EVALUATION OF PALM KERNEL MEAL IN SWINE DIETS

BY

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DECLARATION

I hereby declare that this thesis is wholly the result of the author's research work. The work of other investigators referred to is duly acknowledged. No part of this thesis has been previously submitted for any other qualification.

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CERTIFICATION

This thesis "Evaluation of Palm Kernel Meal in Swine Diets" by Joseph Olu Jegede meets the regulations governing the degree, Master of Science of Ahmadu Bello University and is approved for its contribution to scientific knowledge and literary presentetion.

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DEDICATION

With love, I dedicate this work to my parents and family.

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ABSTRACT

Two trials were conducted to evaluate the utilization of palm kernel meal (PKM) in the diets of weaner and finisher pigs.

In the first trial, forty-five (45) crossbred (Large White x Hampshire) weaner pigs (30 boars and 15 gilts of average initial weight of 13.69 kg were fed diets containing 0, 10, 20, 30 and 40% palm kernel meal. Three pigs were randomly assigned to pens based on initial weight group and sex. There were three replications and five treatments in a randomized block design. At the end of the 56 - day trial period, weight gain and feed intake were not significantly different ($P > 0.05$) across treatments. Feed to gain ratio at 10% PKM was not significantly different ($P > 0.05$) from those on control. However, feed to gain ratio at 20, 30 and 40% PKM were significantly higher ($P < 0.05$) than those on control. Feed cost per kilogramme gain at 10% PKM was not significantly different from that of the control but was significantly reduced ($P < 0.01$) as the level of PKM increased in the diets.

In the second trial, thirty-two (32) crossbred (Large White x Hampshire) finisher pigs (16 boars and 16 gilts) of average initial weight of 41.55kg were fed diets containing 0, 20.55, 40.10 and 61.65% PKM. There were four replications, two pigs per pen and 4 treatments in a randomized block design. At the end of the 64 - day trial period, the results showed that feed intake was not significantly ($P > 0.05$) different across treatments. Weight gain of the pigs fed the control

and 20.55% PKM diets were not significantly ($P > 0.05$) different from one another but were significantly ($P < 0.05$) higher than gains of pigs fed 41.10 and 61.65% PKM diets. Feed to gain ratio for pigs fed 61.65% PKM diet was significantly ($P < 0.05$) poorer than the pigs fed 0, 20.55 and 41.10% PKM diets. The feeding of 41.10 and 61.65% PKM diets significantly ($P < 0.01$) reduced feed cost per unit gain compared to the control and 20.55% diets. All carcass traits (dressing %, percentages of ham, shoulder, loin and belly, loin-eye area and backfat thickness) measured and the weights of the internal organs (empty stomach, liver, lung , heart, kidneys and spleen) did not differ significantly due to treatments.

It is concluded that young pigs can be fed up to 40% PKM diets without affecting their performance. The level of 20.55% PKM caused weight gain in finisher pigs as in the control diet without PKM. Levels of 41.10 and 61.65% caused weight gain which were significantly ($P < 0.05$) lower than those of control and 20.55% PKM diet but lower ($P < 0.05$) feed to gain ratio and feed cost ($P < 0.01$) per kg gain. The feeding of up to 61.65% PKM in the diets of finisher pigs has no adverse effect on the carcass characteristics of pigs. For economic reasons, higher levels (41.10 and 61.65%) of PKM are recommended for finisher pigs.

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ABBREVIATIONS

D.E.	-	Digestible energy
G.E.	-	Gross energy
M.E.	-	Metabolizable energy
M.E.no	-	Metabolizable energy at zero nitrogen retention
D.M.	-	Dry matter
C.P.	-	Crude protein
N.	-	Nitrogen
C.F.	-	Crude fibre
E.E.	-	Ether extract
N.F.E.	-	Nitrogen - free extract
N.D.F.	-	Neutral detergent lignin
PKM	-	Palm kernel meal
Ca.	-	Calcium
P.	-	Phosphorus
g.	-	gramme
Kg.	-	Kilogramme
Kcal	-	Kilocalorie
Mcal	-	Megacalorie
Avg.	-	Average

CHAPTER ONE

INTRODUCTION

The population of Nigeria is increasing at an alarming rate but the production of foodstuffs to feed the populace is increasing at a much slower rate.

The state of nutrition of the world is at a crisis point. Between 1970 and 1980, Nigeria's food production index rose at the rate of 1.5 - 2.0% while the population growth rate was between 2.9 - 3.2%. Thus the food produced could not feed the teeming population (FAO, 1980). The situation resulted in the scarcity of essential food items and when they were available, they were always very expensive. In the past attempts were made to solve the problem, though the consumption of some food items had adverse effect on the country's foreign earnings. However, the increased drive by Government to promote increased local production of foodstuffs in the 1980s has resulted in reduced importation of food items.

An obvious effect of food shortage is the occurrence of malnutrition. FAO (1975) reported that even when the staple cereals and tubers in the diets meet the minimun requirements for calories, they are deficient as sources of protein especially the essential amino acids. These unbalanced diets result in retarded growth, kwashiorkor and a number of nutritional diseases commonly found in the developing countries.

