Effects of feeding varying dietary crude protein and digestible energy concentrations on performance of pigs raised in a humid tropical environment.

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Abstract

This paper aims at investigating relationships and effects of varying protein and energy levels on growth performance, efficiency of feed conversion and efficiency of nutrient utilization of weanling pigs fed from 9 to 60 kg. A total of one hundred and twenty weanling pigs weighing ± 9 kg were allotted randomly to sixteen groups of eight pigs each, for females and four castrated males in a 4 x 4 factorial design. The sixteen diets consist of four digestible energy levels (3,000; 3,300; 3,600 and 3,900 kcal/kg) and four crude protein levels (18; 21; 24 and 27%). The pigs were fed these experimental diets until they attained a predetermined liveweight of 60 ± 1.5 kg. The effects of the varying crude protein and digestible energy were studied on growth and performance parameters. Neither protein nor energy levels significantly affected daily feed intake, but significantly decreased daily feed intake at 27% protein level. Daily protein intake was influenced by protein intake and digestible energy intake was also significantly influenced by digestible energy intake. There were no significant interactions between protein and energy levels with respect to feed intake and intake of protein and energy. Energy but not protein levels significantly influenced rate of live weight gain. Feed conversion efficiency (FEC) was highly ($P < 0.001$) influenced by energy but not protein levels. In both sexes, females and castrated males, increasing dietary levels of protein and energy resulted in improved efficiency of feed utilization within protein levels but there were significant differences between the two highest energy levels for castrated males and within the diets with 3,300, 3,600 and 3,900 kcal/DE/kg for the females. When high protein levels were combined with high energy levels, feed intakes were depressed only on the 27% protein level. Feed conversion efficiency was maximized on the diet with 21 and 24% protein levels with appreciable sex differences, with female pigs requiring more protein than males. Digestible Energy range of 3,300 and 3,600 kcal/kg would be adequate for maximum gain and efficiency of feed utilization in pigs under the humid tropical environment tropical. Feed to gain ratio, a very important economic index should be an important index of the quality of any diet for promoting growth.

Keywords: Feed intake, daily gain, feed efficiency, feed utilization, tropical environment.

Introduction

Considerable attempts have been made to establish feeding standards for imported European pigs raised in a tropical environment but these attempts are still limited to a few reports on the crude protein or a few amino acid requirements (Babatunde *et al*, 1972 and Fetuga, 1972). Among these reports, there appears to be no unanimity as to whether physiological requirements differ between these pigs reared in a tropical environment and those reared in the temperate, although the

consensus would appear to be that there is a reduction in the level of feed intake of pigs when reared in warm tropical environments (Oyeleke *et al*, 1985, Nichols *et al*, 1982, Close, 1989 and Rinaldo *et al*, 2000).

The dietary energy concentration is particularly important in a hot humid environment, since excessive dietary energy concentrations have been shown to depress feed intake (Fetuga, 1984, Adeshinwa and Ogunmodede, 1995). Such effect of high ambient temperatures on feed intake could act together to reduce

further the level of feed intake and therefore useful nutrients consumed thereby adversely affecting growth rate. Digestible energy concentration of the diet has been shown to influence the performance of growing finishing pigs (Cooke *et al*, 1972, Holmes, 1973, Campbell and Dunkin, 1983, Quiniou *et al*, 1995), while it has also been reported that ambient temperature can influence energy intake (Quiniou *et al* 1995). Since important relationships exist between environmental temperature, dietary energy concentration and feed intake, it may well be that some of the earlier reports concerning protein requirement *per se*, it may have been influenced one way or the other by the relationship of energy to protein in the diet. The present study was designed to holistically investigate the influence of varying digestible energy concentration and dietary crude protein, balanced for amino acids on performance of growing /finishing pigs reared from 9 to a predetermined liveweight of 60kg.

Materials and Methods

Animals

A total of one hundred and twenty-eight Large White x Landrace pigs weighing initially about 9.0 ± 1.5 kg were assigned to sixteen groups of eight pigs each, comprising four females and four barrows. Allocation to groups was on the basis of sex, initial weight and as far as possible, litter origin, such as to equalize group mean weight and sex. These groups were then randomly assigned to any one of the sixteen treatments laid out in a 4x4 factorial design. The factors were four crude protein levels and four digestible energy levels.

Experiment diets

The composition of the experimental diets, the basic ingredients used and the nutrient compositions are as presented in Table 1.

There were sixteen diets, in all, consisting of four digestible energy levels 3,000; 3,300; 3,600 and 3,900 kcal/kg and four crude protein levels 18, 21, 24 and 27% at each dietary energy level. Attempts were made to maintain approximately the same ratio of the main protein contributing ingredients, fish meal, blood meal, groundnut cake, and palm kernel meal. This was to ensure that approximately equal proportions of amino acids were supplied from animal and plant sources and to ensure similar ratios of amino acids to protein. Synthetic DL-methionine, L-Lysine hydrochloride were added to maintain a constant balance between the level of amino acids relative to the dietary protein levels. The energy levels used were obtained by appropriate adjustment of the level of yellow maize, cassava flour, wheat offal's and brewers dried grains, while the higher energy diets were arrived at by the inclusion of varying levels of palm oil, a highly digestible oil. Dietary calcium and phosphorus levels were equalized by the inclusion of Di-calcium phosphate. Constant levels of sodium chloride were included in all diets, while zinc oxide was included in the diets to supply additional 100ppm zinc. A commercial vitamin-trace mineral premix were supplied by a commercial Vitamin-Mineral Premix (Pfizer (Nig.) Ltd Product). All experimental diets were analyzed at each mixing and at regular intervals during the course of the experiment for their proximate constituents (A.O.A.C, 2005). Digestible energy values were determined using standard procedures (Fetuga *et al*, 1977). The amino acid content of each diet (Table 2) was calculated from amino acid analysis of the ingredients obtained on several batches using a Technicon (TSM) amino acid analyzer (Fetuga, 1973) and the values expressed as percentage of

