The effects of dietary soyabean oil-cake meal on performance and gut histology of piglets

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Abstract

The effects of four diets containing different protein sources on the performance and gut histology of piglets were compared. The diets contained as the main protein sources either: milk powder plus fishmeal, milk powder plus high-protein (48% crude protein) soyabean oil-cake meal, fishmeal plus high-protein soyabean oil-cake meal or high-protein soyabean oil-cake meal alone. No differences ($p > 0.05$) were observed between treatments for average daily gain, feed conversion ratio, intake or intestinal villus height. It was concluded that high-protein soyabean oil-cake meal can be utilised successfully in diets for weaner pigs either in combination with other protein sources or as main protein source without detrimental effects on production parameters or gut histology. These results apply to diets are formulated on the basis of digestible amino acids using soyabean oil-cake meal has been correctly processed.

Keywords: Weaner, piglet, digestible amino acids, gut histology, soyabean oil-cake meal
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Introduction

There is a firm belief amongst some producers that piglets must be fed high levels of milk products in order to maximise growth rate and production. As some of these milk products are expensive, substitution with other protein sources such as high-protein soyabean oil-cake meal could reduce production costs. Weaning at 3-4 weeks exposes the piglet to nutritional, environmental and social stress that usually results in a post weaning lag-phase manifested as slow growth, scouring and general ill-thrift (Ravindran & Kornegay, 1993). The piglet is also very vulnerable to infections during this period, since the immune and enzyme systems are still incompletely developed. The early weaning process creates an initial physiological situation requiring a particular nutrient form and balance in the feed (Seve, 1985). As a result, it is common practice to use milk products and pre-cooked starches in creep diets (Aherne & Nielsen, 1982; Campbell & Dunkin, 1983; Campbell & Taverner, 1986; Campbell *et al*., 1988). It has also been well documented that growth rate and efficiency of feed utilisation of early-weaned piglets is appreciably better when milk proteins are used instead of soyabean proteins (Wilson & Leibholz, 1981; Walker *et al*., 1986; Zijlstra *et al*., 1996). Weaning has also been shown to cause changes in the morphology of the small intestine (Miller *et al*., 1986; Van Beers-Schreurs *et al*., 1998). These changes include reduction of villus height, increased depth of the lamina propria, reduced disaccharidase concentrations and reduced absorption (Dunsford *et al*., 1989). The decrease in villus height may be caused by pathogens (Vellenga *et al*., 1992), antigens (Miller *et al*., 1986; Li *et al*., 1991) or reduced feed intake (Nunez *et al*., 1996; Pluske *et al*., 1996; Van Beers-Schreurs *et al*., 1998).

Reduced performance in pigs fed soyabean protein has been associated with reduced digestibility of dietary amino acids (AA) (Wilson & Leibholz, 1981; Leibholz, 1986; Viljoen & Ras, 1989). Differences in ileal amino acid digestibility values between protein sources used to feed early-weaned piglets have been reported by several authors (Leibholz, 1985a; Leibholz, 1985b; Fan *et al*., 1995; Viljoen *et al*., 1998a). Feedstuff digestibility is influenced by aspects such as anti-nutritional factors (Sauer & Ozimek, 1986; Huisman & Jansman, 1991), inclusion levels (Viljoen *et al*., 1998b), post weaning feed intake which affects pancreatic development and thus enzyme activity (Makkink *et al*., 1994) and amino acid damage due to overheating during processing (Marty & Chavez, 1995). Some of the above-mentioned aspects are intrinsic characteristics of the protein source under investigation. It was noted by Li *et al*. (1991) that conventionally processed commercial soyabean oil-cake meal may contain antigens that cause immunological responses in early-weaned pigs resulting in decreased villus height.

