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Effect of Dietary Fiber Level on the Performance and Carcass Traits of Mong Cai, F1 Crossbred (Mong Cai×Yorkshire) and Landrace×Yorkshire Pigs

Ninh Thi Len[1], Jan Erik Lindberg[2] and Brian Ogle[2,*]

[1] Department of Animal Nutrition, National Institute of Animal Husbandry, Thuy Phuong - Tu Liem, Hanoi, Vietnam

ABSTRACT : The effects of feeding diets containing 20% (L) or 30% (H) neutral detergent fiber (NDF) (DM basis) on performance and carcass traits were studied in three breeds of pig, including pure Mong Cai (MC), crossbred Landrace×Yorkshire (LY) and crossbred MC×Yorkshire (F1). The experiment had a factorial design with two factors, breed and diet. Eighteen piglets of each breed (60±3 days) were randomly allocated to three treatments: L-L, low fiber diet in both growing and finishing periods; L-H, low and high fiber diet in the growing and finishing period, respectively; and H-H, high fiber diet in both periods. The diets were iso-energetic and iso-nitrogenous within feeding period. The main fibrous ingredients of the diets were rice bran and cassava residue. There were no effects of fiber level on daily dry matter feed intake (DMI), expressed as g/kg metabolic body weight ($BW^{0.75}$), in both feeding periods ($p>0.05$). DMI was highest for MC, followed by F1 and LY ($p<0.001$). Average daily gain (ADG) in L-L and L-H was higher than in H-H in the growing period ($p<0.001$) and overall ($p<0.05$), while feed conversion ratio (FCR) was higher in H-H than in L-L and L-H in the growing period ($p<0.05$) and overall, but no significant differences between treatments were found in the finishing period. In both periods, Landrace×Yorkshire had the highest ADG and the lowest FCR, followed by F1 and Mong Cai ($p<0.001$). There were no interactions between breed and diet for performance and carcass traits. Carcass and dressing percentage was lower for L-H and H-H than for L-L ($p<0.05$). There were no significant differences among treatments in back fat thickness and lean meat percentage, or in crude protein and ether extract contents of lean meat. Carcass, dressing and lean meat percentage was highest for LY, lowest for MC and intermediate for F1 ($p<0.001$). It can be concluded that feeding a high fiber diet in the growing period reduced pig performance, but there was no effect in the finishing period. Pure Mong Cai pigs are not particularly suitable for meat purposes, although the F1 cross with Large White had reasonably good growth performance and carcass quality. (**Key Words :** Carcass Traits, Fiber, Growth Performance, Mong Cai Pigs)

INTRODUCTION

Between 2000 and 2004, the pig population in Vietnam increased by 7.4% annually (FAO, 2004). It is estimated that around 80% of the total pig population of 26 million is found in rural areas and most are raised in small-scale, semi-intensive and extensive systems (Lapar et al., 2003). It is important with respect to the economic efficiency and sustainability of these smallholder systems to utilize locally available feeds, such as rice bran, cassava residue, and sweet potato vines (Rodriguez and Preston, 1997), which are cheap, but usually contain high levels of dietary fiber. Feeding fibrous diets results in a number of advantages, such as improved well-being of animals, improvement of gut transit time and reduction of stomach ulcers (Low, 1993). However, when included in monogastric diets their high fiber content results in decreased diet digestibility (Nongyao et al., 1991; Wang et al., 2006) and dilution of dietary nutrients (Schulze et al., 1994; Noblet and Le Goff, 2001).

Several reports have indicated that indigenous pig breeds can utilize fiber better than exotic breeds (Fevrier et al., 1992; Kanengoni et al., 2002; Ndindana et al., 2002), especially with diets that are very high in fiber. However, Ly et al. (1998) were unable to detect any difference in the ability of indigenous Cuban pigs to digest very high fiber diets compared with an improved breed, and Morales et al. (2002) found that indigenous Iberian pigs had lower digestibility of carbohydrates compared with Landrace pigs

* Corresponding Author: Brian Ogle. Tel: +46-18-672061, Fax: +46-18-672995, E-mail: Brian.Ogle@huv.slu.se

[2] Department of Animal Nutrition and Management, Swedish University of Agricultural Sciences, 750 07 Uppsala, Sweden.
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Table 1. Chemical composition (% of DM) and metabolisable energy (ME) content of feed ingredients