Table 1: Diet composition % dry matter

	Dates															
Ingershams	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Ground Yellow maize (70% cp)	32.4	31	30	30	43	41	38	37	40	45.57	41.7	38.21	52.2	48.46	43.96	40.42
Cassava flour (1.3% cp)	13.17	11.35	8.96	5.67	10.68	8.45	6.01	3.14	7.11	5.31	3.39	0.39	4.7	1.9	-	-
Wheat offal (22.3% cp)	20	15.16	11.02	7.21	13.2	10.3	7.27	4.76	8.71	6.8	3.14	5.25	4.49	3.17	-	-
Feed Beans (9.5% cp)	10	10.41	11.02	10.81	3.3	3.44	3.64	3.57	1.69	1.14	1.2	1.18	0.36	0.38	0.4	-
Polished meal (8.5% cp)	7.57	10	12.43	14.96	8.49	11.19	13.64	16.45	8.87	11.41	14.22	16.81	9.93	11.57	14.33	16.92
Crystalline Meal (9% cp)	4.39	0.5	8.41	10.32	3.97	7.14	8.96	10.62	5.71	7.38	9.2	10.89	5.94	7.48	9.28	10.95
Fish Meal (65% cp)	2.6	3.73	4.79	5.85	3.79	4.05	3.06	6	3.23	4.19	5.2	6.14	3.29	4.24	5.25	6.19
Black Molasses (cp)	5.35	7.25	9.15	11.03	6.15	8.03	10.06	11.46	6.33	8.32	10.35	12.22	9.57	8.42	10.44	12.31
Patnaul	-	-	-	-	2.38	2.31	2.37	2.32	5.55	5.6	5.69	6.8	8.67	8.77	8.92	8.94
Dicalcium Phosphate	2.8	2.8	2.8	2.8	7.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
Tricalcium Phosphate	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Carbon ash	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Zinc oxide	100ppm	100ppm	100ppm	100ppm	100ppm	100ppm	100ppm	100ppm	100ppm	100ppm	100ppm	100ppm	100ppm	100ppm	100ppm	100ppm
Ammonium	+	+	+	+	+	-	+	+	+	+	+	+	+	+	+	+
L-Alanine %	0.2	0.18	0.16	0.68	0.17	0.17	0.13	0.01	0.16	0.15	0.12	0.07	0.17	0.14	0.11	0.07
D,L-methionine %	0.03	0.04	0.07	0.05	0.07	0.1	0.17	0.17	0.07	0.08	0.11	0.14	0.08	0.09	0.11	0.16
L-Tyrosophan %	0.01	0.02	0.03	0.03	0.02	0.03	0.04	0.04	0.03	0.03	0.05	0.05	0.03	0.04	0.05	0.06
Calculated Cattle Protein %	18	21	24	27	18	21	24	26	18	21	24	27	18	21	24	27
Decomposed Cattle Protein %	18.64	21.48	24.48	20.02	18.67	21.72	23.18	27.24	18.14	20.89	24.23	27.51	18.07	21.01	23.69	27.74
Calculated Digestible energy Kcal/kg	3000	3300	3300	3300	3000	3300	3300	3300	3000	3300	3300	3300	3000	3300	3300	3300
Decomposed Digestible energy kcal/kg	3050	3089	3117	3114	3341	3201	3325	3380	3396	3626	3596	3635	3857	3856	3970	4017
Calculated nitrogen-protein ratio	16.67	14.26	12.5	11.11	18.33	13.71	13.75	12.22	20	17.14	15	13.33	21.67	18.57	16.25	14.44
Cattle fiber %	7.9	7.04	6.82	6.69	5.68	5.96	5.9	5.97	5.65	6.07	5.28	6.37	5.27	5.31	6.1	5.61
Fiber extract %	1.78	2.57	2.35	2.61	2.93	3.636	3.98	4.63	5.35	6.23	6.46	6.06	7.51	7.04	7.76	8.03
Ash %	6.82	6.25	7.86	6.81	5.4	7.31	7.38	8.61	6.42	5.6	6.8	6.86	5.2	7.53	7.13	6.3
Nitrogen Free extract %	62.99	62.96	58.49	56.87	66.82	61.35	58.96	53.56	64.44	61.81	57.33	53.7	53.95	60.51	55.3	52.12

^{††} Composition of vitamin-mineral Premix: (A) Polysar (Mig.) Ltd. (Pretoria) was as follows:

Stearic acid 5,000.00 g, Zinc D 900.00 g, Vitamin B₆ (Riboflavin) 4.00 mg, Panthothenic acid 14.00 mg, Vitamin B₁₂ 2.00 mg, Vitamin B₁ 50.00 mg, Chlorine chloride 500.00 mg, Zinc 200.00 mg, Zinc 200.00 mg, Vitamin B₁₂ 2.00 mg, Vitamin B₁ 50.00 mg, Manganese (Mn) 50.00 mg, Copper 75.00 mg, Cobalt (Co) 50.00 mg, Iodine (I) 2.00 mg.

