MARDI Res. Bull. (1987) 15(2), (99–108)

EFFECTS OF FIBRE AND ENERGY LEVELS ON PERFORMANCE AND CARCASS CHARACTERISTICS OF GROWING-FINISHING PIGS

H.K. ONG* and R.I. HUTAGALUNG**

Keywords: Fibre, Energy, Performance, Carcass, Pigs, Malaysia.

RINGKASAN

Satu percubaan telah dilaksanakan untuk mengkaji kesan aras gentian dan tenaga terhadap pembesaran dan ciri karkas khinzir. Sejumlah 90 ekor khinzir dengan berat badan purata sebanyak 25 kg telah dibahagikan menjadi sembilan kumpulan. Percubaan faktorial 3 x 3 ini mengandungi sembilan diet yang terdiri daripada tiga aras gentian (10%, 15% dan 20% gentian detergen neutral, NDF) dan tiga aras tenaga (2.9, 3.1 dan 3.3 Mcal tenaga terhadam/kg). Pertambahan berat badan purata (ADG) didapati berkurang dengan bertambahnya aras gentian dalam diet (P<.01). Tiada perbezaan yang bererti didapati dalam pengambilan makanan purata (ADF) antara aras gentian yang berbeza. Kecekapan penukaran makanan didapati meningkat berikutan dengan bertambahnya gentian dalam diet. Peratus karkas dan tebal lemak belakang menurun sementara bahagian saluran penghadam meningkat dengan bertambahnya aras gentian. Aras gentian didapati tidak mempengaruhi kaedah pemotongan karkas dan kandungan abu tulang. ADG meningkat sementara kecekapan penukaran makanan menurun secara kuadratik berikutan dengan kenaikan aras tenaga dalam diet. Tiada perbezaan yang bererti didapati dalam ADF antara aras tenaga yang diuji. Peratus karkas, tebal lemak belakang dan jumlah tisu lemak bertambah berikutan dengan kenaikan aras tenaga. Bahagian saluran penghadam didapati lebih tinggi apabila aras tenaga dalam diet menurun. Aras tenaga didapati tidak mempengaruhi luas *M. longissimus*, kaedah pemotongan karkas dan kandungan abu tulang. Data daripada kajian ini menunjukkan bahawa keperluan tenaga bagi khinzir membesar di Malaysia ialah lebih kurang 3.1 Mcal/kg tenaga terhadam (DE).

INTRODUCTION

Earlier studies have demonstrated the inhibitory effects of high levels of dietary fibre on the growth of pigs (AXELSSON and ERICKSSON, 1953; CRAMPTON, ASHTON and LLYOD, 1954; TEAQUE and HANSON, 1954). However, more recent studies showed that fibre levels in the diet had no effects on rate and efficiency of gain, or carcass leanness if the energy density was constant (COLE, DUCKWORTH and HOLMES, 1967a; BAIRD, McCAMPBELL and ALLISON, 1970). BAIRD *et al.* (1975) further found that it is energy density, rather than bulk in the diet that determines feed intake. These latter reports support the suggestion that it is reduced energy intake and not fibre level that is responsible for the differences in performance. Furthermore, it has been shown that environmental temperature affects the utilization of fibre in pigs (STAHLY and CROMWELL, 1981; DAWSON, STAHLY, CROMWELL, TURLINGTON and DINTZIS, 1984; STAHLY, CROMWELL and OVERFIELD, 1984; TURLINGTON, STAHLY, CROMWELL, DAWSON and DINTZIS, 1984). This experiment was conducted to study the effects of levels of dietary fibre and energy on the performance and carcass characteristics of growing-finishing pigs reared under tropical Malaysian conditions.

MATERIALS AND METHODS

Chemical Analyses

The main feed ingredients used in this experiment were corn, soybean meal, local brewers dried grains (BDG), and a leaf meal of unconfirmed botanical origin imported from China (CLM). Among these, BDG and CLM were more fibrous. Samples of CLM and BDG were analysed for dry matter (DM), crude protein (CP), ether extract (EE), crude fibre (CF), ash, acid insoluble ash (AIA), neutral detergent fibre (NDF), acid detergent fibre (ADF), acid

*Livestock Research Division, MARDI, Serdang, Selangor, Malaysia.
**Dept. of Animal Science, Universiti Pertanian Malaysia, Serdang, Selangor, Malaysia.

detergent lignin (ADL) and amino acids. Nitrogen content was determined by the micro-Kjeldahl method (Tecator Kjeltec). Ash, CF and EE were analysed according to the methods described in A.O.A.C (1975). Determination of AIA was carried out by the method of McCarthy, Aherne and Okai (1974). Analytical methods for ADF, NDF, and ADL were based on Goering and Van Soest (1970). Cellulose was estimated as the difference between ADF and ADL. Hemicellulose was estimated as the difference between NDF and ADF. Amino acid composition was determined using a Beckman 119 amino acid analyser.