Results of Viljoen (1998) showed that weaner diets based on different protein sources can be utilised with equal efficiency (feed conversion) when balanced according to digestible amino acid content. However, it was found that differences in feed intake attributable to the use of protein sources of different origin resulted in differences in growth rates. The palatability of high-protein soyabean oil-cake meal could possibly obviate this problem. Zhang *et al*. (1985) compared simple, low cost diets without skim milk powder to a more complex and expensive basal diet containing 17.8% skimmed-milk powder, and reported similar food-to-gain ratios for the diets. The aims of this study were to determine whether high-protein soyabean oil-cake meal could be substituted for milk powder or fishmeal in weaner diets, and to determine the effects of this on the histology of the small intestine.

Materials and methods

Weaner piglets of a commercial crossbred strain were used. Eighty piglets (40 boars and 40 gilts) weaned at an age of 28 days with an average live mass of 6.5 kg were randomly allocated to four experimental diets (20 piglets, i.e. 10 boars and 10 gilts per treatment). Diets were formulated to contain, as the main protein sources, either milk powder (MP) and fish meal (FM) (Control; designated MP+FM), MP and high-protein soyabean oil-cake meal (HPS) (designated MP+HPS), FM and HPS (designated HPS + FM) or HPS alone (designated HPS) (Table 1).

Table 1 Composition of experimental diets (kg/100 kg diet)

Ingredients (kg)	MP* + FM**	MP + HPS***	HPS + FM	HPS
Maize meal	65.11	65.80	71.31	70.13
Soyabean oil-cake meal (48% crude protein)	-	13.00	5.20	20.80
Skimmed milk powder	7.60	11.40	-	-
Fishmeal	9.80		10.00	-
Fine bran	11.50	2.30	6.90	-
Sunflower oil	2.60	2.30	2.57	3.08
Synthetic lysine	0.57	0.66	0.65	0.77
Synthetic methionine	0.13	0.20	0.16	0.25
Synthetic tryptophan	0.12	0.09	0.12	0.09
Synthetic treonine	0.24	0.26	0.26	0.29
Monocalcium phosphate	0.42	1.46	0.72	1.75
Feed lime	1.23	1.70	1.35	1.86
Fine salt	0.18	0.33	0.27	0.48
Premix	0.50	0.50	0.50	0.50

*MP – Milk powder; **FM – Fish meal; ***HPS – High-protein soyabean oil-cake meal

Table 2 Digestible nutrient composition of experimental diets (calculated on an air-dry basis)

Nutrient	Unit of measure	MP* + FM**	MP + HPS***	HPS + FM	HPS
Crude protein	%	15.04	15.01	15.04	15.02
Lysine	%	1.28	1.28	1.28	1.28
Total sulphur containing amino acids	%	0.69	0.70	0.70	0.73
Tryptophan	%	0.25	0.25	0.25	0.25
Threonine	%	0.81	0.81	0.81	0.81
DE (pig)	MJ/kg	14.50	14.50	14.50	14.50
Fat	%	6.77	5.29	6.76	6.12
Fibre	%	2.73	2.45	2.67	2.71
Calcium	%	1.05	1.06	1.07	1.04
Phosphorous	%	0.44	0.45	0.43	0.41
Sodium	%	0.21	0.20	0.21	0.20
Chloride	%	0.37	0.35	0.35	0.33

*MP – Milk powder; **FM – Fish meal; ***HPS – High-protein soyabean oil-cake meal

Diets were formulated according to digestible amino acids using the ideal amino acid pattern described by Kemm *et al*. (1990) (Table 2). Piglets were kept in pairs (i.e. a boar together with a gilt) in flat-deck type cages (1.5 x 1.0m) with perforated metal floors, self feeders and automatic water nipples. Animals were weighed weekly. Feed was supplied *ad libitum* using self-feeders, and residues were weighed back weekly for determination of feed intake. Average daily gains (ADG) and feed conversion ratios (FCR) were calculated. Average daily gain was estimated by fitting a linear model ($R^2 > 0.92$) to live mass data. The slope of this curve represents the ADG which was used for further data analysis.