Livestock and poultry are known to be efficient sources of proteins and essential amino acids. The superiority of animal protein over vegetable proteins has long been established and accepted. Animal protein supplies

all the essential anino acids required by man in single, unaltered products and contribute substantial amounts of the essential minerals and vitamins which may be deficient in vegetable proteins (Oyenuga, 1974).

Eusebio (1980) reported that pigs are second to poultry in the production of edible meat per tonne of liveweight. But he stressed that there are some factors that limit the expansion of pig production. One of such factors is the fact that pigs compete with man in the consumption of cereals and oil seeds. Naturally, man's interest will override that of the pigs hence most of these food items are consumed by man.

A situation has therefore come whereby man must look for various ways of increasing food production. This will enable man to produce enough foodstuffs so as to reduce the problems associated with malnutrition and also cater for the livestock industry. The livestock industry, with reference to swine production in particular, must be provided with alternative feed sources that are readily available, cheap and nutritionally balanced.

Attempts are therefore made to find alternative sources of feedstuffs or their by-products for these animals which the humans cannot consume. Such feedstuffs or by-products include oil seed meals, brans, hulls, middlings, brewers spent grains, fruit pulps, single cell protein and a host of others (Oyenuga, 1968; FAO, 1975; Babatunde et al., 1975; Fetuga et al., 1977a,b).

Palm kernel meal is a by-product of the mechanical or solvent extraction of the palm kernel from the oil palm tree (Elaeis guineensis Jacq). The oil palm trees

are abundantly grown in the Southern rain forests and in the guinea savannah zones of Benue and Kwara States of Nigeria yielding thousands of tonnes of palm kernels (Zeven, 1967; Ng, 1972). Nigeria was the leading world producer and exporter of palm kernels in the 1960s (FAO, 1975).

Reports of the analysis of Palm Kernel Meal showed that it contained 18.6 - 21.3% crude protein and 9.06 - 11.4% crude fibre. Results of feeding trials indicated that pigs performed satisfactorily on, and are able to tolerate palm kernel meal based diets. (Carstenen, 1932; Oyenuga, 1968; Fetuga et al., 1977a,b; Nwokolo et al., 1977).

Palm kernel meal appears to be cheaper than other convenitional oil seed meals like groundnut cake and soyabean meal. Thus, considering its nutritive value, palm kernel meal could be a useful feed ingredient in the diets of swine.

The objective of this research work is to investigate the value of palm kernel meal in the diet of pigs. This is with a view to determining the level at which palm kernel meal can be incorporated in the diets of pigs without adversely affecting their performances. The economics of palm kernel meal inclusion are also to be considered.

CHAPTER TWO

2. LITERATURE REVIEW

2.1. Production and Utilization

The oil palm tree (Elaesis guineensis Jacq.) grows abundantly in the tropical rain forests lying between 12°N and 12°S. It is essentially grown in tropical rain and savannah forests of southern Nigeria (Hartley, 1967; Oyenuga, 1968). The major economic products of the oil palm tree are palm oil, palm kernel and palm kernel oil which are obtained from the fruits. These products are used either in the homes or industries. The world's leading producers of palm kernels in the 1960s are shown in table 8 (Zeven, 1967; Ng. 1972.)

The by-product of the mechanical or solvent extraction of the oil palm kernel is palm kernel meal (PKM). Literature indicates that palm kernel meal has long been fed to various livestock and poultry (Schmdt and Vogel, 1932; Carstenen, 1932; Vogel, 1932; Temperton and Dudley, 1941). These reports showed that the animals performed satisfactorily when fed certain levels of palm kernel in their diets.

2.2. Nutritive Value of Palm Kernel Meal

The chemical make up of any feedstuff, to a great extent, determines its nutritive value especially when it is to form part of the ration of an animal. Variations do occur in the chemical composition (dry matter, energy, crude protein, crude fibre, ether extract, ash and nitrogen free-extract) of samples from the same feedstuff (Maynard, 1953; Crampton and Harris, 1969).

In the case of palm kernel meal, these compositional variations may be due to the variety, soil type, method of processing - mechanical or solvent extraction and the extent to which oil has been extracted (Hartely, 1967; Zeven, 1967). Yeong (1983) analysed samples of PKM in Malaysia and compared with samples from elsewhere. He observed that there were regional differences in the composition of PKM. The accuracy and method of laboratory analysis also contribute to these differemces. Crampton and Harris (1969) noted that inspite of its limitations the proximate analysis is probably the most generally used and accepted chemical scheme for describing the nutritional properties of feed-stuffs. The chemical camposition of PKM by various workers is shown in tables 9 and 10 of the appendix.

2.2.1. Dry Matter

This refers to the amount of moisture in the feedstuff. The moisture content or dry matter determination is important in bulk purchasing and storage of feed ingredients. Crampton and Harris (1969) observed that feeds containing more than 14% moisture could not be stored in bulk since they were likely to be mouldy. On the other hand, animals universally dislike dusty feeds (that is, feeds low in moisture content), and consequently eat rations prepared from powdery ingredients less readily than rations with a more granular compsition (Crampton and Harris, 1969). Various workers have recorded a range of 89.00 - 91.00% dry matter for samples of PKM (Oyenuga, 1968; Owusu-Domfeh *et al*. 1970; Fetuga *et al*., 1973a).

