Some Nigerian Protein Concentrates as Foods and Feeds

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SUMMARY

THE nutrients, amino acid composition and protein quality of a range of Nigerian foods and feeds have been studied in chemical and biological tests with pigs and rats.

Lysine, methionine, tryptophan and, to a lesser extent, threonine, were the amino acids present in the least amounts in most of the concentrates. Apparent and true digestibility of the concentrates were high except for palm kernel meal (PKM), African locust bean (ALB), and cashewnut scrap meal (CSM).

All the animal protein concentrates showed good nutritional qualities except blood meal (BM), which, despite its high lysine content, showed very poor nutritional values and supported no gain in pigs or rats, probably due to its low methionine — cystine and tryptophan content, coupled with a possible isoleucine-leucine antagonism.

Among the plant proteins, ALB showed particularly low values, while cashewnut good grade meal (CM) was found to be superior to soyabean meal (SM). The cashewnut scrap kernel meal (CSM) was inferior to the good grade meal. When evaluated at a critical protein level with growing pigs, it was found to be superior to groundnut meal. In practical type diets for fattening pigs, CSM diets were superior to the groundnut meal (GNM) diets, in terms of growth and efficiency of feed utilization.

The PKM, despite its apparent balance of amino acids showed poor nutritional values for the rat. In a test with practical type diets, pigs on PKM grew at a highly significantly slower rate and had highly significantly poorer feed and protein efficiency ratios than the pigs on other diets.

In another trial involving supplementation of PKM diets with either GNM, fishmeal (FM), BM or milk powder (MP), pigs on the PKM diet supplemented with 10% GNM, had a significantly slower rate of gain and effciency of feed conversion ratio than those on other diets containing lower quantities of PKM supplemented with other protein concentrates.

Supplementation of PKM diets with FM and BM gave significantly better results than supplementation with GNM or MP.

INTRODUCTION

THE feeding of the vast population of the tropical and subtropical areas of the world as well as the fast increasing population of farm livestock has continued to pose a problem. It is however, now being appreciated that more than anything else, lack of information on the composition and utilisation of the many and varied protein sources indigenous to Africa is the major problem rather than a real shortage of the sources of protein as is widely believed.

An appropriate formulation of feeds for livestock firstly implies as accurate as possible knowledge of the feeding value of the ingredients used, particularly with regard to the amino acid composition, nutrient digestibility and utilisation as well as the energy value of available feeds. The availability of such information would lead to more judicious use of some more commonly known sources and perhaps also step up the use of hitherto neglected sources. This paper reports a series of studies at Ibadan, aimed at elucidating the composition and utilisation of the more common and a few less common protein sources.

MATERIALS AND METHODS

Feeds

The feeds evaluated included blood meal (BM) (Kano Native Authority), milk powder (MP), (Nigerian Creamries, Vom), Fishmeal I and II (FM I & FM II) (Commercial samples), Fishmeal III, (FM III), (prepared from residues of smoked fish purchased as several batches from Dugbe market in Ibadan), groundnut cake (commercial samples from the Kano Oil Mills), palm kernel meal (PK) (Vegetables Oils Nigeria Ltd., Ikeja, Lagos), good grade and scrap cashewnut kernels (CM & CSM) (Western Nigeria Development Corporation, Cashew Processing Factory, Eleiyele, Ibadan). The samples used for the rat studies were ground and extracted to exhaustion with petroleum spirits (BP 40—60°C, while the scrap meal used in the pig studies was extracted in the premises of Vegetable Oils Nigeria Limited, using the expeller method), African locust bean seed (ALB) was obtained from local farmers around Oyo and Iseyin in the Western State of Nigeria and evaluated in different forms that represent stages in the fermentation of the locust bean (Fetuga, Babatunde and Oyenuga, 1974). Heat treated soyabean meal (SM) was from the Northern Nigeria Marketing Board and freeze dried, ether extracted whole hen's eggs (HE) was produced in the department of Animal Science, University of Ibadan. The total amino acid composition was determined on 100 mg of each sample in duplicate after hydrolysis with 10 ml of 6N hydrochloric acid in an atmosphere of nitrogen at 110°C for 24 hours, using the automated Hitachi Perkin-Elmer amino acid analyser — Model KLA-3B (Hitachi Limited, Tokyo, Japan). Tryptophan was chemically determined using the method of Miller (1967)