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Table 2. Calculated amino acid composition expressed as percent of diet

Amino acids	Diets	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Arginine		1.33	11.6	1.88	2.1	1.37	1.61	1.87	2.14	1.39	1.61	1.89	2.15	1.37	1.62	1.89	2.11
Histidine		0.68	0.83	0.96	1.08	0.78	0.88	1.01	1.15	0.79	0.91	1.16	1.16	0.8	0.91	1.04	1.15
Isoleucine		0.64	0.64	0.72	0.88	0.66	0.66	0.73	0.81	0.57	0.63	0.72	0.9	0.36	0.63	0.72	0.76
Leucine		1.83	2.12	2.4	2.69	1.9	2.15	2.45	2.74	1.94	2.19	2.47	2.74	1.98	2.2	2.47	2.71
Lysine		1.18	1.375	1.575	1.769	1.18	1.375	1.575	1.769	1.18	1.375	1.575	1.769	1.18	1.375	1.575	1.765
Methionine		0.23	0.29	0.34	0.41	0.26	0.32	0.36	0.43	0.28	0.33	0.39	0.45	0.29	0.34	0.4	0.46
Cystine		0.26	0.28	0.31	0.32	0.23	0.25	0.27	0.3	0.21	0.24	0.26	0.28	0.2	0.23	0.25	0.27
Methionine + cystine		0.49	0.57	0.65	0.73	0.49	0.57	0.65	0.73	0.49	0.57	0.65	0.73	0.49	0.57	0.65	0.73
Phenylalanine		1.00	1.19	1.37	1.55	1.02	1.19	1.37	1.55	1.00	1.18	1.38	1.59	1.00	1.19	1.37	1.54
Tyrosine		0.74	0.86	0.96	1.07	0.75	0.85	0.94	1.03	0.74	0.83	0.93	1.04	0.75	0.84	0.93	1.01
Phenylalanine + tyrosine		1.74	2.05	2.33	2.62	1.771	2.04	2.31	2.58	1.74	2.01	2.31	2.45	1.75	2.03	1.88	2.86
Threonine		0.78	0.97	1.05	1.15	0.81	0.93	1.04	1.17	0.81	0.92	1.05	1.18	0.8	0.92	1.05	1.15
Tryptophan		0.19	0.22	0.255	0.285	0.19	0.22	0.255	0.285	0.19	0.22	0.255	0.285	0.19	0.22	0.25	0.285
Valine		1.03	0.72	1.49	1.7	1.07	1.29	1.51	1.72	1.1	0.77	1.51	1.74	1.12	1.33	1.52	1.72

Table 3. Amino acid composition of diets as percent of Total Protein

Amino acid	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Arginine	2.39	7.62	7.83	7.78	7.61	7.67	7.79	7.83	7.72	7.67	7.88	7.96	7.61	7.71	7.88	7.81
Histidine	3.78	3.95	4.00	4.00	4.33	4.19	4.21	4.26	4.38	4.33	4.83	4.30	4.44	4.33	4.33	4.26
Isoleucine	3.56	3.42	3.38	3.26	3.33	3.14	3.04	3.00	3.17	3.00	3.09	3.33	3.11	3.00	3.00	2.81
Leucine	10.17	10.10	10.00	9.96	10.36	10.23	10.21	10.15	10.78	10.43	10.79	10.15	11.00	10.48	10.29	10.03
Lysine	6.55	6.55	6.83	6.55	6.55	6.55	6.55	6.55	6.55	6.55	6.55	6.55	6.55	6.55	6.55	6.55
Methionine	1.28	1.38	1.42	1.52	1.55	1.52	1.58	1.59	1.56	1.57	1.62	1.67	1.61	1.61	1.67	1.70
Cystine	1.44	1.33	1.29	1.19	1.28	1.19	1.12	1.11	1.16	1.14	1.08	1.04	1.11	1.10	1.04	1.00
Methionine+cystine	2.75	2.71	2.71	2.71	2.73	2.71	2.70	2.70	2.72	2.71	2.70	2.72	2.71	2.71	2.71	2.70
Phenylalanine	5.56	5.67	5.71	5.74	5.67	5.67	5.71	5.74	5.56	5.62	5.75	5.81	5.81	5.56	5.17	5.67
Tyrosine	4.10	4.09	4.00	3.96	4.17	4.05	3.91	3.85	4.11	3.95	3.88	3.85	4.17	4.00	3.88	3.74
phenylalanine+tyrosine	9.66	9.76	9.71	9.70	9.84	9.72	9.62	9.59	9.67	9.57	9.63	9.65	9.73	9.67	9.59	9.41
Threonine	4.30	4.63	4.38	4.26	4.50	4.43	4.33	4.50	4.38	4.38	4.37	4.44	4.38	4.38	4.38	4.26
Tryptophan	1.06	1.05	1.06	1.06	1.05	1.06	1.06	1.06	1.06	1.06	1.05	1.06	1.06	1.06	1.06	1.06
Valine	5.72	6.04	6.21	6.30	6.14	6.29	6.37	6.11	6.11	6.24	6.39	6.44	6.22	6.33	6.33	6.37

protein are given in Table 3.