Parameter	Maize	Soybean meal	Rice bran	Fish meal	Cassava residue
Analysed values					
Dry matter	91.2	90.5	90.2	90.6	91.2
Crude protein	8.7	46.0	10.5	50.0	1.8
Crude fibre	4.6	3.5	17.5	1.30	16.3
Neutral detergent fiber	13.5	18.6	46.4	2.40	45.6
Calcium	0.14	0.35	0.21	5.10	0.11
Phosphorus	0.27	0.55	1.12	2.60	0.20
Calculated values*					
Lysine	0.25	2.70	0.45	2.80	-
Methionine+cystine	0.33	1.19	0.51	1.38	-
Threonine	0.29	1.72	0.44	1.78	-
Tryptophan	0.09	0.62	0.14	-	-
ME (MJ/kg DM)	13.6	13.8	9.6	11.1	96.2

* Vietnamese Feed Tables (Chinh et al., 2001).

Table 2. Ingredient and chemical composition of the experimental diets (%of DM)

Ingredient	Growing period		Finishing period	
	Low fiber (L)	High fiber (H)	Low fiber (L)	High fiber (H)
Maize meal	50.16	9.04	58.1	19.8
Soybean meal	19.5	23.0	16.0	19.0
Rice bran	10.0	26.0	10.0	25.0
Fish meal	5.0	5.0	3.0	3.0
Cassava residue meal	10.0	26.0	10.0	25.0
Soya oil	3.0	9.00	0.50	6.00
Di-calcium phosphate	0.60	0.30	1.10	0.50
Limestone	1.00	1.00	0.70	1.15
Mineral-vitamin premix	0.25	0.25	0.25	0.25
Lysine	0.14	0.06	0.05	0.00
DL-methionine	0.05	0.05	0.00	0.00
Salt (NaCl)	0.30	0.30	0.30	0.30
Nutritive value				
ME (MJ/kg DM)**	13.0	13.0	12.5	12.5
Crude protein*	17.1	17.1	15.1	15.0
Crude fiber*	6.4	10.1	6.6	10.1
Neutral detergent fiber*	19.7	29.5	20.1	29.3
Calcium*	0.87	0.80	0.81	0.79
Phosphorus*	0.61	0.68	0.65	0.65
Lysine**	0.96	0.95	0.75	0.76
Methionine+cystine**	0.56	0.55	0.48	0.46
Threonine**	0.61	0.63	0.54	0.55
Tryptophan**	0.18	0.19	0.17	0.17

* Analysed; ** Calculated from vietnamese feed tables (Chinh et al., 2001).

when fed the same diet. In Vietnam, the indigenous Mong Cai breed is considered to be very tolerant of poor quality diets (Rodriguez and Preston, 1996) and able to digest the fibrous components better than improved breeds (Borin et al., 2005). However, there is little information available concerning the ability of indigenous growing pigs and their crosses of different ages to utilise extremely high fiber diets. The objective of this study was to compare the performance and carcass quality of three breeds of pig (local, exotic and F1 crosses between them) when fed diets with low and high fiber contents in the growing and finishing periods.

MATERIALS AND METHODS

The experiment was conducted at the Experimental Farm of the National Institute of Animal Husbandry, Hanoi, between October 2004 and January 2005. The mean daily temperature ranged from 25°C in October to 16°C in January.

Animals and housing

A total of 54 piglets of three breeds : Mong Cai, Landrace×Yorkshire and F1 crosses between Mong Cai and Yorkshire at an age of 60±3 days was used in the study. The

Table 3. Effects of fibre level in the diet and breed on average daily feed and nutrient intake (g/kg $BW^{0.75}$/day *)

Parameter	Treatment (T)			Breed (B)			SEM	p value	
	L-L	L-H	H-H	MC	F1	LY		T	B
Growing period									
DMI	111	111	112	119[a]	112[b]	102[c]	2.8	0.925	0.001
NDFI	22[a]	22[a]	34[b]	28[a]	26[b]	24[c]	0.7	0.001	0.001
Finishing period									
DMI	110	114	114	119[a]	115[a]	105[b]	2.7	0.214	0.001
NDFI	22[a]	34[b]	34[b]	32[a]	31[a]	28[b]	0.4	0.001	0.001
Overall									
DMI	111	112	113	119[a]	113[b]	103[c]	1.1	0.467	0.001
NDFI	22[a]	28[b]	34[c]	30[a]	28[b]	26[c]	0.6	0.001	0.001

[a, b, c] Means within a row and factor with different superscripts are significantly different ($p<0.05$).