Rat Studies

The feeds were evaluated with weanling albino rats of the Wistar strain, 28-30 days old and weighing initially about 45-50 g. Because of insufficiency of space and male rats at the same time the study was conducted in three series making sure that starting weights were as close as possible. Protein quality indices were measured as protein efficiency ratio (PER) net protein retention (NPR), biological value (BV), net protein utilisation (NPU), apparent and true digestibility (AD & TD) using techniques described by the National Academy of Sciences-National Research Council (NAS/NRC, 1963).

The basal diet used contained corn starch, 65.0%, glucose 5.0%, sucrose, 10.0%, non-nutritive cellulose, 5.0%, groundnut oil, 10.0%, mineral supplement 4.0% and vitamin mixture (Miller, 1963), 1.0%. The protein sources were included in the basal diet at the expense of corn starch such that they provided 10% crude protein in the final diet.

Pig Studies

Three trials were carried out with pigs to assess the suitability of some of the protein feeds in near practical diets for pigs.

Expt. 1 In the first experiment 48 gilts and barrows, weighing initially between 12—14 kg were first isolated into their weight and sex groups and then randomly allocated into eight treatment groups of six pigs each, care being taken to equalize the sex ratios and average initial liveweights. The diets fed in this experiment were compounded in such a way that each of the major local protein concentrates, fishmeal I and III, (FM I & III), skim-milk powder (MP), blood meal (BM), cashewnut scrap meal (CSM), African locust bean (ALB), groundnut meal (GNM) and palm kernel meal (PKM) was the major source of protein in the diet, contributing about 57% of the entire 15.0% protein in the diets, while maize supplied the remainder of the protein. The trial lasted eight weeks and body weight gain and feed intake records were kept on a weekly basis. Total protein efficiency ratio (TPER) was calculated for each diet as the weight gain of pigs on each protein source divided by the total protein consumed by the same group of pigs.

Expt. II. The second experiment was conducted to further study the possibility of inclusion of high levels of palm kernel meal in diets for growing fattening pigs. Thirty five gilts and barrows were randomized into 5 equal treatment group of seven animals each as described for the first experiment. Each group received one of five diets of the composition shown in Table 1. Diet 1 was the control growers' diet used at the University of Ibadan

TABLE 1

Composition of (xperimental diets (Pigs, Experiment II)

Ingredients (%)	*Diets* 1	2	3	4	5
Yellow maize	69.5	41.0	54.5	51.0	46.5
Blood meal	3.0	3.0	7.0	—	—
Groundnut meal	18.0	—	—	10.5	—
Fishmeal	1.5	1.5	—	—	—
Rice bran	2.5	—	—	—	—
Milk powder	—	—	—	—	15.0
Palm kernel meal	—	49.0	33.0	33.0	33.0
Molasses	1.5	1.5	1.5	1.5	1.5
Palm oil	1.0	1.0	1.0	1.0	1.0
Bone meal	1.5	1.5	1.5	1.5	1.5
Vitamin-mineral Premix	0.5	0.5	0.5	0.5	0.5
Salt (NaCl)	0.5	0.5	0.5	0.5	0.5
Analysis of dry matter (%)					
Crude protein	16.84	16.17	16.68	16.57	16.85
Crude fibre	3.65	5.64	4.28	4.13	4.26
Ether extract	4.35	5.32	4.78	5.03	4.82
Calcium	1.40	1.49	1.25	1.23	1.56
Phosphorous	0.73	0.85	0.75	0.79	0.83
Lysine	0.86	0.78	0.90	0.59	0.81
Methionine + Cystine	0.41	0.45	0.38	0.43	0.46
Threonine	0.79	0.71	0.79	0.64	0.72
Tryptophan	0.19	0.16	0.14	0.17	0.20
Gross energy, kcals/kg	4614	6863	4824	4982	4975