Statistical Design and Analysis

A 3 x 3 factorial experiment was conducted using 90 pigs (both castrates and females of Landrace x Duroc and Landrace x Yorkshire x Duroc crossbreds) averaging about 25 kilogrammes. The pigs were housed individually in a randomized complete block design with ten replicates per treatment. Data were analysed for main and interactive effects using the Statistical Analysis System (Barr, Goodnight, Sall, Blair and Chilko, 1976). The main effects were further partitioned into linear and quadratic effects.

Dietary Treatments

Nine diets were formulated to contain three levels of fibre, (10%, 15% and 20% of NDF as fed basis) and three levels of energy (2.9, 3.1 and 3.3 Mcal DE/kg) as shown in *Table 1* and *Table 2*. These levels were designated as low, medium and high, respectively. The chemical and amino acid compositions of CLM and BDG are shown

Table 1. Composition of experimental diets (25–45 kg liveweight)

Ingredient, %	LF			MF			HF		
	LE	ME	HE	LE	ME	HE	LE	ME	HE
Corn, yellow (IFN 4–02–935)	59.90	66.90	73.90	55.90	59.90	54.40	46.70	41.20	35.70
Soybean meal (IFN 5–20–637)	25.00	24.00	23.00	17.50	16.50	17.50	12.00	13.00	14.00
Leaf meal, China (IFN 1–20–735)	–	–	–	15.00	15.00	15.00	30.00	30.00	30.00
Brewers dried grain (IFN 5–00–516)	–	–	–	5.00	5.00	5.00	7.00	7.00	7.00
Palm oil (IFN 4–24–953)	–	–	–	–	1.00	5.50	2.00	6.50	11.00
Salt (IFN 6–04–152)	.35	.35	.35	.35	.35	.35	.35	.35	.35
Dicalcium phosphate (IFN 6–01–080)	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Limestone (IFN 6–02–632)	.90	.90	.90	.40	.40	.40	–	–	–
DL Methionine (IFN 5–03–086)	.10	.10	.10	.10	.10	.10	.20	.20	.20
Vitamin-mineral premix*	.25	.25	.25	.25	.25	.25	.25	.25	.25
Kaolin (IFN 8–08–040)	12.00	6.00	–	4.00	–	–	–	–	–
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Calculated content:									
DE, Mcal/kg	2.92	3.13	3.34	2.94	3.13	3.34	2.95	3.15	3.35
Protein (N x 6.25), %	16.02	16.21	16.39	16.53	16.45	16.41	16.67	16.62	16.56
Methionine + cystine, %	.68	.68	.68	.64	.64	.64	.68	.67	.67
Lysine, %	.88	.87	.86	.85	.83	.84	.83	.84	.86
NDF, %	8.99	9.57	10.15	15.20	15.48	15.07	20.22	19.79	19.36
Calcium, %	.73	.73	.73	.75	.75	.75	.80	.80	.80
Phosphorus, %	.63	.65	.66	.64	.65	.64	.63	.62	.61

*Contained the following per kg of diet: vit. A, 10 000 I.U.; vit. D3, 2 000 I.U.; vit. E, 5 mg; vit. B2, 4 mg; vit. B3, 10 mg; vit. B6, 1 mg; vit. B12, 0.02 mg; vit. K, 1 mg; nicotinic acid, 20 mg; iodine, 4.9 mg; Fe, 100 mg; Cu 125 mg; Zn, 100 mg; Mn, 40 mg; Co, 2 mg; Se, 0.1 mg.

LF = Low fibre; MF = Medium fibre; HF = High fibre;
LE = Low energy; ME = Medium energy; HE = High energy.

Table 2. Composition of experimental diets (45–80 kg liveweight)

Ingredient, %	LF			MF			HF		
	LE	ME	HE	LE	ME	HE	LE	ME	HE
Corn, yellow (IFN 4–02–935)	67.15	73.90	81.40	63.15	66.90	60.65	50.20	45.20	39.60
Soybean meal (IFN 5–20–637)	18.25	17.00	15.50	10.25	9.50	10.75	4.50	5.50	6.50
Leaf meal, China (IFN 1–20–735)	–	–	–	15.00	15.00	15.00	32.00	32.00	32.00
Brewers dried grain (IFN 5–00–516)	–	–	–	5.00	5.00	5.00	8.00	8.00	8.00
Palm oil (IFN 4–24–953)	–	–	–	–	1.00	6.00	3.00	7.00	11.60
Salt (IFN 6–04–152)	.35	.35	.35	.35	.35	.35	.35	.35	.35
Dicalcium phosphate (IFN 6–01–080)	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Limestone (IFN 6–02–632)	.90	.90	.90	.40	.40	.40	–	–	–
DL Methionine (IFN 5–03–086)	.10	.10	.10	.10	.10	.10	.20	.20	.20
Vitamin-mineral premix*	.25	.25	.25	.25	.25	.25	.25	.25	.25
Kaolin (IFN 8–08–046)	11.50	–	–	4.00	–	–	–	–	–
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Calculated content:									
DE, Mcal/kg	2.95	3.14	3.35	2.95	3.14	3.36	2.96	3.14	3.35
Protein (N x 6.25), %	13.76	13.81	13.83	14.04	14.06	14.04	14.38	14.37	14.31
Methionine + cystine, %	.62	.62	.63	.57	.57	.57	.61	.60	.59
Lysine, %	.70	.69	.66	.66	.64	.66	.65	.66	.68
NDF, %	8.91	9.43	10.00	15.05	15.34	14.87	20.77	20.39	19.95
Calcium, %	.72	.71	.71	.73	.73	.73	.81	.81	.81
Phosphorus, %	.61	.62	.64	.62	.62	.62	.61	.60	.59