* $BW^{0.75}$ = ((initial body weight+final body weight)/2)$^{0.75}$

mean initial live body weight was 11.0, 14.0 and 21.0 kg for Mong Cai, F1 and Landrace×Yorkshire, respectively. For each breed, 9 castrated males and 9 females were randomly allocated to the three treatments, and were housed in individual 1.5×0.5 m pens, each with a feeder and an automatic nipple drinker. Within breed, the pigs were selected from three litters from the same farm. All pigs were allowed a 7 day period for adaptation and were vaccinated against pasteurellosis and hog cholera before data collection started.

Experimental design and dietary treatments

The study was conducted according to a completely randomized design with two factors (three breeds and three dietary treatments), and data were collected in the growing (60-120 days) and finishing (120-170 days) periods. The treatments were: L-L, a low fiber diet fed in both growing and finishing periods; L-H, low and high fiber diets fed in the growing and finishing period, respectively; and H-H, a high fiber diet in both periods. The chemical composition of the main feed ingredients (maize meal, soybean meal, fish meal, cassava residue meal and rice bran) is shown in Table 1. The diets were iso-energetic and iso-nitrogenous within feeding period, and the proportions of the main fiber sources, cassava residue and rice bran, were adjusted to give concentrations of neutral detergent fiber (NDF) of 20 or 30% (of DM) in the low and high fiber diets, respectively (Table 2).

Before the experiment started, samples of the main feed ingredients were taken for analysis of chemical composition. Metabolisable energy (ME) and amino acid values of the feed ingredients were obtained from "Chemical Composition of Animal Feeds in Vietnam" (Chinh et al., 2001). The diets were mixed and pelleted (4-5 mm) every two weeks and stored in airtight plastic bags before feeding.

Feeding and data collection

Pigs in all treatments were fed *ad libitum* throughout the study. Each morning, the offered and refused feed was weighed and recorded. The pigs were weighed in the morning after fasting for 12 h at the beginning and at the end of each experimental period. At the end of the experiment, four representative pigs of each breed in each treatment (2 males and 2 females) were slaughtered for measurement of carcass traits, and samples were taken for analysis of the chemical composition of the loin lean meat. The pigs were killed by exsanguination after 12 h of feed withdrawal. The hot carcass weight was the weight after slaughter, but excluding blood, hair, visceral organs and gastrointestinal tract. Dressed weight was the hot carcass weight minus head, lower legs, tail and leaf fat. Lean meat was separated from visible fat, skin and bone of the dressed carcass, and the loin lean was sampled for analysis of dry matter (DM), crude protein (CP) and ether extract (EE). Back fat thickness was measured at the 10th rib.

Chemical analysis

All feed samples were analysed for DM, CP, crude fiber (CF), calcium (Ca) and phosphorus (P) by standard methods (AOAC, 1990). Neutral detergent fibre (NDF) was analysed by the method of Goering and Van Soest (1991). Loin lean meat samples were analysed for CP and EE.

Statistical analysis

The data were analysed using ANOVA in MINTAB software version 13.0. Breed, treatment, sex and breed by treatment interactions were considered as main effects. However, as breed by treatment interactions were non-significant they were removed from the model. Effects of sex were not significant and are not shown in the tables, except with respect to some carcass parameters, which are shown in Table 5.

RESULTS AND DISCUSSION

Feed intake

The effects of diet and breed on feed and nutrient intake are shown in Table 3. In the growing period, the pigs in treatments L-L and L-H were fed the same low fiber diet, and the pigs in treatment H-H were given the high fiber diet,

Table 4. Effect of fiber level in the diet and breed on body weight changes (kg), average daily gain (kg/day) and feed conversion (kg feed/kg gain) of growing-finishing pigs