Housing and Feeding

Pigs were housed in concrete floored pens, each with 8 individual feeding units. The pigs were assigned numbers on their back and on the corresponding feeding unit buckets, such that the number on the pigs tallied with the number on the bucket and diet to which the animal was allocated.

Each adjacent pen housed 8 animals and each pig had a feeding record to facilitate keeping of records. Feeding troughs were provided in the individual feeding units. The animals were fed three times daily at 07.30 hours, 12.30 hours and 16.30 hours when they were led into the individual feeding stalls and allowed to eat all they could within 90 minutes. After eating they were allowed into adjacent play pens where fresh water was made available *ad libitum*. Water was changed four times daily, since the pigs wallowed occasionally.

Management

The animals were therefore subjected to routine de-worming monthly, immediately after the weekly weighing, with 'Piperazine Citrate*'. The inner and outer pens were disinfected with solution of 'Izal*', every morning after thoroughly washing the pens.

Records

Pigs were weighed weekly and weekly feed consumption was also recorded for individual pigs..

Statistical analyses

The data from the experiment were subjected to the multi-factor analysis of variance and where significant differences were indicated means were compared using the Duncan's new multiple range test (Steel and Torrie, 1980). Regression analyses were also carried out on some parameters. Protein levels and intakes and energy levels and intakes were regressed separately against the selected parameters. Step wise regression analyses were also carried with

both protein and energy intakes as independent variables to evaluate the relative contribution of these to the observed differences. All of these statistical analyses were achieved using the SPSS Programme on the IBM Computer.

Results

Feed, Protein And Energy Intakes.

Table 4 summarizes the results for average daily feed, protein and digestible energy intake by pigs on the different diets.

Neither energy nor protein levels significantly affected daily feed consumption of pigs. However there was a noticeable decrease in feed consumption at the highest protein level fed. Daily protein intake was significantly influence (P 0.01) by protein but not energy levels, while daily digestible energy intake was also significantly (P 0.01) influenced by energy but not protein levels. No significant interactions were obtained between energy and protein levels for the intake of feed and both protein or energy.

Stepwise regression analysis showed that dietary energy accounted for 53.09% ($r=0.743$) to the variability in daily feed consumption while protein accounted for only 0.70% ($r=0.30$). No significant sex differences were observed for these intakes.

Average daily gain and number of days to reach slaughter

Average daily live weight gains and the number of days taken to reach the predetermined slaughter weight are presented in Table 5. Energy but not protein levels significantly influenced the rate of live weight gain. There was a highly significant interaction between protein and energy levels (P 0.001) in their effect on growth rate, while no significantly sex, differences, sex x protein or sex x energy interaction were obtained. Stepwise regression analysis showed that variability

Table 4: Influence of varying dietary protein and energy concentration on feed, protein and energy intake of pigs reared between 8 and 60kg

Intake of pigs reared between 8 and 60kg					
Digestible energy kcals/kg	Percentage Crude Protein				Mean
	18	21	24	27	
<u>Average daily feed intake (kg)</u>					
3,000	1.21	1.39	1.26	1.21	1.27
3,300	1.31	1.29	1.4	1.22	1.32
3,600	1.34	1.36	1.32	1.32	1.34
3,900	1.3	1.25	1.38	1.32	1.31
Mean	1.31	1.32	1.34	1.27	-
A.S.E = + 0.015					
<u>Average daily Protein g/day</u>					
3,000	223.86	295.92	307.36	325.36	288.05
3,300	263.07	277.98	325.02	325.79	297.97
3,600	242.51	284.88	319.24	363.74	302.59
3,900	234.69	262.91	285.92	364.18	286.93
Mean	241.03 x	280.42y	309.31y	344.77z	-
A.S.E = ± 3.82					
<u>Digestible Energy intake Meal/Day</u>					
3,000	3.67	4.22	3.93	3.77	3.95x
3,300	4.58	4.23	4.66	4.18	4.41y
3,600	4.82	4.93	4.71	4.8	4.82y
3,900	5.01	4.82	5.48	5.3	4.82
Mean	4.52	4.55	4.7	4.58	-
A.S.E = ± 0.46					

In this and subsequent tables:

A.S.E. = Average standard error of treatment means – x y, z

Main treatment means followed by the same letters are not significantly different.