*Contained the following per kg of diet: vit. A, 10 000 I.U.; vit. D3, 2 000 I.U.; vit. E, 5 mg; vit. B2, 4 mg; vit. B3, 10 mg; vit. B6, 1 mg; vit. B12, 0.02 mg; vit. K, 1 mg; nicotinic acid, 20 mg; iodine, 4.9 mg; Fe, 100 mg; Cu 125 mg; Zn, 100 mg; Mn, 40 mg; Co, 2 mg; Se, 0.1 mg.

LF = Low fibre; MF = Medium fibre; HF = High fibre;
LE = Low energy; ME = Medium energy; HE = High energy.

Table 3. Chemical composition of brewers dried grain (BDG) and China leaf meal (CLM)[1]

Chemical composition	CLM		BDG	
	n	x̄	n	x̄
Dry matter	4	90.08±0.99	4	91.87±0.81
Protein (N x 6.25)	4	20.20±1.83	4	26.12±0.10
Ether extract	4	2.75±0.04	4	6.14±0.94
Crude fibre	3	23.53±0.81	3	15.93±0.67
Total ash	4	14.93±1.55	4	3.52±0.26
Acid insoluble ash	4	7.00±0.15	4	1.28±0.30
Neutral detergent fibre	3	42.61±0.67	3	32.55±2.12
Acid detergent fibre	3	29.70±0.36	3	19.69±1.12
Acid detergent lignin	3	6.83±1.63	3	3.34±0.30
Cellulose	3	22.86±1.54	3	16.35±1.38
Hemicellulose	3	12.92±0.42	3	12.86±1.00
Tannin	2	0.32±0.02	–	–
Calcium	2	1.50±0.08	2	**0.34±0.02**
Phosphorus	2	**0.27±0.01**	2	0.58±0.06

[1]Values except dry matter are expressed as % on dry matter basis.
n is the number of replications.
x̄ is the mean value.

Table 4. Amino acid composition of China leaf meal (CLM) and brewers dried grain (BDG)[1]

Amino acids	CLM	BDG
Indispensable amino acids		
Lysine	1.04	1.18
Arginine	1.09	1.15
Histidine	0.44	0.75
Isoleucine	0.93	1.39
Leucine	1.54	3.15
Methionine	0.17	0.58
Phenylalanine	1.03	1.91
Threonine	0.82	1.10
Valine	1.01	1.75
Non-essential amino acids		
Alanine	1.04	1.67
Aspartic acid	1.74	1.74
Cystine	0.09	0.44
Glutamic acid	2.05	6.13
Glycine	0.92	1.21
Proline	0.76	2.58
Serine	0.80	1.27
Tyrosine	0.67	1.13

[1]Means of two determinations expressed as % on dry matter basis.
Tryptophan was destroyed during hydrolysis.

in *Table 3* and *Table 4*, respectively. The DE values for corn, soybean meal, CLM, BDG, and palm oil were 3.5, 3.3, 2.0, 2.1 and 8.0 Mcal/kg, respectively.

Feeding Management

The pigs were housed in concrete-floored individual pens with feed troughs and water push-nipples. The maximum and minimum temperatures during the feeding period were 32.6°C and 22.3°C, respectively. The mean rainfall and evaporation during the same period were 196.9 mm and 109.7 mm, respectively. Average relative humidity at 0730 h and 1330 h were 97.2% and 62.2%, respectively. Individual feed bin with cover was provided for each pig. There were two main feedings (in mash form) each day, with frequent inspection for necessary addition to simulate *ad libitum* feeding. Feed refusal was recorded daily. Feed intake and liveweight gain were recorded at weekly intervals.

Carcass Evaluation and Bone Ash Determination

Pigs were on experimental diets until they attained approximately 80 kilogrammes. They were fasted for 12 h prior to slaughter. Warm carcasses were weighed and chilled at about 4°C for 24 hours. Measurements and weights of the following were recorded: backfat thickness (average of three readings, opposite first rib, last rib and last lumbar), loin, ham, picnic and boston butt, *M. longissimus* areas, total fatty tissue (total fat dissectable from carcass), lean cuts and primal cuts. Lean cuts were taken as the sum of skinned ham, picnic and boston butt, and loin while primal cuts were taken as the sum of skinned ham, picnic and boston butt, loin and belly. Bone samples were obtained from the head, neck and tubercle region of the 9th, 10th and 11th rib, and from the corresponding thoraxic vertebrae. These bones were autoclaved, stripped of all soft tissues and identified. The stripped bones were soaked in petroleum ether for 24 h and spread to dry for 2 hours. They were then dried at 100°C for 24 hours. The dried weight of each bone was obtained after cooling. The bones were ashed at 600°C overnight and the ashed weight of each bone sample was obtained to determine percent ash of dry, fat-free bone sample.