Teaching and Research Farm and contained about 16.8% crude protein. Diet 2 contained 49% PKM, supplemented with low levels of blood meal and fishmeal. Diets 3, 4 and 5 contained 33% PKM supplemented with BM, GNM or MP alone respectively, the levels of supplementation being the same in the three cases, but they were such that the PKM and the supplements contributed the same proportions of the total protein, thus diet 2 was the only diet in which the PKM contributed the major proportion of the dietary protein (about 50%) while in the other diets, the percentage contribution of PKM to the total dietary protein was about 38%. Records of feed intake and liveweight gain were kept on a weekly basis and the animals were slaughtered for conventional carcass data collection as they attained 92 kg liveweight.

Expt. III The third experiment was designed to compare at two levels the effect of discarded cashewnut meal and groundnut meal on the growth performance and some carcass characteristics of fattening pigs.

Forty Landrace x Large White pigs weighing initially about 51 kg were allocated to five treatment groups on the basis of sex and litter origin such that there were eight pigs in each group, four males and four females. Each group was fed one of the five diets shown in Table 2. Diet 1, the control, was the one commonly used in our University Farm. Diets 2 and 3 containing 15.38% and 17.98% crude protein respectively, were compounded such that groundnut meal at the 17.14% and 22.85% levels furnished approximately 50% and 58% of the total dietary protein respectively while diets 4 and 5 were the equivalents of diets 2 and 3 except that discarded cashewnut meal replaced the groundnut meal and contained approximately the same amount of crude protein 15.48 and 17.76% respectively. Records of body weight gains and feed intake were kept on a weekly basis and as all pigs attained approximately 92 kg liveweight, they were slaughtered after an 18-hour fast and conventional carcass data collected on individual animals.

All experimental data were subjected to analysis of variance (Steel and Torrie, 1960) and treatment means compared by the Duncan's Multiple Range Test (Duncan, 1955).

TABLE 2

Composition of experimental diets (Pigs, Experiment III)

Ingredients	*Diets* 1	2	3	4	5
Yellow maize	66.50	71.36	65.65	61.52	54.65
Fishmeal	1.50	—	—	—	—
Groundnut meal	16.00	17.14	22.85	—	—
Cashewnut scrap meal	—	—	—	26.98	33.85
Rice bran	7.50	7.50	7.50	7.50	7.50
Bone meal	1.50	1.50	1.50	1.50	1.50
Oyster shell	0.50	0.50	0.50	0.50	0.50
Lard	1.25	1.25	1.25	1.25	1.25
Vit.-Min-Antibiotic Mix[a]	0.25	0.25	0.25	0.25	0.25
Salt (NaCl)	0.50	0.50	0.50	0.50	0.50
Crude protein %	17.86	15.38	17.98	15.48	17.76

a/ A Pfizer Livestock Feeds Product supplying the following per kg of finished ration: Vit. A, 9823 IU; Vit. D_3, 1965 IU; Vit. E, 69 IU; Vit. K, 20 mg; Vit. B_{12}, 10 mg/ton Riboflavin, 41mg; Nicotinic acid, 246 mg; Pantothenic acid, 98 mg; Folic acid, 10 mg, Cobalt 5 mg; Copper 244 mg; Iodine, 20 mg; Manganese, 341 mg; Zinc, 100 mg; Iron, 100 mg and oxytetracycline hydrochloride, 20g/ton.

RESULTS AND DISCUSSION

Amino acid composition

The amino acid composition of concentrates commonly used in animal feeds and those commonly used as human food are shown in Tables 3 and 4 respectively. Lysine was found to be high in all the animal protein sources, and also in ALB and SM but marginal in GNM, CSM, CM and PKM.