Table 5: Influence of varying protein and energy concentration on the average daily gain and number of days taken to attain pre-determined slaughter weights.

pre-determined slaughter weights.		Crude protein levels (%)				Mean
	Digestible energy kcals/kg	18	21	24	27	
Average daily gain (kg)	3,000	0.46	0.53	0.47	0.5	0.49x
	3,300	0.59	0.56	0.56	0.53	0.56y
	3,600	0.56	0.56	0.56	0.54	0.56y
	3,900	0.57	0.58	0.6	0.6	0.59
	Mean	0.55	0.56	0.56	0.54	-
A.S.E = ± 0.02						
Number of day to reach slaughter	3,000	110	98	111	104	105.8x
	3,300	87	96	91	97	92.8xy
	3,600	92	89	90	93	91.0xy
	3,900	90	88	80	86	86.0xy
	Mean	94.8	92.8	93	95	-
A.S.E = ± 4.21						

Table 6: Influence of varying protein and energy concentration on the efficiency of feed conversion of pigs reared between 9 and 60kg liveweight

Digestible levels Kcals/kg	Castrated males					Females					Pooled means				
	Protein levels (%)				Mean	Protein levels (%)				Mean	Protein levels (%)				Mean
	18	21	24	27		18	21	24	27		18	21	24	27	
3,000	2.67	2.65	2.67	2.53	2.63x	2.62	2.64	2.73	2.45	2.61x	2.65	2.64	2.70	2.49	2.62x
3,300	2.47	2.59	2.71	2.54	2.58x	2.25	2.12	2.35	2.00	2.18x	2.36	2.36	2.36	2.27	2.38x
3,600	2.52	2.46	2.66	2.55	2.55x	2.45	2.51	2.10	2.33	2.35x	2.49	2.46	2.46	2.44	2.44x
3,900	2.50	2.35	2.25	2.09	2.22x	2.39	1.99	2.11	2.40	2.22x	2.30	2.17	2.17	2.25	2.23x
Mean	2.47	2.51	2.57	2.43	-	2.43	2.32	2.32	2.30	-	2.45	2.41	2.41	2.36	-
A.S.E. = ±0.09						A.S.E. = ±0.10					A.S.E. = ±0.09				

in liveweight gain due to energy intake was 82.11% ($r = 0.90$) while protein intake accounted for only 0.04% ($r = 0.05$) of the observed differences. Increasing dietary digestible energy level from 3,000 to 3,300 kcals DE / kg diet resulted in significant improvement in growth rate while increasing energy levels beyond this did not improve gains at 3,600 kcals/kg, but resulted in slight but insignificant increases at 3,900 kcals DE/kg diet, within all protein levels there was the noticeable tendency for growth rate to improve as energy level was increased. Rate of live weight gain was highest on the 24 and 27% protein diets when energy level was raised to 3,900 DE/kg, although these were hardly significantly superior to the digestible energy concentration of 3,300 kcals/kg. The average number of day the pigs on the different diets took to reach the predetermined slaughter weight of 60 ± 1.5 kg (Table 5) was highly significantly ($P 0.001$) influenced by energy but not

protein levels.

Feed conversion efficiency and efficiency of energy utilization

Feed conversion efficiency (Table 6) was significantly influenced ($P 0.01$) by energy but not protein levels. No significant proteins x energy interactions were obtained, while highly significant ($P 0.001$) sex differences and significant ($P 0.01$) sex x energy interactions occurred. Separate data for the sexes are therefore presented along with the pooled data in Table 6.

In both sexes, increasing dietary energy levels resulted in improved efficiency of feed utilization within protein levels, there were however no significant differences between the two highest energy levels for male and between diets with 3,300, 3,600 kcals DE/kg for females. The pooled data for both sexes showed no significant improvements in feed efficiency when energy levels were increased beyond 3,300 kcals DE/kg diet. Digestible energy intake accounted for 46.46% ($r = 0.68$) of the

Table 7: Influence of varying protein and energy concentration on the efficiency of energy utilization (Kg. gain/Kg DE intake) of pigs reared between 9 and 60kg liveweight.

Digestible (Kcals/kg)	energy level	Crude Protein Levels (%)				Mean
		18	21	24	27	
3,000		127.62	125.25	121.37	131.97	126.70x
3,300		128.40	134.23	118.40	116.40	124.36x
3,600		117.66	113.04	121.28	114.98	116.74y
3,900		115.89	121.62	116.07	113.05	116.65y
Mean		122.39	123.69	119.28	119.10	-
A.S.E. = ±2.27						

variability (47.49%) in efficiency of feed utilization, while protein accounted for only 1.03% ($r = -0.15$). Females gave the best efficiency of feed utilization on the diet with 3,300 kcals DE/kg, while best efficiency of feed utilization for castrates was on the highest energy level.

Efficiency of digestible energy utilization (Table 7) was significantly ($P < 0.01$) influenced by dietary energy but not protein level. No significant sex differences were obtained, neither were there significant protein x energy, sex x protein, sex x energy or protein x energy x sex interactions. The best efficiency of energy utilization was obtained on the highest protein and energy level combinations. Increasing energy levels between 3,000 and 3,600 kcals DE/kg did not significantly improve efficiency while a further increase to 3,900 kcals DE/kg resulted in an efficiency of energy utilization significantly better than at lower levels.