RESULTS

The effects of varying levels of dietary fibre and energy on the performance and carcass characteristics are shown in *Table 5*. There were significant effects ($P<.01$) in a quadratic trend for both fibre and energy on ADG, feed to gain ratio, dressing percentage, percent digestive tract, backfat thickness and percent fatty tissue. No apparent effects were detected for either fibre or energy on carcass leanness (shown by percent lean cuts, percent primal cuts and *M. longissimus* areas), ADF and bone ash content. The interactive effects of fibre and energy on all the variables were not significant.

Table 5. Performance and carcass traits of pigs fed varied levels of fibre and energy

Item: NDF level (%)	10			15			20		
Energy level (Mcal/kg)	2.9	3.1	3.3	2.9	3.1	3.3	2.9	3.1	3.3
Performance									
Av. daily gain (g)[d]	674	710	723	579	639	642	510	542	559
Av. daily intake (kg)[e]	2.28	2.22	2.14	2.23	2.22	2.25	2.20	2.21	2.14
Feed/gain[d]	3.16	3.17	3.09	3.89	3.53	3.48	4.33	4.00	3.87
Carcass									
Dressing percentage (%)[a,d]	66.45	69.14	69.49	64.90	67.21	68.20	61.97	64.75	66.09
Full digestive tract (%)[b,d]	9.16	8.25	7.34	11.55	10.77	9.11	13.06	11.45	10.29
Empty digestive tract (%)[b,d]	5.62	4.85	4.07	5.85	5.21	4.68	6.52	5.71	4.99
Backfat thickness (cm)[d]	2.17	2.49	3.01	2.12	2.42	2.77	2.10	2.43	2.73
Fatty tissue (%)[c,d]	15.76	17.17	20.63	14.75	16.62	19.19	14.32	16.10	18.63
M. longissimus area (cm^2)[e]	24.42	26.97	26.33	24.64	26.64	24.93	25.55	25.54	24.85
Lean cuts (%)[c,e]	34.37	35.83	35.40	35.35	35.43	34.69	35.58	35.97	35.73
Primal cuts (%)[c,e]	43.79	44.12	45.07	44.74	44.82	44.00	43.15	44.11	44.71
Bone ash (ribs) (%)[e]	56.36	57.08	57.46	58.03	57.47	57.41	57.92	56.83	56.69
Bone ash (vertebrae) (%)[e]	45.13	44.34	46.45	46.03	45.53	45.54	46.21	44.46	42.75

[a]Based on chilled carcass without head.
[b]Percent of slaughter weight.
[c]Percent of carcass weight.
[d]Significant at $P<0.01$ for both fibre and energy but not significant for fibre x energy interactions.
[e]Not significant for both fibre and energy.

Table 6. Effect of dietary fibre level on performance and carcass characteristics of pigs

Item	Dietary NDF level, %			Significance of effects	
	10	15	20	Linear	Quadratic
Performance					
Av. daily gain (g)	703a	620b	537c	**	**
Av. daily intake (kg)	2.21	2.23	2.18	N.S.	N.S.
Feed/gain	3.14a	3.63b	4.07c	**	**
Carcass					
Dressing percentage (%)[d]	68.36a	66.90b	64.27c	**	**
Full digestive tract (%)[e]	8.25a	10.48b	11.60c	**	**
Empty digestive tract (%)[e]	4.84a	5.25b	5.74c	**	**
Backfat thickness (cm)	2.56a	2.44b	2.42b	N.S.	**
Fatty tissue (%)[f]	17.86a	16.85b	16.35b	N.S.	**
M. longissimus area (cm^2)	25.91	25.41	25.31	N.S.	N.S.
Lean cuts (%)[f]	35.20	35.16	35.76	N.S.	N.S.
Primal cuts (%)[f]	44.33	44.52	43.99	N.S.	N.S.
Bone ash (ribs) (%)	56.97	57.64	57.15	N.S.	N.S.
Bone ash (verterbrae) (%)	45.30	45.70	44.47	N.S.	N.S.

[d]Based on chilled carcass without heads.
[e]Percent of slaughter weight.
[f]Percent of carcass weight.
**Significant at $P<0.01$.
N.S. = Not significant.
a, b, c Figures in the same row with different subscripts are different.