TABLE 3

Amino acid composition of some protein concentrates commonly used in animal feeds (g/16g N)

Amino acid	*Soyabean meal (SM)*	*Yellow maize (YM)*	*Palm kernel meal (PKM)*	*Skimmilk powder (MP)*	*Blood meal (BM)*	*Groundnut meal (GNM)*	*Fishmeal I (FM I)*	*Fishmeal II (FM II)*
Arginine	8.64	5.84	14.90	3.46	4.90	12.30	5.87	6.40
Histidine	2.78	5.22	2.34	3.09	5.82	3.04	33.42	3.54
Isoleucine	4.19	4.19	3.28	5.09	**1.17**	3.58	4.78	4.80
Leucine	8.02	13.82	6.35	9.95	12.80	7.09	7.94	8.20
Lysine	6.34	3.07	3.82	7.98	**8.78**	3.90	7.98	8.90
Methionine	1.25	1.12	1.74	2.40	**0.38**	**0.91**	2.81	3.00
Cystine	1.68	1.33	1.44	**0.35**	0.58	**1.14**	1.01	1.24
Phenylalanine	5.68	5.42	3.87	4.93	7.20	5.60	5.18	4.98
Tyrosine	4.33	2.93	2.93	5.41	3.26	4.34	3.14	3.08
Threonine	3.94	5.12	3.73	4.67	5.01	3.04	5.00	4.50
Tryptophan	1.26	0.69	1.14	1.86	**0.65**	1.24	1.02	0.89
Valine	5.58	5.63	5.22	6.24	8.70	4.27	4.73	5.40
Alanine	4.83	9.42	3.92	3.52	7.52	4.19	6.95	6.74
Aspartic acid	11.46	8.70	9.52	8.00	11.26	11.82	10.84	11.20
Glutamic acid	17.86	19.50	21.82	22.14	9.55	21.12	14.94	12.84
Proline	5.32	11.47	3.78	10.48	3.86	5.06	8.20	7.46
Serine	5.44	12.40	531	6.08	5.25	5.33	4.78	4.77
Glycine	4.58	7.17	4.60	2.14	4.22	6.30	6.78	6.96

The sulphur amino acids, methionine and cystine were in short supply in most of the plant protein concentrates except CM, CSM and PKM. The low sulphur amino acid content of ALB is essentially that of a low content of methionine as the cystine content is higher than the values recorded for all other plant protein concentrates and FM, MP and BM. BM had a particularly low level of the sulphur amino acids, while MP was found to be rich in methionine but poor in cystine.

Low levels of tryptophan were encountered in ALB, FM I, FM II and BM. Other sources had fair amounts of this amino acid.

Threonine was found in good enough quantities in the animal protein sources while low levels were encountered in ALB, CSM and GNM. More recently threonine has come to be regarded as a limiting amino acid in cereals and cereal based diets, it is possible therefore that diets based on these plant proteins may be marginally deficient in threonine.

BM presents a special case with respect to its pattern of amino acids because apart from its low methionine, cystine and tryptophan levels, it has an extremely low level of isoleucine and very high level of leucine, giving an undesirable ratio of

TABLE 4

The amino acid composition of some protein concentrates more commonly used as human food