2.2.2. Protein

Compared with the conventional plant protein supplements like groundnut cake and soyabean meal, palm kernel meal is very low in its protein content. Reports in the literature indicate that the crude protein content of PKM ranges between 18.5 and 21.3% while for groundnut cake and soyabean meal, the crude protein ranges from 45.0 - 49.9% and 44.0 - 51.2% respectively (Oyenuga, 1968; Owusu-Domfeh et al., 1970; Fetuga et al., 1973a; Oyenuga and Fetuga, 1975; Nwokolo et al., 1977; NRC, 1979; Onwudike, 1987a).

2.2.3. Amino Acid Profile

The protein content serves as an index of the total amino acids of a feedstuff and at the same time as a source of energy. The amino acid quality of a feedstuff determines the extent to which its protein is utilized.

Collingwood (1958) and Oyenuga (1968) observed that the protein of PKM contained all the essential amino acids except for methionine which was limiting (Tables 10 and 11). They noted that it would be a useful feed ingredient for monogastric animals. Owusu-Domfeh et al. (1970) also obtained amino acid levels of PKM samples from Ghana which were similar to those reported by other workers except that the Ghanaian PKM was low in sulphur amino acids - methionine and cystine - which might be due to acid hydrolysis. They also observed that the first limiting amino acid in PKM was lysine followed by methionine and tryptophan and reported the values of 3.12 and 1.22 g/16gN for lysine and methionine respectively. Oyenuga (1968) had a earlier reported the values of 3.50 and 2.30 g/16gN for the respective amino acids.

In a report on an assay of amino acids of same Nigerian feedstuffs, Fetuga et al (1973a) observed that amongst the plant proteins, the cashew nut meal and PKM gave the highest total sulphur amino acid values (3.18g/16gN). The PKM gave a higher methionine content (1.74g/16gN) or than either the cashew nut meal (1.4g/16gN) or groundnut meal - (0.91/16gN). Nwokolo et al. (1977) reported values of 3.45g/16gN and 2.35g/16gN respectively for lysine and methionine.

In a more recent report, Onwudike (1987a) recorded the values of 3.56 and 1.69g/16gN for lysine and methionine of PKM. Yeong (1983) reported on the amino acid content of Palm Kernel meal from Malaysia. He observed that the values were lower than those reported elsewhere. He, therefore, concluded that regional differences might have been responsible for these variations.

2.2.4. Crude Fibre

The crude fibre of a feed is that portion which remains insoluble after it has been boiled with dilute acid or alkali. It consists mainly of lignin and collulose (Woodman and Evans, 1957a). The crude fibre is an index that can be used to predict the feeding value of feed ingredients. A feed ingredient that is high in crude fibre content is usually less digestible and less nutritive to the monogastric animals.

Reports show that the crude fibre content of PKM varies from 9.06% (Oyenuga, 1968) to 10.3% (Fetuga et al., 1973a) while Owusu-Domfeh et al. (1970) recorded its cellulose content to be 37.02%. Nwokolo et al. (1977)

reported that the acid detergent fibre and acid detergent lignin of PKM were respectively 43.7 and 21.1%. These results showed that PKM has a high content of crude fibre compared to groundnut cake with 4.57% CF (Fetuga et al., 1973a). Oyenuga (1968) and Owusu-Domfeh et al. (1970) observed that the high fibre content, dry and gritty nature of PKM did not allow animals to accept it readily in their rations.

2.2.5. Ether Extract

This is the oil content of the feedstuff and its values depend largely on the extent of the oil extraction. Oyenuga (1968) recorded a value of 8.3% while Feguga et al. (1973a) indicated a value of 6.74% as the ether extract of PKM samples. A much lower value of 1.71% ether extract was recorded by Owusu-Domfeh et al. (1970) for Ghanaian samples.

In comparison with other protein sources of plant origin, Oyenuga and Fetuga (1975) recorded the values of 6.7, 6.4, 7.9 and 5.6% as the ether extract of PKM, groundnut cake, soyabean meal and cotton seed cake respectively. The ether extract portion of the feed, apart from providing some essential fatty acids, results in improved energy utilization.

2.2.6. Ash Content

This is the inorganic residue from the firing of a sample at about 600°C. The nutritional significance of the ash or mineral content depends on the feed under consideration. The total ash values of PKM as recorded by several workers ranges between 3.72 and 5.67% (NRC, 1979; Oyenuga, 1968; Owusu-Domfeh et al., 1970; Fetuga et al., 1973a).

These workers also reported a range of 0.21 - 0.31% for calcium and 0.41 - 0.74% for phosphorus in PKM samples.

Nwokolo et al. (1977) recorded values of minerals in PKM similar to those of NRC (1979). In an earlier report, Nwokolo et al. (1976) observed that the mineral content per kg of PKM were calcium, 3.6g, phasporus, 8.0g, magnesium, 4.4g, managanese, 135mg, iron, 356mg, zinc, 41mg and copper, 27mg. This is an indication that PKM is only very low in copper and zinc.