Parameter	Treatment (T)			Breed (B)			SEM	p value	
	L-L	L-H	H-H	MC	F1	LY		T	B
Growing period									
IBW	15.5	15.3	15.4	11.3	13.7	21.1	0.3	0.575	0.001
FBW	47.9^a	47.3^a	44.4^b	33.7^a	45.2^b	60.7^c	0.6	0.001	0.001
ADG	0.540^a	0.536^a	0.484^b	0.374^a	0.525^b	0.659^c	0.1	0.001	0.001
FCR	2.69^a	2.70^a	2.91^b	3.30^a	2.70^b	2.51^c	0.1	0.012	0.001
Finishing period									
IBW	47.9^a	47.3^a	44.4^b	33.7^a	45.2^b	60.7^c	0.6	0.001	0.001
FBW	81.2^a	80.3^a	76.5^b	58.0^a	80.1^b	99.9^c	1.3	0.002	0.001
ADG	0.667	0.659	0.641	0.485^a	0.697^b	0.785^c	0.1	0.389	0.001
FCR	3.71	3.85	3.80	4.32^a	3.66^b	3.57^b	0.2	0.499	0.001
Overall									
ADG*	0.597^a	0.591^a	0.555^b	0.425^a	0.603^b	0.716^c	0.1	0.002	0.001
ADCG**	0.490^a	0.479^a	0.443^b	0.332^a	0.479^b	0.602^c	0.1	0.001	0.001
FCR***	3.21^a	3.28^{ab}	3.38^b	3.83^a	3.20^b	3.04^c	0.1	0.024	0.001

a, b, c Means within a row and factor with different superscripts are significantly different ($p<0.05$).

IBW, FBW: Initial and final body weight, respectively. * ADG: Average daily gain. ** ADCG: Average daily carcass gain.

** $ADCG = \frac{(\text{BW end finishing period} \times \text{carcass percentage}) - (\text{initial BW} \times 0.69)}{110}$

*** FCR: Feed conversion ratio = kg feed/kg gain.

but as calculated metabolizable energy (ME) and crude protein (CP) concentrations in the two diets were identical there were no differences in DM, CP and ME intakes among treatments ($p>0.05$). Also, in the finishing period and overall, there were no differences in DM and nutrient intakes among treatments ($p>0.05$). Overall, the pigs in treatment H-H had the highest NDF intake, followed by L-H and L-L ($p<0.001$). The effect of dietary fiber concentration on feed intake is very variable and related to such factors as the age of the pig, botanical origin of the fibre, processing method and chemical composition of the diet (Low, 1993). However, if growing pigs are fed *ad-libitum*, dietary energy concentration is the main factor controlling feed intake (Chiba et al., 1991), and differences in fiber content should not affect DM intake provided that the feed bulk and palatability are acceptable (Coffey et al., 1982). This was confirmed in the present study, where the diets were iso-energetic, palatable and the bulk volume of the H feed was only 1.1 times that of the L feed, which was obviously not enough to limit DM intake. For example Ndindana et al. (2002) and Len et al. (2007) did not find any effect of diets with different concentrations of NDF on feed intake in both indigenous and exotic growing pigs, as the diets were iso-energetic. Jorgensen et al. (1996) and Freire et al. (2000) also found no differences in ME intake between low and high fiber diets for young piglets and growing pigs. The numerically higher DM intake in the finishing period than in the growing period confirmed that the pig's ability to consume fibrous feeds improves with age. Low (1993) summarized the results of some previous studies and also concluded that intakes of high fiber diets in the finishing phase were consistently higher than in the growing phase. There was no difference in DM intake between the sexes in the growing period and overall, but the castrated males had higher feed intake than the gilts in the finishing period ($p<0.05$).

Among the three breeds, Mong Cai had the highest DM and nutrient intake (expressed as g/kg $BW^{0.75}$), followed by F1 and Landrace×Yorkshire ($p<0.001$). Overall, DMI of the Mong Cai was 5.3% higher than of the F1 and 15.5% higher than of the Landrace×Yorkshire pigs, probably as a result of the higher energy requirement of the Mong Cai, which is an obese breed, whereas the Landrace×Yorkshire has been selected for lean, and thus probably indirectly selected for a reduced appetite. According to Webb (1989) within breed, the genetic correlation of feed intake is positive with growth rate, and negative with lean meat. Renaudeau et al. (2005a) also found that an indigenous pig (Creole) had higher daily feed intake than the Large White when expressed as g/kg $BW^{0.75}$, and similar results were found by Freire et al. (1998), Freire et al. (2000) and Len et al. (2007).