Five piglets per treatment were slaughtered at the end of the trial (8 weeks of age). The small intestine was removed following slaughter, placed in physiological saline solution and the mesenteric web was cut, allowing the intestine to be unfolded. Samples were taken at the terminal duodenum, mid-jejunum and distal jejunum (i.e. at points corresponding to 25%, 50% and 75% of the length of the small intestine) (Dunsford *et al*., 1989; Healy *et al*., 1994). The piglets with masses closest to the mean mass were selected for slaughter. Gender was not taken into consideration and only typical pigs were used in order to avoid selection of either exceptionally small or large piglets. Villus height and lamina propria depth was determined by means of interactive image analysis as described by Dunsford *et al*. (1989). The mean of ten villus height and ten lamina propria depth measurements were recorded from each of three cross-sections made per sample. Data was analysed by analysis of variance (Genstat 5, 1993).

Results and discussion

Average daily gain (ADG) did not differ ($p > 0.05$) between sexes (boars: 376 g/d; gilts: 354 g/d) or treatments (Table 3). Li *et al*. (1991), however, found that pigs fed diets containing soyabean meal had a lower rate of gain. The absence of treatment differences in the current trial may be attributed to the fact that diets were formulated on a digestible amino acid basis. Presumably, that had not been the case in the study of Li *et al*. (1991). Total intake was measured per pen and did not differ ($p > 0.05$) between treatments. This could be of significance, as gut morphology is negatively influenced by reduced feed intake (Nunez *et al*., 1996; Pluske *et al*., 1996; Van Beers-Schreurs *et al*., 1998). As intake did not differ between treatments ($p > 0.05$) it was assumed that intake did not influence villus height. Feed conversion ratios did not differ ($p > 0.05$) between treatments, confirming the results obtained by Zhang *et al*. (1985). FCR tended to differ ($p = 0.059$) between the MP + HPS and HPS diets. This might be due to differences between the estimated and true digestible energy values of raw materials used in the diets.

Table 3 Average daily gain (ADG), feed conversion ratio (FCR) and total intake (± standard deviation) from 4-8 weeks of age in piglets fed diets containing different protein sources.

Treatment	ADG (g/day)	FCR (kg feed/kg gain)	Total intake (kg)
MP* + FM**	353 ± 102	1.56 ± 0.05	30.63 ± 4.10
MP + HPS***	349 ± 106	1.61 ± 0.09	31.48 ± 7.44
HPS + FM	370 ± 106	1.58 ± 0.13	32.08 ± 6.61
HPS	383 ± 77	1.49 ± 0.08	32.07 ± 4.54

*MP – Milk powder; **FM – Fish meal; ***HPS – High-protein soyabean oil-cake meal

Villus height differed significantly ($p < 0.05$) between the terminal duodenum and the other areas of sampling, but no significant differences were observed between treatments (Table 4). These results are in contradiction to that of Dunsford *et al*. (1989) and Li *et al*. (1991) who found that villus height was decreased by high concentrations of soyabean meal. This could be attributed to a number of factors including differences in the age of piglets at sampling, the use of digestibility values for diet formulation in the present trial or differences in anti-nutritional factor content of the soyabean oil-cake meal used.

Table 4 Villus height (mm, ± standard deviation) measured at different anatomical sites in the small intestine of piglets fed diets containing different protein sources.

Treatment	Terminal duodenum	Mid-jejunum	Distal jejunum
MP* + FM**	1.846 ± 0.37	1.670 ± 0.20	1.516 ± 0.19
MP + HPS***	1.804 ± 0.28	1.498 ± 0.35	1.416 ± 0.16
HPS + FM	1.744 ± 0.27	1.608 ± 0.35	1.472 ± 0.29
HPS	1.598 ± 0.19	1.432 ± 0.14	1.376 ± 0.20

*MP – Milk powder; **FM – Fish meal; ***HPS – High-protein soyabean oil-cake meal

Conclusion

It was concluded that HPS can be utilised successfully in combination with other protein sources or as the main protein source in diets for weaner pigs without detrimental effects on either production parameters or gut histology. This may only be valid for diets formulated on the basis of digestible amino acids and for soyabean oil-cake meal that has been correctly processed.

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