2.2.7. Nitrogen - Free Extract

This is the water soluble portion of the carbohydrates of a feedingstuff. It is primarily a source of energy to the animal. The range of nitrogen-free extract recorded for PKM samples by various workers is 38.19 - 56.70% (Oyenuga, 1968; NRC, 1979; Owusu-Domfeh et al., 1970; Oyenuga and Fetuga, 1975 ; . Fetuga et al., 1973a).

2.2.8. Gross Energy Content

An accurate knowledge of the energetic worth of a feed is essential for an efficient production. The energy density in the diets of animals governs the intake of all the nutrients. The gross energy (GE) of the feedstuff is the total potential energy of that feedstuff when it is completely oxidized in a bomb calorimeter at 25 - 30 atmospheres of pressure (Maynard, 1953). The GE is not usually all available to the animals because there are lossess at various steges of feed digestion and utilization.

The value of the gross energy of palm kernel meal depends, to a certain extent on the method of extraction. Palm kernel meal samples extracted by mechanical method

have higher gross energy values than those obtained by solvent extraction. This is because the former retains more oil and hence the higher caloric value.

Reports indicate that PKM samples had a range of between 4.28 and 4.68 kcal/g gross energy values. Owusu-Domfeh et al.. (1970) obtained a value of 4.28 kcal per gramme for the gross energy of palm kernel meal samples while slightly higher values of 4.42, 4.34, 4.46 and 4.37 kcal/g respectively were recorded by Fetuga et al., (1973a) Oyenuga and Fetuga (1975), Oluyemi et al. (1976) and Onwudike (1987a). In their analysis, Nwokolo et al. (1977) recorded 4.68 kcal/g as the gross energy of palm kernel meal samples.

2.3. Digestibility of Nutrients in Palm Kernel Meal

Digestibility refers to the breakdown of a feedstuff by the digestive enzymes in the gastrointestinal tract to a form that is readily available to the animal.

Research findings indicate that the digestibility of other nutrients in the diets of animals is depressed as a result of feeding fibrous feedstuffs (Crampton and Harris, (1969). Fetuga et al. (1973a) observed that the crude fibre contents of African locustbean (10.2%) and PKM (10.3%) were very high compared to that of the cashew meal (1.2%) and concluded that fibre could result in a lowered digestibility of the protein of PKM thus reducing the extent to which the associated amino acids could be utilized. These workers indicated that the fibres in palm kernel meal were of structural nature and might be arranged and distributed in such a way that protein is trapped by the fibres. This would resist the digestion by enzymes and bacteria in the

gastro-intestinal tract of monogastric animals and might even protect some proteinous materials trapped within them from the hydrolytic breakdown in the digestive tract.

Collingwood (1958), Oyenuga (1968) and Owusu-Domfeh et al. (1970) observed that the low digestibility of palm kernel meal might be due to its fibrous, dry and gritty nature which could cause considerable salivation during mastication in the monogastric animals. They, therefore, suggested the feeding of PKM to monogastric animals on a limited basis. Oyenuga (1968) emphasised that PKM should be introduced gradually into the rations of monogastric animals and fed in small quantities mixed with other palatable foodstuffs like molasses. The author recommended the use of PKM in the diets of ruminant animals.

Fetuga et al. (1973a) observed that the apparent digestibility of protein from PKM was significantly inferior to those for cooked and autoclaved cashew seed meal, soyabean meal and groundnut meal.

Research findings indicate that the average % digestibility of PKM (appendix table 11) ranged between 64.4 and 84.5% (Nwokolo et al., 1977; Yeong, 1983; Onwudike, 1987a). In a trial with broiler chicks, Nwokolo et al. (1977) reported that the percent amino acid availability of PKM ranged between 63.3% for glycine and 93.2% for arginine. They recorded an overall average of 84.5%. These workers indicated that lysine (90.0%) and methionine (91.4%) in PKM were highly available.

Working also with broiler chicks, Yeong (1983) obtained an average of 64.4% of available amino acids in PKM. The values of 58.6 and 72.1% were recorded for lysine and methionine respectively.

In a more recent study involving starter and grower chicks, Onwudike (1987a) observed that the percent amino acid availability in PKM ranged between 52.1% (glycine) and 92.7% (Arginine) and an overall average of 84.3%. This author recorded the values of 88.9 and 92.1% for lysine and methionine respectively.

Reports indicated that the mineral content of PKM is averagely available to monogastric animals. Nwokolo et al., (1977) noted that calcium and phosphorus were highly available compared with other minerals. These authors obtained the following values as the percent availability of the different minerals in PKM: calcium (68.6%), phosphorus (70.8%), magnesium (56.4%), copper (44.7%) and zinc (13.9%) and an overall mineral availability as 50.1%.

The efficiency of feed utilization depends greatly on the proportion of the energy of the feed that is available to the animal. The intake of other feed nutrients is, to a large extent, affected by energy availability of the feedstuffs (Crampton and Harris, 1969).