Table 6 shows the effects of the three levels of dietary fibre on the performance and carcass traits. The ADG decreased while feed to gain ratio increased with increased dietary fibre. The ADF among the treatments were not significantly different. Dressing percentage decreased while the percentage of digestive tract

Table 7. Effect of dietary energy level on performance and carcass characteristics of pigs

Item	Energy level, Mcal/kg			Significance of effects	
	2.9	3.1	3.3	Linear	Quadratic
Performance					
Av. daily gain (g)	588a	631b	641b	N.S.	**
Av. daily intake (kg)	2.24	2.21	2.18	N.S.	N.S.
Feed/gain	3.79a	3.57b	3.48b	N.S.	**
Carcass					
Dressing percentage (%)[d]	64.44a	67.03b	68.06c	**	**
Full digestive tract (%)[e]	11.25a	10.15b	8.91c	**	**
Empty digestive tract (%)[e]	6.00a	5.26b	4.58c	**	**
Backfat thickness (cm)	2.13a	2.44b	2.84c	**	**
Fatty tissue (%)[f]	14.94a	16.63b	19.49c	**	**
M. longissimus area (cm^2)	24.87	26.38	25.37	N.S.	N.S.
Lean cuts (%)[f]	35.10	35.74	35.27	N.S.	N.S.
Primal cuts (%)[f]	43.89	44.35	44.59	N.S.	N.S.
Bone ash (ribs) (%)	57.44	57.13	57.19	N.S.	N.S.
Bone ash (verterbrae) (%)	45.79	44.78	44.91	N.S.	N.S.

[d]Based on chilled carcass without heads.
[e]Percent of slaughter weight.
[f]Percent of carcass weight.
**Significant at $P<0.01$.
N.S. = Not significant.
a, b, c Figures in the same row with different subscripts are different.

increased, as the fibre level increased. Backfat thickness decreased quadratically with increased fibre. When expressed as a percentage of carcass weight, the total fatty tissue decreased quadratically as fibre level increased. Fibre level did not affect the *M. longissimus* area, lean cuts, primal cuts and bone ash content.

The effects of energy level on the performance and carcass traits are shown in *Table 7*. With increased energy, ADG increased while feed to gain ratio decreased in a quadratic trend. There were no significant differences in ADF. Dressing percentage, backfat thickness and total fatty tissue increased while percentage digestive tract decreased as dietary energy increased. Dietary energy did not affect *M. longissimus* area, lean cuts, primal cuts and bone ash content.

DISCUSSION

Results of analyses showed that both CLM and BDG contained useful nutrients. The amino acid composition of CLM resembled that of alfalfa meal (NRC, 1979), while BDG also showed an amino acid profile similar to that reported by KORNEGAY (1973). However, both feedstuffs are relatively fibrous, as can be seen from the NDF values, being 42.6% and 32.6% in CLM and BDG, respectively. Since in the NDF determination all the highly digestible cell contents of plant materials are removed, the residue, containing hemicellulose, cellulose and lignin could be expected to give a good measure of indigestible fibre in the diets. Furthermore, since the insoluble undigested fibre is the principal fraction promoting the passage of food (VAN SOEST, ROBERTSON, ROE, RIVERS, LEWIS and HECKLER, 1978), diets with high proportions of CLM and BDG would result in faster rate of passage in the animals, which could lower the digestibility of nutrients.

The results of growth performance differed from those of BAIRD, MCCAMPBELL and ALLISON (1975), whose data suggested that if the energy level was adequate, the pigs could tolerate relatively wide ranges of fibre in the diet. Data obtained from this experiment showed that increased dietary fibre depressed ADG. This could be attributed to reduced digestibility (CUNNIGHAM, FRIEND and NICHOLSON, 1962; BAIRD, ALLISON and HEATON, 1974; KUAN, STANOGIAS and DUNKIN, 1983) resulting from lack of enzymes penetration or a faster rate of passage, although RUST, OWENS and MAXWELL (1984) reported that intake levels of 2% versus 3% of body weight did not influence organic matter digestibility or rate of passage. However, the inclusion of 30% alfalfa hay, 30% cotton seed hulls or 30% corn silage decreased organic matter digestibility and increased rate of passage (RUST *et al.*, 1984). It appears that the degree of fibre utilization of pig is quite variable, depending on factors like source of fibre, level of fibre in diet, characteristics of the non-fibrous portion of the diet, age of pigs and forms of feed. It was found that if fibrous feeds were fed to pigs in pelleted form, the digestibility of fibre increased (NGIAN, 1981).

The lack of significance in ADF was also contrary to the finding that increased ADF was associated with reduced dietary energy (MERKEL *et al.*, 1958; TROELSEN and BELL, 1962; COLE *et al.*, 1976a, b). The failure of pigs to increase intake of low-energy diets, could be due to several reasons. The high-fibre, low-energy diets contained relatively large proportions of CLM and BDG, both of which have been shown to be bulkier than corn meal (ONG and HUTAGALUNG, 1985). The higher bulk could have affected stomach fill. Poor palatability of diets with CLM, especially at 32% inclusion is suspected. Bitter compounds could be formed in some leaf meals through caramelization reactions during the drying process (MYER and CHEEKE, 1975). In addition, it might contain inhibitors such as saponins, which have been found in some alfalfa meal (CHEEKE *et al.*, 1978). LEAMASTER and CHEEKE (1979) demonstrated that if given the choice, growing pigs selected an alfalfa-free diet over diets containing 1% or higher alfalfa meal. Further, the low-fibre, low-energy diets used in this study contained a fair amount of kaolin which acted as energy diluent. This could also adversely affect the palatability of diets.