Pig performance

The effects of dietary fiber level and breed on pig performance are shown in Table 4. The results indicate that for growing animals (60-120 days) the effect of a high fiber level in the diet on growth rate was greater than for finishing pigs (120-170 days). During the growing phase, the pigs in treatment L-L and L-H were given the same diet, with a lower fiber content than those in treatment H-H, and therefore as expected, average daily weight gain (ADG) of the pigs given diet L was not different, but was significantly higher than for the H pigs ($p<0.001$). Although the H and L diets were iso-energetic and iso-nitrogenous, nutrient

Table 5. Effects of fiber level in the diet, breed and sex on carcass traits and chemical composition of lean meat

Parameter	Treatment (T)			Breed (B)			Sex (S)		SEM	p value		
	L-L	L-H	H-H	MC	F1	LY	M	F		T	B	S
Body weight (kg)	80.9	80.1	80.5	58.6	82.3	101	80.5	80.4	0.6	0.62	0.001	0.966
Hot carcass (%)	79.6[a]	78.6[ab]	77.3[b]	76.3[a]	77.8[ab]	81.5[b]	78.5	78.4	0.5	0.03	0.001	0.846
Dressing (%)	71.5[a]	70.8[ab]	69.3[b]	66.8[a]	70.1[b]	74.8[c]	70.6	70.4	0.5	0.03	0.001	0.962
Back fat (cm)	2.34	2.37	2.39	2.87[a]	2.33[b]	1.90[c]	2.60[a]	2.13[b]	0.1	0.30	0.001	0.001
Lean (%)	51.2	51.5	50.8	41.7[a]	50.8[b]	61.1[c]	50.7	52.4	1.3	0.63	0.001	0.068
CP in lean meat (%)	22.4	22.1	22.2	22.1	22.2	22.4	22.4	22.2	0.7	0.42	0.280	0.601
EE in lean meat (%)	1.69	1.70	1.67	1.76[a]	1.69[b]	1.60[c]	1.71	1.65	0.1	0.35	0.001	0.090

[a, b, c] Means within a row and factor with different superscripts are significantly different ($p<0.05$).

digestibility in the H diet in the growing period was shown in an earlier study by Len et al. (2006) to be lower than in the L diet. Other studies have confirmed the negative effect of high levels of dietary fiber on nutrient digestibility. For example, Nongyao et al. (1991) and Wang et al. (2006) reported decreased apparent ileal and fecal digestibility of amino acids as a result of including fibrous feedstuffs in diets for growing pigs, and Wang et al. (2004) found that supplementation of diets for growing pigs with wheat bran and sugar beet pulp reduced fecal digestibility of energy.

In the finishing period, however, there were no differences in pig performance between treatments ($p>0.05$). The probable explanation for this is that as pigs grow, their digestive tract bacterial profile becomes more stable, especially the hind-gut bacteria (Varel et al., 1982), and also the capacity of the hindgut increases in response to fibrous diets (Bach Knudsen and Jørgensen, 2001). Previous studies have confirmed that the ability of pigs to digest and utilize fibre in the diet is proportional to their age and live body weight (Fernandez et al., 1986; Shi and Noblet, 1993; Reverter et al., 1999; Le Goff et al., 2003). However, Jørgensen et al. (1996) found that animals given a high fiber diet in fact had higher daily live weight gain compared with pigs on a low fiber diet. Their explanation for this was that on fibrous diets the weight and size of the visceral organs and gastrointestinal tract increase, as does the weight of gut-fill, mainly as a result of the higher water-holding capacity of fiber (Zhao et al., 1996; Qin et al., 2002). Therefore a more accurate measure of performance in pigs given diets with different levels of fiber is average daily carcass gain (ADCG), and this was calculated in the present study by assuming that carcass percentage of live body weight at beginning of the trial was 69% (Batterham et al., 1986), and by using actual carcass percentage values at slaughter (Table 5). The results in Table 4 show that the overall ADG of pigs in treatments L-H and H-H was only 1% and 7.5% lower than in treatment L-L ($p<0.01$), but ADCG was 2.5% and 9.5% lower, respectively, in treatments L-H and H-H compared to treatment L-L ($p<0.001$). During both growing and finishing periods, the ADG and ADCG of the castrated males and gilts were not different ($p>0.05$).