The digestible energy (D.E.) is the gross energy of a feedstuff less the faecal energy. For farm animals on well - balanced diets the faecal energy losses ranged from 20 to 50% of the gross energy (Maynard, 1953). The metabolizable energy (M.E.) is the digestible energy less the urinary energy and the energy of the gaseous products (methane) of digestion. The latter is not usually considered for monogastric animals (Wiseman and Cole, 1979).

Oyenuga and Fetuga (1975) observed that the D.E. M.E. and M.E.no. (zero nitrogen retention) for PKM samples were 3.28, 3.09 and 3.00 kcal/g respectively. Compared

with other plant protein sources, the workers noted that the D.E. and M.E. of PKM were lower than those of groundnut meal (4.21 and 3.90) and cotton seed cake (3.29 and 3.15) kcal/g respectively.

Owusu-Domfeh et al. (1970) had earlier indicated that the energy digestibility (24.7%) in PKM was exceptionally y lower than those of other plant protein sources in their trial with rats. Fetuga et al. (1973b) made similar observations when diets containing PKM were compared with those of other plant proteins sources in a trial with the mice.

In trials involving poultry, several investigators have reported varying values for metabolizable energy of palm kernel meal. The values reported include 2.70 kcal/g Oluyemi et al. (1976), 2.80 kcal/g Nwokolo et al. (1977), 2.65 kcal/g Onwudike (1987a) while lower values of 1.48 and 1.61 kcal/g were respectively reported by Yeong et al. (1981) and McDonald et al. (1973). Oluyemi et al. (1976) observed that with oil seed meals, the G.E., D.E. and M.E. values may vary widely for different batches of the feedstuff. This is because of the variable levels of residual oil in these meals depending on whether the oil is extracted by mechanical or selvent method.

Nwokolo et al. (1977) showed that the M.E. of alkali treated PKM samples (1.845 Kcal/g) was significantly (P/0.01) lower than the M.E. of the untreated PKM (2.80 kcal/g). They observed that alkali treatment of PKM was not a useful process for improving its energy availability to poultry. birds. In formulating the rations of poultry birds, Yeong and Mukherajee (1983) suggested that PKM should be kept

at a lower level so that the dietary energy level could be increased to a higher level by adding energy feedstuffs like grains or energy rich by-products. The workers reported that this was due to the fibrous nature of PKM which depressed the digestibility of other nutrients when fed at high levels in the diets.

2.4. Utilization of Palm Kernel Meal by Rats, Ruminants and Poultry

2.4.1. Rats

Reports indicate that owing to the low digestibility of palm kernel meal as a result of its high fibre content and gritty nature, rats and monogastrics, in general, cannot utilize the nutrients in PKM efficiently (Oyenuga, 1968; Owusu-Domfeh et al., 1978).

Fetuga et al. (1973b) observed that compared with other plant protein sources, the rats fed PKM showed a slower growth rate; an indication that PKM was not well utilized by rats. They pointed out that PKM showed nutritive value lower than the cashew nut and groundnut meal and much poorer than animal protein concentrates except blood meal. The high fibre content of the palm kernel meal resulting in low digestibility has been attributed to its low nutritive value.

2.4.2. Ruminants

The ruminants differ from other monogastric animals in having enlarged complex stomachs made up of four compartments. This large capacity is essential to allow feed retention so that micro-organisms can break down cellulose and other complex carbohydrates. The enzymes of monogastric animals cannot hydrolyse such complex carbohydrates.

Schmidt and Vogel (1932) and Vogel (1932) used PKM in the rations of dairy cattle and obtained satisfactory results. They recommended the use of palm kernel meal for producing good quality butter fat. The use of PKM as a source of protein for growing cattle has been reported to produce satisfactory results. Umunna et al. (1980) observed better growth rate and efficiency of feed utilization when PKM was fed at 20 and 40% levels in the diets of growing cattle compared to the control.

Based on the total performance and cost considerations Kwatu et al. (1983b) reported that it was economical to use up to 40% PKM in the ram fattening diets. They observed that the fattening rams fed PKM at 20 and 40% levels in the corn-based diet yielded better live-weight gains and feed to gain ratios compared to the control. However, carcass traits were not significantly affected by PKM inclusion in the rations. Kidney and mesenteric fat values decreased as the level of PKM inclusion increased.

2.4.3. Poultry

The use of palm kernel meal in poultry rations has been on a limited basis. Oyenuga (1968) observed that palm kernel meal was not palatable to poultry because of its gritty and dry nature and should be gradually introduced into the rationsof the birds.

Temperton and Dudley (1941) used PKM in combination with the groundnut meal in poultry diets and concluded that when PKM substituted for wheat middlings and groundnut meal for fish meal and skimmed milk, satisfactory egg production was maintained in batteries over a period of nine months.

It appears that the formulation of the diets containing PKM plays a significant role in the utilization of the diets by the various classes of poultry. Nwokolo et al. (1977) and Onwudike (1987a) observed that an effective use of palm kernel meal by poultry could be achieved by combining it with other protein sources to provide a better and balanced diet especially in terms of amino acid combination.