The results on the performance are in agreement with those of HALE, JOHNSON and WARREN (1968) who found that gains and gain to feed ratio were reduced at higher fibre levels in pigs fed diets varying from 2.2% to 10.5% in crude fibre. Similarly, POWLEY, CHEEKE, DAVIDSON and KENNICK (1981) found that levels of 20%, 40% and 60% alfalfa meal decreased gains and increased feed to gain ratio with each increment of alfalfa, while voluntary feed intake was similar at each level of alfalfa meal. It was suggested that due to low palatability or presence of other factors in alfalfa meal, pigs did not compensate for lower dietary energy levels by increasing their intake when diets containing alfalfa meal were fed.

Reduced dressing percentage caused by high fibre levels seemed to be associated with heavier gut fill as shown by the higher percentage of digestive tract. The effects on dressing percentage, percent digestive tract and backfat thickness exerted by energy levels were in reverse of that exerted by fibre levels. Thus, dressing percentage increased while the gut fill and backfat thickness decreased with increase in level of dietary energy. However, the results did not indicate any effect of either fibre or energy levels on carcass leanness, as shown by the non-significant differences in percent lean cuts, percent primal cuts and *M. longissimus* area. There are conflicting reports on the effects of fibre level on carcass traits. BAIRD *et al.* (1975) found that feeding a low fibre diet resulted in a lower dressing percentage, lower backfat thickness, higher percent ham, higher percent loin and significantly more lean cuts than a high fibre diet. However, KENNELLY and AHERNE (1980) reported that dietary fibre had no influence on carcass measurements.

Carcass effects due to energy level could be confounded by the composition of diet. A high proportion of the energy in the high-fibre, high-energy diet of this study was supplied by palm oil. Increase in the amount of palm oil could have improved the overall digestibility, producing less heat increment and resulting in carcass that was less lean. Conflicting results could also be attributed to differences in digestibility caused by unequal amounts of nitrogen-free extract in the diet resulting from variations in diet composition. Thus, IMOTO and NAMIOKA (1978) found that crude fibre digestibility was higher in pigs fed low-carbohydrate diets than in those fed high-carbohydrate diets. Furthermore, the effects of dietary fibre and energy are influenced by environmental temperature and perhaps humidity in which pigs are kept. STAHLY and CROMWELL (1979) found that efficiency of energy utilization responded quadratically as environmental temperature increased, with the most efficient gains obtained at 22.5°Celsius. In addition, the value of a fibrous feedstuff is greater in pigs housed in a cold environment than in a warm environment (STAHLY and CROMWELL, 1981).

Results on the effects of energy on carcass yield were similar to those obtained by WAGNER, CLARK, HAYS and SPEER (1963), TALLY, ASPLUND, HENDRICK and LARRY (1976) and ARGANOSA, SALAYOG, BANDIAN, ARGANSA and LOPEZ (1977), who found that carcass yield in pigs fed high-energy diets was higher than that of pigs fed low-energy diets. Backfat thickness was greater in pigs fed high-energy diets whereas *M. longissimus* areas were essentially the same for pigs fed high or low levels of energy (ARGANOSA *et al.* 1977). Results on the proportion of digestive tract are also in agreement with that of ARGANOSA, *et al.* (1977) who reported that pigs fed low-energy diets had heavier percentages of large intestines and other slaughter losses than pigs fed high-energy diets. Reduced proportion of digestive tract would account for the higher dressing percentage of pigs fed high-energy diets. More recently, PEKAS, YEN and POND (1981) found that high-fibre diets resulted in a heavier stomach, small intestines and colon-rectum in lean-type pigs.

Since there were no significant differences in ADG and feed to gain ratios in pigs fed either 3.1 or 3.3 Mcal/kg DE, it can be said that in terms of performance, there is no advantage in providing growing pigs in the tropics with more than 3.1 Mcal/kg DE. This is in agreement with the results of CHEN and WOO (1985) who suggested the energy requirement of growing pigs in the tropics to be between 3 048 and 3 315 kcal/kg DE.

Bone ash content was not affected either by dietary fibre or energy, indicating no impairment in mineral metabolism, although an increased intake of fibre has been shown by PARTRIDGE (1978) to exert a depressing effect on the apparent absorption of calcium, phosphorus, magnesium, potassium and zinc in the small intestine of pigs.

ACKNOWLEDGEMENTS

The authors would like to thank Ms F. Lim, Ms Husna Kassim and Ms S.Y. Yu for chemical analyses; Mr Shokri Othman for statistical analyses; Ms S.P. Soo, Mr J.J. Roch, Mr S. Poovan, Mr K. Balasubramaniam, Mr H.T. Chong and Mr S. Rajendran for technical assistance.

ABSTRACT

An experiment was conducted to study the effects of levels of dietary fibre (determined as neutral detergent fibre, NDF) and energy on growth performance and carcass characteristics of growing-finishing pigs. Ninety pigs averaging 25 kg were allocated to nine treatments in a 3 x 3 factorial arrangement with three levels of fibre (10%, 15% dan 20% of NDF) and three levels of energy (2.9, 3.1 and 3.3 Mcal digestible energy/kg). Average daily gain (ADG) decreased with increased fibre level (P<.01). There were no differences in the average daily feed intake (ADF) among fibre levels.