Amino acid	*Cashewnut scrap kernel meal (CSM)*	*Cashewnut good grade meal (CM)*	*African locust bean seed* Seed with testa (ALB+T)	Seed without testa (ALB)	Fermented seed (ALBF)	*Freeze-dried hen's egg (HE)*
Arginine	9.87	10.70	6.66	6.58	6.68	6.10
Histidine	1.96	2.06	2.99	3.14	2.54	2.43
Isoleucine	3.79	3.86	3.60	3.41	3.62	6.29
Leucine	6.63	6.51	6.90	6.22	6.44	8.82
Lysine	3.86	4.04	6.68	6.79	6.17	6.98
Methionine	1.38	1.40	**0.61**	**0.83**	**0.58**	3.36
Cystine	1.68	1.78	1.92	1.80	1.68	2.43
Phenylalanine	3.74	3.89	4.40	3.84	3.97	5.63
Tyrosine	2.68	2.37	3.57	**1.98**	1.94	4.16
Threonine	3.09	3.10	3.33	2.45	2.48	5.12
Tryptophan	1.34	1.37	0.89	**0.83**	**0.82**	1.62
Valine	5.23	5.80	4.16	3.98	3.99	6.85
Alanine	3.77	3.70	4.50	3.79	3.86	5.92
Aspartic acid	8.13	9.20	8.91	8.42	3.49	9.02
Glutamic acid	19.42	18.74	17.44	14.90	10.82	12.74
Proline	3.46	3.72	5.47	7.90	7.92	4.16
Serine	4.35	4.76	4.98	3.66	3.89	7.65
Glycine	4.16	4.60	4.54	3.44	4.06	3.31

isoleucine to leucine which might affect the utilization of other amino acids in blood meal protein.

Protein quality

The protein quality indices for several of the feeds evaluated are presented in Table 5. The digestibility of most of these feeds were high, ranging between 90—98% except ALB, CSM and PKM. The low digestibility of the PKM and ALB may be attributable to their high fibre content (10.3% and 8.99—12.61% respectively). The lowered digestibility of CSM on the other hand may be due to heat damage, since the sample was obtained from heat-scorched kernels from the roasting process of good grade cashewnut manufacture. Ford (1965) and Neishem and Carpenter (1967), have shown that excessive heat treatment of proteins results in reduced proteolysis in vitro and in vivo and hence in a reduction in the observed digestibility values.

Protein quality indices (PER, NPR, BV, NPU) showed the animal protein sources except BM to be superior to all plant proteins. Among the animal protein sources BM gave very poor results. All of the rats fed BM as the sole source of protein lost weight and gave negative PER values, low NPU, BV and NPR. Such poor values have been reported for blood meal by several workers including Eggum (1968), Miller and Bender (1955) and Hegsted, Neff and Worcester (1968). This poor quality of BM is probably related to its very low levels of the sulphur amino acids, tryptophan and isoleucine. An isoleucine to leucine ratio of more than 1: 10 is encountered in BM. Since antagonism between leucine and isoleucine more than likely does exist, it is conceivable that this might have contributed immensely to the poor utilisation of the blood meal protein.

In general rats receiving plant protein diets tended to consume less feed and grow

TABLE 5

The nutritive value of some Nigerian protein concentrates when fed to weanling albino rats at 10% protein level in diets

Feeds	*Weight gain in 10 days g*	*Protein intake g*	*PER*	*NPR*	*NPU*	*BV*	*AD*	*TD*
Cashewnut meal (good grade)	14.8	7.30	2.01	4.01	63.0	6.6	83.8	91.8
Cashewnut scrap kernel meal I	7.1	6.36	1.12	3.13	46.7	55.3	77.9	84.6
Cashewnut scrap kernel meal II	3.9	5.24	0.76	2.86	41.3	48.9	77.4	84.3
Palm kernel meal	13.9	10.32	1.27	2.62	44.1	56.7	67.9	74.2
Fishmeal I	32.2	8.70	3.69	4.88	76.0	81.7	85.8	93.4
Fishmeal II	31.1	9.10	3.41	4.45	73.0	78.5	84.7	92.4
Fishmeal III	22.5	9.50	2.36	3.47	58.5	64.3	82.4	89.2
African locust bean (seed raw with testa)	-7.76	1.95	-3.91	1.03	18.7	24.6	67.8	75.9
African locust bean (seed raw without testa)	-5.90	2.79	-2.16	1.48	22.2	27.8	72.4	81.6
African locust bean (seed cooked with testa)	-8.00	2.64	-3.15	1.63	26.7	34.8	68.4	76.8
African locust bean (seed cooked without testa)	-2.62	3.41	-0.79	2.51	33.8	39.6	75.6	88.6
African locust bean (fermented)	-7.70	2.27	-3.63	1.04	27.2	31.5	73.4	86.4
Skimmilk powder	22.3	8.76	2.55	4.21	65.4	71.0	86.4	91.8
Blood meal	-10.9	4.50	-2.46	0.83	18.9	19.3	87.9	98.2
Groundnut meal	9.8	6.36	1.53	3.55	54.2	60.2	84.9	90.1
Soyabean meal	11.6	6.37	1.82	3.94	59.4	64.5	79.9	92.0
Freeze-dried whole hen's egg (ether extracted)	26.8	6.78	3.94	6.04	94.0	98.4	93.7	98.4