Yeong et al. (1981) observed that the feeding of (0, 15 and 30%) PKM to poultry without balancing the energy and other components of the diets affected feed intake. They observed that body weight gain and feed to gain ratios of birds receiving rations with lower levels (0 and 15%) of PKM were superior to those on higher level (30%) of palm kernel meal.

Onwudike (1987b) fed PKM at 28 and 35% levels in a trial with starter and grower chicks. He concluded that with starter pullets, PKM protein could replace up to 60% (that is, 28% of PKM in the diet) of the protein supplied by groundnut cake without any deleterious effects on their performance. Beyond this level, the rate of growth and feed conversion efficiency were significantly depressed.

The replacement of all the groundnut cake protein by palm kernel meal in the diets of grower pullets did not produce any significant effect on the performance of the birds. At laying, egg production, egg weight, weight of first eggs dropped and feed intake were not significantly affected but the cost of feed per kilogramme gain decreased significantly with increasing levels of palm kernel meal (Onwudike, 1987b).

Armas and Chicco (1977) fed 0, 15, 36 and 45% levels of palm kernel meal with or without lysine and methionine

supplementation to 5-day old broiler chicks. They observed that the average weight at 4 or 6 weeks of age was less with the 45% PKM diets than with the other groups. In Malaysia Yeong et al. (1981) compared levels of 0 - 30% PKM in the diets of broiler chicks and recommended the 15% level of PKM for optimum performance of broiler chicks.

Armas and Chico (1977) attributed the reduced performance of the birds as the levels of PKM increased in the rations to the increased level of dietary fibre which resulted in depressed digestibility of other nutrients in the diets. It was further observed that the abdominal fat decreased significantly as the levels of PKM in the diets of broiler chicks increased (Onwudike, 1987c).

2.5. Utilization of Palm Kernel Meal by Pigs

2.5.1. Effect of Palm Kernel Meal on Performance Characteristics of Pigs

Palm Kernel meal has been considered as a fibrous feed ingredient. Dietary fibre was for long thought to be of little nutritional value for simple-stomached animals including pigs. Early reports (Woodman and Evans, 1947a; Forbes and Hamilton, 1952), however, observed an apparent digestibility of the plant cell walls by pigs as high as that reported for ruminants. Later reports proved that dietary fibre had nutritional value and that it contributed to the maintenance of monogastric animals. (Farrell and Johnson, 1970). Reports also indicated that dietary fibre had been used to produce better performance and good quality carcasses in the market pigs (Bohman et al., 1953; Crampton et al., 1954; Pond et al., 1962).

Oyenuga (1968) observed that the fibrous, dry and gritty nature of palm kernel meal rendered it inefficient in the nutrition of pigs. He, however, suggested that it could be fed at low levels and mixed with palatable feedstuffs like molasses. Babatunde et al. (1975), used PKM as the sole protein concentrate or with other protein concentrates in the diets of growing pigs. They fed 45.63% PKM to weaner pigs and observed that the pigs gained at a rate significantly (P/0.05) lower than those on other protein concentrates (fish meal, blood meal and milk powder). Similarly, the efficiency of feed utilization was significantly poorer for pigs on the PKM diets than those on any of the other protein sources. The feeding of 32% PKM diet to finisher pigs by the same authors produced similar trends as for the weaner pigs.

In another trial, Babatunde et al. (1975) fed 33 - 49% PKM diets supplemented with 3 - 15% blood meal, groundnut cake, fish meal or milk powder, in finisher pigs. The pigs on the control diet without PKM inclusion were significantly better in terms of weight gain and feed to gain ratio. These workers attributed the better performance of the animals on PKM supplemented with fish meal and lysine diets to the combination of lysine and methionine in PKM and fish meal.

In an experiment involving growing finishing pigs, Fetuga et al. (1977a) fed diets containing 18.8 - 46.5% PKM and 4.6 - 11.3% blood meal to pigs. They observed that there were significant declines in the rate of growth, feed and energy conversion efficiencies as the proportion of PKM in the diets increased. However, feed intake was not affected.

The workers agreed that the better performance of the animals receiving high blood meal and low PKM diets was as a result of the complementary effects of the amino acid make-up of the two ingredients. Blood meal is a protein source which is high in lysine but very poor in methionine and cystine (Fetuga et al., 1973a) but the reverse is the case for PKM (Owusu-Domfeh et al., 1970). However, an earlier report by Oyenuga (1968) revealed that methionine was the limiting amino acid in PKM.

In order to improve the acceptability of PKM by pigs, as earlier suggested by Oyenuga (1968), Fetuga et al. (1977) incorporated cane molasses in the diets of finisher pigs containing 33 - 38% PKM. This according to them, would improve palatability and efficiency of nutrient utilization for the growth of the animals. These workers observed significant improved growth rate, feed intake and feed conversion efficiency in the diets containing cane molasses. They concluded that the improved performance was obtained through improved digestibility of the fibre fraction of palm kernel meal.

Oyenuga (1968) had earlier implicated the fibrous, gritty and unpalatable nature of PKM as some of the factors limiting its use in the diets of pigs. But Fetuga et al. (1977a,b) revealed that by careful combination of feed ingredients, palm kernel meal could be included in the diets of pigs to produce satisfactory or improved performance. Oyenuga and Fetuga (1975) observed that energy was less efficiently utilized in PKM by growing - finishing pigs, hence it could be used in fattening pig diets where dietary energy restriction is a desirable practice.