Discussion

The objective of the present study was to investigate the possible role of varying digestible energy and crude protein levels on the utilization of these nutrients on feed intake, protein and energy intake, average daily gain, feed conversion efficiency and efficiency of feed utilization, particularly as very little information exists on energy utilization in pig diets in the humid tropics. Reduced feed intake appears to be implicated in the poorer performance of pigs reared in warm humid environments (Rao *et al*, 1976, Fetuga, 1984, Tewe and Adeschinwa, 1995). In the present study there were no significant main treatment effects on daily feed intake. Daily feed and therefore daily digestible energy and protein intakes were independently influenced by dietary protein and energy levels. This reported tendency is very much in agreement with the result in

this study. In contrast to this observation, some reports found decreasing feed intakes with increasing dietary energy levels (Oyeleke *et al*, 1985, and Adeschinwa, 2008) although digestible energy intake remained high at energy levels, as more energy is required to meet maintenance requirements and deposition of fat and protein. Another report (McCracken, *et al*, 1980) showed that decrease in digestible energy intake does not occur markedly in growing pigs until the energy level exceeded 3,640 kcal DE. Increasing energy of the diet depressed feed intake only when the protein content of the diet was inadequate or the protein of poor quality (NRC, 1988, Longe, 1988 and Fashina, 1991). In the present study, the levels of protein were adequate and balanced for the essential amino acids. Studies have demonstrated (Oyeleke *et al*, 1985, Adeschinwa, 2008) that protein quality was as important as energy protein ratio in determining feed intakes. All of these suggest that variations may occur from study to study as a result of differences in the types and combinations of diets used and sources of both protein and energy. Metabolism of fat, protein and carbohydrate follow different pathways to provide energy for body functions (Briffa, 2012). Such depressions were only noticeable at the highest protein level in combination with either 3,000 or 3,300 kcals DE/kg, in diets with similar protein level but containing either 3,600 or 3,900 kcal DE/kg, the depression was less marked. This may be due to the reduced associative dynamic effects of protein and fat which are known to be lower than the combined effects of protein and carbohydrates. This reason is adduced since in the present study energy increments were achieved by the inclusion of palm oil at the high levels, while the lower energy was

essentially derived from carbohydrates.

Several studies (Devendra and Paris, 1970, Rinaldo *et al*, 2002, Fetuga, 1984, Le Dividich and Canope, 1978, Cole, 1984, and Le Dividich and Herpin, 1994) reported similar low feed intakes under tropical environment as a result of the higher ambient temperature. This reduced feed intake was regarded as an adaptive mechanism to avoid excessive heat load (Steinbach, 1971) and has implications for the performance of pigs in this environment, since inadequate intake of protein and energy could adversely affect the inherent potential for best performance characteristics (Nichols *et al*, 1982, Close *et al* 1983)). While increasing protein level from 18 to 27% level did not significantly influence gain, increasing energy levels within each protein level had the effect of increasing rate of liveweight gain. That there were no significant differences in rate of gain with the range of protein levels studied, is in consonance with the earlier experiments (Oyeleke *et al*, 1985, and Oyeleke *et al* 1988), where gains on all protein levels above 16% were similar and not significantly different. Earlier reports (Babatunde *et al*, 1972, Fetuga *et al*, 1975, Devendra and Parris, 1970) had suggested that protein levels in the range 20 – 24% were needed to maximize growth in pigs in a tropical environment. The present result emphasizes the importance of amino acid adequacy and balance in meeting the protein needs of the pig. There was a highly significant protein x energy level but differences among protein levels were not significant. Pigs fed high protein, high energy diets gained significantly more rapidly than those fed the low protein, low energy or low protein high energy or low energy or high protein diets. This observed interaction is in close agreement with some reports (Hale and Johnson, 1970, Campbell

and Dunkin, 1983) which showed that pigs fed high energy – high protein diets gained at least 3% faster than those fed other combinations. In a stepwise regression comparing the effects of protein and energy intake on average daily gain, of the total variability energy and protein intake explained 82.15% , with energy intake accounting for 82.11% ($r=0.90$) and protein only 0.04% ($r = 0.05$). That differences in responses of pigs could occur in warm compared to cooler in situations of varying energy and protein concentrations is quite a possibility, since differences in basal energy metabolism have been reported in situations of varying environmental temperatures (Scerley *et al*, 1978, Versterger and Close, 1994). Moreover, the ingredient makeup of the diets and the procedures adopted in achieving the energy differential could be an important factor determining the pattern of response observed. Usually lower energy levels are achieved by the inclusion of diluents in diets while higher levels are achieved by the inclusion of highly digestible ingredients and fat. Such a situation could result in a reduction in the digestibility of the carbohydrates and protein in the diet with diluents thus adversely affecting the utilization of protein whereas protein utilization is enhanced at higher levels of energy probably through a higher digestibility of the components. It was reported (Campbell and Taverner, 1988, Wegner *et al*, 1988) that higher dietary energy levels may be required in a stressful environment when fat is the major energy source to compensate for low calorie intakes associated with the observed reduction in feed intake in such environment. The observed higher gains on the highest energy level in this study may, in fact, result from increased energy intake due to added lipids and the maintained level

of feed consumption resulting from a lowered heat increment due to protein – fat combination. There were no significant interaction between protein and energy in terms of feed conversion efficiency, while energy increases, but not protein, tended to improve this parameter. This report agrees closely with those of earlier reports (Cooke *et al*, 1972, Cromwell *et al*, 1978, Campbell and Dunkin 1983) that indicated that energy level had an over-riding influence compared to protein. Energy intake accounted for 46.46% ($r = 0.68$) of the total variability due to main treatment effects, (47.49%) while protein accounted of only 1.03% ($r = -0.15$). In a study (Oyeleke *et al*, 1987), optimum feed efficiency was obtained on the 18% protein diet in castrated males while in females, 22% protein in the diet was required to optimize efficiency of utilization for gain. In another study (Oyeleke *et al*, 1987), optimum efficiency was observed on the highest protein levels fed, which was 20%. Utilization of feed for gain appeared to be maximized in castrated males when an 18% protein diet containing 3,900 kcal DE/kg was fed, while in females this occurred on the 21% protein diet at the highest energy fed. It would appear from the foregoing that a proper nutrient combination should decrease the cost of metabolism. These workers suggested that the heat increment was lowest with the protein and fat mixture. This suggestion would appear to be borne out by the observed tendency for efficiency of feed utilization to be best on the high energy, high fat diets.