more slowly than rats on the animal protein sources. CM showed superior protein quality indices to the SM, thus confirming the earlier observations of Piva, Santi and Ekpenyong (1971), who had found samples of Tanzanian cashewnut meals to be superior to properly heated soyabean meal. This fairly good quality of the CM could be attributed to its fairly high content of methionine and cystine, high tryptophan content and a fair amount of lysine. The CSM showed significantly poorer quality indices than the CM. These observed lower values for CSM might be attributable to heat damage and therefore reduced digestibility, and consequently a reduced availability of the essential amino acids as explained by Ford (1965) and Neiṣhem and Carpenter (1967). All forms of the ALB evaluated could not support gains in rats and showed very poor protein quality indices. Testa removal and cooking however tended to enhance quality even though weight losses were not completely overcome by these treatments. The improvement in quality due to cooking and testa removal appeared to be associated with an enhanced digestibility. The major causes of weight loss and overall poor quality appears to be more related to the wide deficiencies of the ALB in methionine and cystine as well as tryptophan. PKM was inferior to CM and GNM. The high fibre content and consequently its low digestibility to the monogastric animal might be its most important drawbacks in terms of its protein quality, because total amino acid analysis showed no extreme deficiencies of any of the essential amino acids. Owusu-Domfeh, Christensen. and Owen (1970) report lysine as the first limiting amino acid in Ghanaian PKM, but the value of 3.82g/16gN reported in this study is comparable to the level in GNM and close to that in CM. Its methionine and cystine content is comparable to that in CM and higher than in other plant protein sources reported here. Similarly its tryptophan content is fairly high. It would thus appear that the PKM protein is fairly well balanced with respect to its essential amino acids, but its poor digestibility reduces the amount of these amino acids which are digested, absorbed and utilised by the animal. GNM showed quality indices which could be regarded as intermediate in comparison to other protein sources.

Pig studies

Results of the first experiment with pigs are summarised in Table 6. Pigs on PKM

TABLE 6

The supplementary value of some indigenous protein concentrates to maize

Items	*Fish meal I*	*Fishmeal III*	*Skim-milk powder*	*Blood meal*	*Cashewnut scrap meal*	*African locust bean (cooked)*	*Groundnut meal*	*Palm kernel meal*
Initial wt, kg	13.80	13.76	13.85	13.90	14.10	14.15	13.65	13.80
Final wt., kg	38.30	27.66	34.95	33.90	25.66	23.25	22.49	17.74
Mean daily gains, g	439.0a	247.5c	376.0b	357.1b	206.5cd	162.5de	149.00e	70.3f
Mean daily feed intake, g	896.8b	631.0cd	948.0ab	1055.3a	719.7c	518.3de	587.3cd	429.8e
Feed conversion efficiency (kg feed/kg gain)	1.98f	2.58e	2.52e	2.97f	3.50c	3.71b	4.01b	6.35a
Total protein efficiency ratio (TPER)	3.13a	2.39b	2.44b	2.08c	1.80d	1.63e	1.56e	1.00f
True digestibility %	91.8a	91.6a	92.1a	90.8ac	89.9ac	75.4b	88.9c	73.9b
Dietary N-retained, %	63.4a	56.96b	58.86b	51.0c	48.2d	43.1e	46.2ed	34.3f