2.5.2. Effect of Palm Kernel Meal on Carcass Characteristics of Pigs.

Reports in the literature indicate that the inclusion of fibrous feedstuffs in the diets of fattening pigs results in leaner and superior carcass quality.

In a trial with growing - Finishing pigs, Fetuga et al. (1977a) observed that increased contribution of protein from PKM resulted in increased dietary crude fibre but did not produce significantly superior carcasses even though it resulted in reduced digestible energy intake. These workers argued that the diets containing less PKM had blood meal contributing more lysine. This may have influenced favourably the growth of lean tissue in the pigs.

The inclusion of palatable feedstuffs like molasses in the diets of swine has been observed to improve the digestibility of the fibrous portion of the diets (Oyenuga, 1968; Brooks and Iwanga, 1967). Based on this observation, Fetuga et al. (1977b) incorporated 1 - 30% cane molasses in 33 - 38% PKM based diets containing 6 - 10.5% blood meal in a trial with growing - fattening pigs. They observed superior carcass quality on PKM diets compared to the groundnut cake based control diet. The superior carcass quality obtained was attributable to the better utilization of nutrients in the diets by molasses coupled with the amino acid combination of PKM and blood meal. The authors concluded that the lower cost of PKM relative to groundnut cake and that of cane molasses to maize could result in additional economic benefits if PKM - cane molasses combinations were used in formulating swine diets.

2.6. Crude Fibre in Swine Diets

2.6.1. Fibre Utilization by Pigs

Pigs are fed largely on concentrate feeds and the ingredients of such feeds are generally chosen for their easier digestion. The pig is thus less able to use fibre than other farm livestock. Its digestive tract includes a simple-stomach of relatively small capacity in constrast with the complex stomachs of the ruminnts and the large caecum of the horses (Woodman and Evans, 1947a; Cunha, 1977). Crampton and Harris (1969) observed that high fibre basal diets are normally fluffy and carry low proportion of nutrients per unit volume rather than per unit weight. This has been traced to the crude fibre levels in such feedstuffs. Thus, the substitution of high fibre feeds on a weight for weight basis results in reduced nutrient intake by the animals.

The incorporation of cellulose in pig diets depresses the apparent digestibilities of crude protein and ether extract (Woodman and Evans, 1947a). The authors indicated that the reduced crude protein digestibility was probably due to a number of factors: and increase in the metabolic nitrogen, an increase in the rate of passage of feed in the alimentary canal and the shielding by cellulose of the substrates from the digestive enzymes.

The chemical composition of crude fibre is variable but cellulose is generally the major component. The differences in the composition are probably responsible for the wide range of digestibility differences of crude fibre in the diets of pigs (Woodman and Evans, 1947a). However, Farrell (1973) incorporated high plant cell

wall constituents (fodder cellulose) in the diet of finisher pigs. He concluded that there were no associative effects on the apparent digestibilities of dry matter, energy and nitrogen in mixed diets of ground lucerne and pig - meal.

Kuan et al. (1983) observed that the proportion of cell wall materials extracted as neutral detergent fibre from lucerne leaf meal in the diets of pigs resulted in linear increases in the apparent digestibilities of dry matter, crude protein, ether extract and energy. They noted that there were no significant effects on the digestibility of fibre and its components. However, nitrogen retention increased linearly with increased cell wall materials in the diets.

The inclusion of fibrous feeds in the diets of pigs have been reported to affect their growth rates. Farrell and Johnson (1970) fed diets containing cellulose (Wood dust) at levels of 0, 8 and 20% to finisher pigs. They observed that pigs on the high fibre diets had slower growth rates and higher digesta weight in the caecum accompanied with retention times of the digesta in the digestive tract.

The feeding of corn cobs at 0, 7.5 and 15% levels to growing pigs resulted in reduced daily weight gains and higher feed to gain ratios. The average digestible energy was not affected. The reduced weight gains observed was attributed to the dilution of the energy content of the diets as the fibre content increased. The energy densisty and not the bulk per se is responsible for the depressed weight gains (Baird et al., 1975; Lloyd et al., 1958).

De Goey and Ewan (1975a) fed young pigs a cellulose diluent (Solka flock) with the basal diet. The body weight

gain and feed to gain ratios were not significantly affected but the apparent digestion coefficients and energy values decreased. They concluded that the energy of the cellulose was not utilized by young pigs.

Feeding iso-nitrogenous and iso-caloric diets to pigs Bowland et al. (1970) observed that dietary nitrogen intake, nitrogen retention, energy intake and weight gains were not affected by increased crude fibre levels. The deposition of lean and fat also did not vary markedly as the levels of crude fibre in the diets increased.

Several research findings indicate that if carcass leaness is to be improved through feeding, the reduction in dietary energy intake is required. Increasing the fibre level, without increasing the energy level, can accomplish this. But fibre itself does not increase carcass leaness, the reduced total dietary energy intake does (Bohman et al., 1953; Baird et al., 1970; Bowland et al., 1970).