The effect of genotype on growth rate in both feeding periods was very clear ($p<0.001$). The Mong Cai had 29.5% and 40.6% lower ADG and 30.6% and 44.9% lower ADCG compared with F1 and Landrace×Yorkshire, respectively. The explanation for these differences is the considerably lower genetic growth potential, and possibly also the greater weight of the digestive tract of Mong Cai compared with F1 and Landrace×Yorkshire.

The effects of diet on feed conversion efficiency are also shown in Table 4. In the growing period, feed conversion ratio (FCR) was not different between pigs in treatment L-L and treatment L-H, but was significantly better than that of pigs in treatment H-H ($p<0.05$). There were no treatment effects on DMI, and so the poorer FCR was entirely a result of the lower ADG of the H-H pigs. As DMI and ADG in the finishing phase were similar among treatments no differences were found for FCR.

Feed conversion efficiency of Landrace×Yorkshire was better than that of F1 and Mong Cai, mainly as a result of its lower feed intake and higher growth rate. There would also have been an additional effect of carcass composition, as the Landrace×Yorkshire pigs used were from a lean meat line, and had a lower carcass fat percentage than the F1 and Mong Cai. The poorer feed conversion of the Mong Cai in the present study is in agreement with Fevrier et al. (1992), who found that in a paired feeding trial, the Chinese Meishan, an indigenous breed with a fatty carcass, grew more slowly and had and higher back fat thickness than Landrace×Yorkshire, resulting in a poorer FCR. The feed energy cost of fatty tissue growth is more than three times that of lean tissue growth, mainly on account of the different water content of these tissues (Whittemore, 2003).

Carcass traits and chemical composition of lean meat

It is clear from the data shown in Table 5 that the high-fiber diet negatively affected hot carcass and dressing percentage, and pigs in treatment H-H had carcass and dressing percentages that were about 2 percentage units lower than of pigs in treatments L-L and L-H ($p<0.05$). This was probably due to the increased weight of visceral organs and gastrointestinal tract and digesta, also found in other studies where pigs were given high-fiber diets (Jørgensen et al., 1996; Zhao et al., 1996; Qin et al., 2002). However, there were no effects of dietary treatment on other carcass traits or on the chemical composition of lean ($p>0.05$). The results in our study are in agreement with Partanen et al. (2002) and Fevrier et al. (1992), who also found that carcass characteristics (back fat thickness and carcass lean) were not affected by fibre level in the diet.

Carcass, dressing and lean meat percentages were highest in Landrace×Yorkshire, followed by F1 and Mong Cai ($p<0.001$), while back fat thickness and EE content in lean meat were lowest in Landrace×Yorkshire and highest for Mong Cai, with F1 being intermediate ($p<0.001$). There were no significant differences in CP content in loin lean meat between three breeds ($p>0.05$). The differences in carcass traits between breeds found in the current study can be mainly accounted for by differences in the genetic potential for lean meat of the three breed types. Affentranger et al. (1996) confirmed that for growing-fattening pigs, meat quality is mainly determined by genotype, and the indigenous pigs of China and SE Asia usually have a higher carcass fat percentage than exotic pigs. In the present experiment, Mong Cai and F1 had lower dressing percentage and higher lean percentage than found in previous studies carried out in Vietnam (Thien et al., 1995; Van et al., 2000; Vuong et al., 2000), probably due to the lower body weight of Mong Cai and F1 at slaughter in the present experiment compared to the previous studies. In the current study, the castrated males had thicker back fat than the gilts ($p<0.001$) and somewhat higher fat content in lean meat. According to Renaudeau et al. (2005b) castrated males are fatter than females as a result of a higher lipogenic ability.

It can be concluded from the results of this study that in the growing period, high fiber diets should not be fed to Landrace×Yorkshire pigs, but can be fed to all the three breed types examined in the finishing period without any negative effects on growth performance or carcass traits. Although the Mong Cai and F1 pigs were clearly inferior with respect to performance and carcass traits, the F1 had reasonable performance and carcass quality on the high-fiber diet. As the F1 cross between Mong Cai and Landrace ×Yorkshire is well adapted to the harsh environmental conditions of the rural areas of Vietnam, and its meat fetches a higher price than that of exotics, it can be recommended to small farmers whose main source of feed is generally fibrous, locally available crop- and agro-industrial by-products.

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