Even though body weight gains were lower than reported for pigs in a temperature environment, the feed : gain ratios were comparable and in some cases better than report in experiments with pigs of the same weight range (Cooke *et al*, 1972, Seerley *et al*, 1978 Campbell and Dunkin, 1983). It

would therefore appear that the observed lower growth rates do not result from inefficient metabolism of nutrients but rather from the reduced intake due to high ambient temperatures. That feed : gain ratio should be better in warm climates is supported by a report (Seerley *et al*, 1978) that indicated a 3% improved efficiency during warmer than cooler months and attributed this to a lower metabolic requirement for body heat during warmer than cooler months. Other researchers (Babatunde *et al*, 1972, Verstergeren and Close, 1994) reported that at high temperatures, there is a greater efficiency of energy utilization for liveweight gain, and also as a result of less heat production (heat loss for thermo regulation) especially when feed intake is comparatively lower and energy supplements are highly digestible. Females were superior to castrated males in terms of feed gain ratio and utilized protein more efficiently at all levels. Castrated males utilized dietary energy better than females at higher levels. This observation, regarding differences between both sexes in terms of efficiency of feed and feed nutrient utilization, were also observed in the previous earlier studies (Oyeleke *et al*, 1985, Oyeleke *et al*, 1987) and were supported by other results (Cole *et al*, 1968 and Cooke *et al*, 1972).

References

- A.O.A.C . 2005. Official Methods of Analysis. (18th edition.) Assoc. Official Agric. Chemists. Washington. DC.
- Adesehinwa , A. K. and Ogunmodede, B. K. 1995. Swine feeds and practical feed composition techniques. In: NAERLS. *Nat. Pig Prod.* 1995; pp 50-64.
- Adesehinwa, A. O. K. 2008; Energy and protein requirements of pigs and the

- utilization of fibrous feedstuffs in Nigeria: A review.
- Babatunde, G. M., Olomu, J. M and Oyenuga, V.A. 1972.** Determination of the crude protein requirements of pigs in a tropical environment. *Anim. Prod.*; 18: 57-67.
- Briffa, J. 2012.** Is calorie a calorie? In: Escape the diet trap. Chapter 7; pp 63-74.
- Campbell, R. G. and Taverner, M. R. 1988.** Relationships between energy intake and protein metabolism, growth and body composition of pigs kept at 14 or 32°C from 9 to 20 kg. *Livest. Prod. Sci.*; 18: 289-303.
- Campbell, R. G. and Dunkin, A. C. 1983.** The effects of energy intake and dietary protein on nitrogen retention, growth performance, body composition and some aspects of energy metabolism of baby pigs. *Brit. J. Nutr.*; 49: 221-230.
- Close, W. H., Berschauer F. and Heavens, R. P. 1983.** The influence of protein: energy value of the ration and level of feed intake on the energy nitrogen metabolism of the growing pig. 1. Energy metabolism. *Br. J Nutr.*; 49: 255-229.
- Close, W. H. 1989.** The influence of the thermal ambient temperature on food intake of pigs. In : Forbes, M J., Varley, M. A. and Lawrence, T. L J., (Eds) . The voluntary food intake of pigs. ; *Occasional Publication of the British Society for Animal Production*, Edinburg. 13: pp 87-96.
- Cole, D. J. A. 1984** The nutrient density of pig diets-allowances and appetite. In: Fat in animal nutrition, J. Wiseman. London: Butterworth: pp301-312.
- Cooke, R., Lodge, G. A. and Lewis, D. 1972.** Influence of energy and protein concentrations in the diet on the performance of growing pigs. 1. Response to protein intake on a high energy diet. *Anim. Prod.*; 14: 35-46
- Cromwell, G. L., Hays, V. W., Trujillo-Figueroa, V and Kemp, J. A. 1978.** Effects of dietary protein and energy levels for growing-finishing swine on performance, muscle composition and eating quality of pork. *J. Anim. Sci.* 47; 505-513.
- Devendra, C. and Parris, E. C. 1970.** Optimum crude protein levels for growing finishing pigs in a tropical environment. *Trinidad Trop. Anim. Health Prod.*; 2: 162-166.
- Fashina, H. A. 1991.** Utilization of soyabean rations by finisher pigs in hot humid tropics; Ph. D, Thesis, University of Ibadan.
- Fetuga, B. L. 1984.** Techniques in feed formulation. Paper presented at the feedmill management workshop.; University of Ibadan, Ibadan.
- Fetuga, B. L. 1972.** An assessment of the protein quality of certain Nigerian foods and feedstuffs in the nutrition of pig and rat. Ph. D. Thesis, University of Ibadan. Ibadan.
- Fetuga, B. L., Babatunde, G. M. and Oyenuga, V. A. 1974.** Some Nigerian protein concentrates as food and feeds. *Proc. Nig. Soc. Anim. Prod*; 1. 98. (Abstract)
- Fetuga, B. L., Babatunde, G. M. and Oyenuga V.A 1975.** Protein levels in diets for European pigs in the tropics. 1. The effects of methionine supplementation. *Anim. Prod.*; 20: 133-146
- Fetuga, B. L., Babatunde, G. M., and Oyenuga, V. A. 1973.** Protein quality of some Nigerian feedstuffs. 1. Chemical assay of nutrients and