However, feed conversion efficiency increased as fiber level increased. Dressing percentage and backfat thickness decreased while the proportion of digestive tract increased with increased in fibre levels (P<.01). Fibre levels did not effect *M. longissimus* area, lean cuts, primal cuts and bone ash content. ADG increased while feed conversion efficiency decreased quadratically as energy level increased. There were no significant differences in ADF. Dressing percentage, backfat thickness, and total fatty tissue increased as energy level increased. As the energy level decreased, the percentage of digestive tracts increased. Dietary energy did not affect *M. longissimus* area, lean cuts, primal cuts and bone ash content. Data obtained indicated that the optimal energy level for growth performance in growing pigs in Malaysia is in the region of 3.1 Mcal/kg digestible energy (DE).

REFERENCES

A.O.A.C. (1975). Official Methods of Analysis (12th Ed.) . Washington, D.C.: Association of Official Analytical Chemists.

ARGANOSA, V.G., SALAYOG, F.A., BANDIAN, M.M., ARGANOSA F.C. and LOPEZ, P.L. (1977). Rate of growth, pork recovery and processing characteristics of pigs slaughtered at different weights. *Food and Fertilizer Technology Center Extension Bull. No.* ***89***, 25 pp.

AXELSSON, J. and ERICKSSON, S. (1953). The optimum crude fiber level in rations of grazing pigs. *J. Anim. Sci.* ***12***, 881.

BAIRD, D.M., ALISSON, J.R. and HEATON, E.K. (1974). The energy value for and influence of citrus pulp in finishing diets for swine. *J. Anim, Sci.* ***38***, 545.

BAIRD, D.M., MCCAMPBELL, H.C. and ALLISON, J.R. (1970). Levels of crude fiber with constant energy levels for growing-finishing swine using computerized rations. *J. Anim. Sci.* ***31***, 518.

______ (1975). Effects of levels of crude fiber, protein and bulk in diets for finishing hogs. *J. Anim. Sci.* ***41***, 1 039.

BARR, A.J., GOODNIGHT, J.H., SALL, J.P., BLAIR, W.H., and CHILKO, D.M. (1976). *SAS User Guide*. Cary : Statistical Analysis System Institute, Inc.

CHEN, T.W. and WOO, K.K. (1985). Protein and energy requirements of growing pigs in tropical Singapore II. Energy requirement. *Singapore J. Prim. Ind.* ***13***, 38.

CHEEKE, P.R., PEDERSEN, M.W. and ENGLAND, D.C. (1978). Responses of rats and swine to alfalfa saponins. *Can. J. Anim. Sci.* ***58***,783.

COLE, D.J.A., DUCKWORTH, J.E. and HOLMES, W. (1967a). Factors affecting voluntary feed intake in pigs. 1. The effect of digestible energy content of the diet on the intake of castrated male pigs housed in holding pens and in metabolism crates. *Anim. Prod.* ***9***, 141.

______ (1967b). Factors affecting voluntary feed intake in pigs. 2. The effect of two levels of crude fiber in the diet on the intake and performance of fattening pigs. *Anim. Prod.* ***9***, 149.

CRAMPTOM, E.W., ASHTON, G.C. and LLOYD, L.E. (1954). Improvement of bacon carcass quality by the introduction of fibrous feed into the hog finishing ration. *J. Anim. Sci.* ***13***, 321.

CUNNIGHAM, H.M., FRIEND, D.W. and NICHOLSON, J.W.G. (1962). The effect of age, body weight, feed intake and adaptability of pigs on the digestibility and nutritive value of cellulose. *Can. J. Anim. Sci.,* ***42***, 167.

DAWSON, K.A., STAHLY, T.S., CROMWELL, G.L., TURLINGTON, H. and DINTZIS, F.R. (1984). Volatile fatty acid production rates in the cecum and colon of pigs as influenced by dietary wheat bran and environmental temperature. *J. Anim. Sci.* ***59*** (suppl. 1), 103.

GOERING, H.K., and VAN SOEST, P.J. (1970). Forage Fiber Analysis. *Agric. Handbook No. 379 ARS.* Washington, DC: USDA.

HALE, O.M., JOHNSON, J.C., JR and WARREN, E.P. (1968). Influence of season, sex, and dietary energy concentration on performance and carcass characteristics of swine. *J. Anim. Sci.* ***27***, 1 577.

IMOTO, S. and NAMIOKA, S (1978). VFA production in the pig large intestine. *J. Anim. Sci.* ***47***, 467.

KENNELLY, J.J. and AHERNE, F.X. (1980). The effect of fibre in diets formulated to contain different levels of energy and protein on growth and carcass quality of swine. *Can. J. Anim. Sci.* ***60***, 385.

KORNEGAY, E.T. (1973). Digestible and metabolizable energy and protein utilization values of brewers dried by-products for swine. *J. Anim. Sci.* ***37***, 479.