a-f, Means followed by the same letters are not significantly different ($P<0.05$)

diets gained at a highly significantly lower rate than those on FM I, FM III, BM and MP ($P<0.01$) and CSM, GNC and ALB ($P<0.05$). Pigs on FM I exhibited the best gains being significantly superior to those on MP, BM and FM III. They also utilised feed more efficiently than pigs on these diets. CSM was significantly ($P<0.05$ superior to GNM PKM and ALB in terms of gain and efficiency of feed utilisation. Nitrogen retention on FM I was significantly superior to those on MP, FM III and BM, which were in turn significantly ($P<0.05$) superior to those on other protein sources. CSM gave significantly higher nitrogen retention being highly significantly ($P<0.01$) lower than for FM I, MP, FM III, BM, CSM and significantly ($P<0.05$) lower than for ALB and GNM. The results of this study showed the protein quality of BM and ALB which could not support gain when fed alone to rats and pigs (Fetuga, Babatunde and Oyenuga, 1973) to be considerably improved when fed as supplements to maize, while the quality of other supplements were little affected by the amino acid contribution of maize. It would appear that part of the deficiency of the BM and ALB in methionine and cystine had been made up by the contribution of these amino acids from maize. This seems to stress the fact that the nutritional value of proteins when assessed singly may not give a true indication of their value in mixed diets, since in combination with other concentrates or the basal cereal source, some of their major deficiencies may be compensated for.

In the second experiment conducted to evaluate the suitability of PKM as the major protein source in mixed diets for growing-fattening pigs (Table 7), pigs on the control diet with no PKM gained at the fastest rate, a rate significantly better than on 33% PKM diet supplemented with low levels of milk powder and groundnut meal (diets 5 and 4 respectively) but not significantly better than those for pits on diets 2 and 3 on PKM diets supplemented with low levels of blood and fish meal, respectively. The pigs on these diets 2 and 3 also grew at a significantly faster rate ($P < 0.05$) than those on diets 4 and 5. The efficiency of feed utilisation followed similar trends. There were no significant treatment differences among the means for all the carcass measurements although the general trend was that of better lean cuts and lower backfat measurement for the pigs on the 49% PKM diet, than for the pigs on the control or lower levels of PKM diets. The results of this experiment indicate that palm kernel meal does not appear to be a protein concentrate to use singly in the diet of growers and fatteners. Better results are obtained with palm kernel when diets are supplemented with low levels of blood meal and fishmeal but not with groundnut cake. The improvement of palm kernel meal diets when blood meal and fishmeal are used as supplements is probably related to their contribution of lysine and threonine to such diets, amino

TABLE 7

Performance characteristics and carcass quality measurements of pigs fed diets high in palm kernel meal supplemented with some other protein concentrates

Items	*Diets*					*SE of means*	*Level of significance*
	1	2	3	4	5		
Initial liveweight, kg	25.65	25.65	25.65	25.58	25.65	—	—
Final liveweight, kg	94.42	91.10	91.75	81.56	84.94	—	—
Mean daily gain, kg	0.61a	0.51ab	0.56a	0.41b	0.42b	0.031	**
Number of days to reach slaughter weight	113.9	128.6	117.9	139.3	145.1	—	—
Daily feed consumed, kg	1.96b	1.82b	1.93b	1.58a	1.58a	0.073	—
Feed/gain ratio kg feed/kg gain	3.23a	3.56abc	3.45a	3.98b	3.83b	0.136	—
Backfat thickness, cm	3.80	3.39	3.67	3.44	3.46	0.13	NS
Carcass length, cm	78.81	78.23	77.90	78.24	78.71	1.04	NS
Loin eye area, sq.cm	24.10	19.92	22.61	18.26	20.14	1.41	NS
% Lean cuts	59.25	59.93	59.59	58.62	58.89	3.21	NS
% Fat cuts	24.29	24.37	24.61	24.44	24.10	0.46	NS

a,bc Means followed by the same letters are not significantly different ($P < 0.05$)
* = Significant difference ($P < 0.05$)
** = Highly significant difference ($P < 0.01$)
NS = Non-significant difference.

acids in which PKM is marginal. Supplementation with GNL did not improve PKM basal diets because it is deficient or marginal in those amino acids limiting the utilisation of PKM. The data on carcass quality are inconclusive, although the indications are that PKM is likely to improve the carcass quality of fattening pigs.