- amino acid composition. *J. Sci. Food Agric.* 24: 1505-1514.
- Fetuga, B. L., Babatunde, G. M., and Oyenuga, V. A. 1977. The value of palm kernel meal in finishing meal diets for pigs. 2. The effect of the addition of cane molasses on the utilization of high level palm kernel meal diets. *J. Agric. Sci. Camb.* ; 88: 663-669.
- Hale, O. M and Johnson, J. C. (Jnr.) 1970. Effects of hormones and diets on performance and carcass characteristics of pigs during summer and winter. *Anim. Prod.* ; 12: 47-54.
- Holmes C. W. 1973. The energy and protein metabolism of pigs growing at a high ambient temperature. *Anim. Prod.* ; 16: 117-133.
- Le Dividich, J. and Herpin, P. 1994. Effects of climatic conditions on the performance, metabolism and health status of weaned piglets. *A rev. Livest. Prod. Sci.*; 38: 79-90.
- Le Dividich, J. L. and Canope, I. 1978. Effects of dietary protein on growing finishing pig performance in a tropical environment. *J. Agric. Univ. Puerto Rico*; 3, 273-282.
- Longe , O. G. 1988. Meeting the energy needs of non-ruminants from non-conventional feed resources in Nigeria. *Proceedings of National workshop on alternative formulation of livestock feeds in Nigeria*, ARMTI, Ilorin, November,; 192-203.
- McCracken, K. J., Eddie, S. M. and Stevenson, W. G. 1980. *Br. J. Nutr.* 43: 289.
- National Research Council, N. R. C. 1988. Nutrient Requirements of swine, 9th edition. Rev. ed ; National Academy Press. Washington, D. C.
- Nichols, D. A., Ames, D. R., and Hines, R. H. 1982. Effect of temperature on the performance and efficiency of finishing swine. *Proc. of the 2nd Int. Livest. Environ. Symposium.* ;April, 20-23.
- Oyeleke, M. O., Balogun, O. O., Fetuga, B. L. and Babatunde, G. M. 1988. Influence of dietary protein levels on rate of tissue deposition and individual muscle development of growing European pigs in a tropical environment. *J. Agric. Sci. Camb.* ; 110: 377-381
- Oyeleke, M. O., Balogun, O. O., Fetuga, B. L. and Babatunde, G. M. 1987. Equalizing lysine, tryptophan and methionine+cystine at different levels in the nutrition of growing pigs. 1. Effects on growth, nitrogen economy and carcass characteristics. *World. Rev. Anim. Prod.* ;23: 15-20.
- Oyeleke, M. O., Balogun, O. O., Fetuga, B. L. and Babatunde, G. M. 1985. A Re-evaluation of the influence of dietary protein level on performance, nitrogen economy and carcass characteristics of weaner-grower pigs in a tropical environment. *World Rev. Anim. Prod.* ; 21: 29-35.
- Quiniou, N., Dubois, S. and Noblet, J. 1995. Effects of dietary crude protein on protein and energy balances in growing pigs. Comparison of two measurement methods. *Livestock Prod. Sci.*; 41: 51-61.
- Rao, R., Khan, M. Y. and Ranjhan, S. K. 1976. Growth rate and feed efficiency of large white Yorkshire pigs fed different levels of dietary energy. *Indian J. Anim. Sci.* ; 18.2. 123-125.
- Rinaldo , D., Le Dividich, J. and Noblet, J. 2000. Adverse effects of tropical on voluntary feed intake and performance of growing pigs. *Livestock Prod.* ; 66: 223-234.
- Seerley, R. W., McDaniel, M. C. and

- McCampbell, H. C. 1978.** Environmental influence on utilization of energy in swine diets. *J. Ani. Sci.*; 47(2) 427-434
- Steel, G. D. and Torrie, J. H. 1980.** Principles and Procedures of Statistics 1973;. A Biometrical Approach 2nd Edition. McGraw Book Company, Inc. New York.
- Steinbach, J., 1971.** Effects of season and breed on sow performance in a seasonal equatorial climate of Southern Nigeria. *J Agric. Sci. Camb.*; 77: 331-336.
- Tewe, O. O. and Adeshinwa, A. O. K. 1995.** Resource requirement for profitable pig farming. *NAERL. Nat. Pig Prod. Workshop.* Ibadan. pp. 16-26.
- Verstegen, M .W. A. and Close, W. H. 1994.** The environment and the growing pig. In: Cole, D J A. Wiseman J., Vailey, M A. (Eds). Principles of Pig Science, Nottingham University Press; pp 333-353.
- Wegner, J., Albrech, E. and Ender, K. 1998.** Morphological aspects of intramuscular fat deposition in cattle. *Arch. Tiez.*; 41. 313-320.

Received: 06/07/13

Accepted: 15/01/14