KUAN K.K., STANOGIAS, G. and DUNKIN, A.C. (1983). The effect of proportion of cell-wall material from lucerne leaf meal on apparent digestibility, rate of passage and gut characteristics in pigs. *Anim. Prod.* **36**, 201.

LEAMASTER, B.R. and CHEEKE, P.R. (1979). Feed preferences of swine: alfalfa meal, high and low saponin alfalfa, and quinine sulphate. *Can. J. Anim. Sci.* **59**, 467.

MCCARTHY, J.E., AHERNE, F.X. and OKAI, D.B. (1974). Use of HCl-insoluble ash as index material for determining apparent digestibility with pigs. Can. *J. Anim. Sci.* **54**, 107.

MERKEL, R.A., BRAY, R.W., GRUMMER, R.H., PHILIPS, P.H. and BOHSTEDT, G. (1958). The influence of limited feeding, using high fiber rations, upon growth and carcass characteristics in swine I: Effects upon feedlot performance. *J. Anim. Sci.* **13**, 206.

MYER, R.O. and CHEEKE, P.R. (1975). Utilization of alfalfa meal and alfalfa protein concentrate by rats. *J. Anim. Sci.* **40**, 500.

NGIAN, M.F. (1981). Does pelleting pay in the tropics? *Pig International* **11**(12), 14.

NRC (1979). Nutrient requirements of swine. In *Nutrient Requirements of Domestic Animals No. 2*. Eighth Revised Edition. Washington, D.C.: National Academy of Science – National Research Council.

ONG, H.K., and HUTAGALUNG, R.I. (1985). Effects of fiber on the quality of pig diets. *Proc. 9th Ann. Conf. of Malaysian Soc. Anim. Prod., March 11–12, 1985,* Universiti Pertanian Malaysia, p. 110.

PARTRIDGE, I.G. (1978). Studies on digestion and absorption in the intestines of growing pigs. 4. Effects of dietary cellulose and sodium levels on mineral absorption. *Br. J. Nutri.* **39**, 539.

PEKAS, J.C., YEN, J.T. and POND, W.G. (1981). Gastrointestinal and performance traits of obese and lean genotype swine: Effect of a high fiber diet. *Amer. Soc. Anim. Sci. Annual Meeting Abstr. No.* **329**, p. 257.

POWLEY, J.S., CHEEKE, P.R., ENGLAND, D.C., DAVIDSON, T.P., and KENNICK, W.H. (1981). Performance of growing-finishing swine fed high levels of alfalfa meal: Effects of alfalfa level, dietary additives and antibiotics. *J. Anim. Sci.* **53**, 308.

RUST. S.R., OWENS, F.N. and MAXWELL, C.V. (1984). Effects of intake level and roughage source on the rate of passage and site of digestion in finishing swine. *J. Anim. Sci.* **59***(Suppl. 1)*, 259.

STAHLY, T.S. and CROMWELL, G.L. (1979). Effects of environmental temperature and carcass characteristics of growing and finishing swine. *J. Anim. Sci.* **49**, 1 478.

——— (1981). Interactive effects of dietary fiber level and environmental temperature on pig performance. *J. Anim. Sci.* **53***(Suppl. 1)*, 92.

STAHLY, T.S., CROMWELL, G.L. and OVERFIELD, J.R. (1984). Influence of season and dietary fiber additions on the performance of growing pigs. *J. Anim. Sci.* **59***(Suppl. 1)*, 102.

TALLY, S.M., ASPLUND, J.M., HENDRICK, H.B. and LARRY, R. (1976). Influence of metabolizable energy level on performance, carcass characteristics and rectal temperature in swine. *J. Anim. Sci.* **42**, 1 471.

TEAQUE, H.S. and HANSON, L.E. (1954). The effect of feeding different levels of cellulosic material to swine. *J. Anim. Sci.* **13**, 206.

TROELSEN, J.E. and BELL, J.M. (1962). Ingredient processing inter-relationships in swine feeds 4. Effects of various levels of fibrous diluents in finishing rations, fed as meal or pellets on performance and carcass quality of swine. *Can. J. Anim. Sci.* **42**, 63.

TURLINGTON, W.H., STAHLY, T.S., CROMWELL, G.L., DAWSON, K.A. and DINTZIS, F.R. (1984). The nutritive value of soybean hulls and oat hulls for growing pigs as influenced by dietary fiber levels and environmental temperature. *J. Anim. Sci.* **59***(Suppl. 1)*, 259.

VAN SOEST, P.J., ROBERTSON, J.B., ROE, D.A., RIVERS, J., LEWIS, B.A. and HECKLER, L.R. (1978). The role of dietary fiber in human nutrition. *Proc. Cornell Nutri. Conf.,* 5 pp.

WAGNER, G.R., CLARK, A.L., HAYS, V.W. and SPEER, V.C. (1963). Effect of protein-energy relationship on the performance and carcass quality of growing swine. *J. Anim. Sci.* **22**, 202.

Accepted for publication on 21 August, 1987.