Results for the third experiment with pigs are presented in Table 8. Pigs on treatment 2 (17.4% groundnut meal) grew at a significantly ($P < 0.05$) slower rate than those on diet 1 (control) and diet 5, the higher protein level cashewnut diet. Treatment 2 was however not significantly different from treatments 3 and 4, while treatments 1, 3, 4 and 5 were also not significantly different from each other. The most efficient utilizers of feed were the pigs on the control group (diet I) followed by the pigs on treatment 5. Compared at each of the two levels, pigs

TABLE 8

Mean liveweight gains, feed intake, feed efficiency and some carcass measurements of market weight pigs fed either of two levels of cashewnut scrap meal (CSM) or groundnut meal (GNM)

Items	*Dietary treatment means* 1	2	3	4	5	*SE of means*
Initial liveweight, kg	51.40	50.80	51.20	50.90	51.30	—
Final liveweight, kg	92.54	92.41	92.40	92.54	92.62	—
Daily gain, kg	0.63	0.50	0.57	0.54	0.61	0.04*
Daily feed consumed, kg	2.26	2.17	2.31	2.22	2.43	0.34(NS)
Feed conversion efficiency kg feed/kg gain	3.58	4.26	4.05	4.11	3.98	0.21*
Number of days to reach slaughter weight	65.3	81.59	72.3	77.1	67.8	—
Backfat thickness, cm	3.72	3.82	3.79	3.74	3.68	0.24(NS)
Carcass length, cm	79.84	78.96	79.44	79.56	78.95	2.18(NS)
% lean meat in carcass	54.82	54.34	54.68	54.82	54.91	1.08(NS)
% bone in carcass	11.87	11.21	11.94	11.88	11.76	0.18(NS)
% fat in carcass	31.48	31.52	31.28	31.14	30.98	0.68(NS)
Average loin eye area cm^2	23.15	22.98	23.21	23.16	2.44	0.94(NS)

* Significant treatment differences among treatment means
NS = Non significant treatment differences among the means

on the CSM diets utilised feed more efficiently than those on the GNM diets, but the differences were not significant. The lower level of GNM inclusion (diet 2) showed the poorest conversion efficiency which was significantly ($P<0.05$) lower than for the control group (diet I). The relevant carcass data are also presented in Table 8. For all of the carcass measurements studied there were no significant treatment differences either due to level of inclusion or to the source of protein fed. Within protein sources however, increasing the level of protein by higher level of inclusion of supplements tended to result in improvements in the quality of the car cass, but such improvements were slight and non-significant. In this experiment, at similar levels of inclusion the CSM was not significantly superior to GNM, only the difference between the higher level of inclusion of CSM and the lower level of GNM was significant. This contrasts with the observation with growing pigs (Expt. I) in which CSM was decidedly superior to GNM. This observed discrepancy is probably associated with the fact that at heavier weights, the animals requirements for amino acids become less critical, but the CSM still showed marginal superiority because the efficiency of utilization of any source improves as the pattern of amino acids approaches that of the essential amino acid requirements of the animals.

From the results of Expts. I and III, it may be concluded that in general CSM is more effective as a protein supplement than GNM in cereal based diets for growing and fattening pigs and that in combination with other sources high in lysine, the fairly high content of methionine and cystine could be used to better advantage than GNM to obtain diets with amino acid patterns approaching more closely the requirement of the animal. This is particularly significant as the earliest part of this paper had shown methionine and cystine to be the amino acid in shortest supply in many protein feeds.

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