
Ash	79	86	80	82	60	49	75	84
NDF	141	148	159	145	176	179	251	218
Unsaturated to saturated fat ratio	4.5	4.7	2.0	2.6	-	-	-	-

than those fed the HF and HF+ diets. Vitamin E and selenium supplementation had no significant effect on DDM and DOM. Lower DA values ($P < 0.05$) were found for pigs fed the un-supplemented LF diet.

DISCUSSION

Effect of lipid type

In the supplemented diets in Experiment1, DDM and DOM were greater when soybean and linseed oil (SL+) were used in place of tallow (T+) or fish oil (F+). A 1.5 % increased in digestibility for soybean oil in comparison to tallow has been reported by Jorgensen and Fernandez (2000). An increase in the ratio of unsaturated to saturated fatty acids has been shown to result in an increased fat digestibility (Wiseman *et al.,* 1990; 1998). Consequently an increase in DDM and DOM could be expected. In our study the ratio of unsaturated to saturated fatty acids was greater in the SL+ diet (4.75) than in the T+ or F+ diets (2.03 and 2.56, respectively), matching the difference observed in DDM and DOM. No statistically significant differences were observed between dietary lipid types for DA (Table 2), which represents mainly mineral digestibility. Information on the effect of lipid types on mineral digestion and absorption in the pig is limited.

Effect of fibre content

In Experiment 2, reducing the level of fibre resulted in a 15 % increase in DDM, a 13 % increase in DOM and a 40 % increase in DA. These results are consistent with those of Fernandez and Jorgensen (1986) who found that increasing the amount of fibre in the diets significantly depressed the nutrient digestibility.

Effect of selenium and vitamin E supplementation

In Experiment 1, the main difference in DDM, DOM and DA was between the SL and SL+ diets, thereby suggesting a positive effect of selenium and vitamin E supplementation on nutrient digestibility.

The extra 0.4 ppm of selenium, in an organic form, and 200 ppm of vitamin E, increased DDM and DOM by 10% and DA by 42% (0.64 vs 0.44) (Table 2).

However, in Experiment 2 no differences in DDM and DOM were observed between the supplemented and un-supplemented diets for both dietary fibre levels. In contrast to Experiment 1, supplementation in Experiment 2 was found to decrease DA by 15 %. Adkins and Ewan (1984) reported a 4% increase in DDM when diets supplemented with 0.10 ppm of selenium were fed to 15 kg pigs. However, Tian *et al.* (2006) did not find any difference in DDM or DA when diets were supplemented with 0.1 ppm or 0.3 ppm of selenium in 50 kg pigs. Increasing the fat soluble vitamins (A, D, E and K) in the diet from 100% to 150% of the National Research Council (1998) requirement had a positive effect on dry matter digestibility (+ 2.8%), calcium digestibility (+ 8.2) and phosphorus (+21%) in 40 kg pigs (Lohakare *et al.,* 2006).

TABLE 2: Least-square means and standard error (SE) for digestibility coefficients for groups of eight pigs fed diets with selenium and vitamin E supplementation indicated by a +, with (a) different types of lipids in Experiment 1, or (b) two levels of fibre in Experiment 2. SL= Soy and Linseed oil; T = Tallow; F = Fish oil; LF = Low fibre diet; HF = High fibre diet.

(a)

Experiment 1	Diet				SE
	SL	SL+	T+	F+	
Dry matter	0.744[a]	0.824[c]	0.789[b]	0.789[b]	0.006
Organic matter	0.775[a]	0.846[c]	0.814[b]	0.815[b]	0.006
Ash	0.436[a]	0.620[b]	0.537[ab]	0.524[ab]	0.013

[a,b,c] Means within a row without a common superscript letter are different from each other (P <0.05).

(b)

Experiment 2	Diet				SE
	LF	LF+	HF	HF+	
Dry matter	0.852[b]	0.836[b]	0.738[a]	0.726[a]	0.009
Organic matter	0.869[b]	0.856[b]	0.767[a]	0.758[a]	0.009
Ash	0.613[c]	0.505[b]	0.416[a]	0.393[a]	0.027

[a,b,c] Means within a row without a common superscript letter are different from each other (P <0.05).

CONCLUSIONS

It is concluded that the total gastrointestinal tract DDM and DOM are not negatively affected by the dietary inclusion of selenium and vitamin E in the diet.

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