A number of workers (Bohman et al., 1953 ; Pond et al., 1981) have linked fibre with increases in weight and or length of the stomach and various segments of the gastro-intestinal tract. They suggested that the enlarged stomachs and intestines in pigs were a means of adapting to the high fibre content in their diets which increased the capacity of the gastro-intestinal tract and facilltated microbial digestion in the lower segment of the gut.

Several factors such as the source, components and levels of incorporation of fibre in the diets of pigs have been reported to reduce the utilization of fibrous feed by pigs (Forbes and Hamilton, 1952; Axelsson and Eriksson, 1953; Fetuga et al., 1975; Cunha, 1977; Stanogias and Pearce, 1983).

Fibre utilization in swine diets has been related to the age and liveweight of the pigs. Cunnigham et al. (1962) observed that only very little increases in the digestibility of fibre could be expected with increasing age and liveweight of pigs.

CHAPTER THREE

3. EXPERIMENTS

3.1. EXPERIMENTS 1

THE EFFECT OF GRADED LEVELS OF PALM KERNEL MEAL ON THE PERFORMANCE CHARACTERISTICS OF YOUNG PIGS.

3.1.1. SUMMARY

Forty - five (45) crossbred (Large White x Hampshire) weaner pigs (30 boars and 15 gilts) of average initial weight of 13.69 kg were fed diets containing 0, 10, 20, 30 and 40% palm kernel meal (PKM). Three pigs were randomly assigned to pens based on initial weight group and sex. There were three replications and five treatments in a randomized block design. At the end of 56 - day trial period, performance of pigs fed different levels of palm kernel meal in terms of feed intake and weight gain were not significantly ($P > 0.05$) different from those on control diet. Feed to gain ratio at 10% PKM was not significantly ($P > 0.05$) different from those on control. However, feed to gain ratio at 20, 30 and 40% PKM were significantly higher ($P < 0.05$) than those on control diet. Feed cost per gain at 10% PKM was not significantly different from that of the control but was significantly reduced ($P < 0.01$) as the level of PKM increased in the diets. It is concluded that young pigs can be fed up to 40% palm kernel meal without adversely affecting their performance.

3.1.2. INTRODUCTION

Animal production industry is geared towards converting cheap and available protein feedstuffs into a more balanced animal proteins. Conventional protein sources such as delinted cotton seed meal, groundnut meal, Soyabean meal and Sunflower meal are expensive and their inclusion in Swine diets may not be economical. Their production is seasonal and their prices increase out of the production season. Palm kernel meal is abundant and cheap source of protein compared to other conventional sources. Palm kernel meal is produced in over more than one third of Nigeria and it is the largest protein meal in the country. The production of palm kernel meal is not seasonal as palm fruits all the year round. However, the peak of production falls between the months of March and May when seasonal protein meal sources are scarce and expensive. Nigeria used to be a leading producer and exporter of palm kernel meal in the 1960s (FOA, 1975).

Palm kernel meal contains 21.30 crude protein, 43.70% acid detergent fibre and 21.10% detergent lignin. The availability of its amino acids ranged from 63 to 93% (Nwokolo et al; 1977). Very few articles have been published on the utilization of PKM by weaner pigs. This might be because of its high fibre content and gritiness due to excessive lignification. Babatunde et al. (1975) fed PKM as a major protein concentrate at levels of 32.00 and 46.5% in the diets of weaner pigs. They found that weight gain, feed intake

and feed to gain ratio were significantly depressed at 30 and 35% PKM levels compared to other conventional protein diets. Yeong et al. (1981) fed 0, 15 and 30% PKM diets to broiler starters and observed that weight gain and feed to gain ratios of birds receiving 0 and 15% PKM were superior to those on 30% PKM diet. Onwudike (1987b) fed PKM at 28 and 35% levels to starter and grower chicks. He reported that the 28% PKM diet did not affect the feed intake, feed to gain ratio and growth rate of the birds. Oyenuga (1968) indicated that pigs should be gradually introduced to PKM diets and preferably mixed with other palatable feed ingredients like cane molasses.

3.1.3. OBJECTIVE

The present trial, therefore, investigates the effect of feeding graded levels of palm kernel meal on the performance characteristics of weaner pigs.

3.1.4. MATERIALS AND METHODS

Forty - five (45) crossbred (Large White x Hampshire) weaner pigs (30 boars and 15 gilts) of average initial weight of 13.69kg were involved in a 56 - day trial period. The animals were randomly assigned to pens based on initial weight group and sex. There were three replications of five treatments in a randomized block design trial and there were 3 pigs per pen.

The experimental diets were based on graded levels of PKM at 0, 10, 20, 30 and 40% as shown in table 1. Molasses was added to all diets at 5% level to improve palatability.

Table 1: Graded Levels of Palm Kernel Meal in Pig Diets: Composition of Diets and Analysis

	Levels of PKM in Diets				
Ingredients, %	0	10	20	30	40
Maize	42.49	34.48	26.47	18.42	10.44
Groundnut cake	28.80	26.81	24.82	22.84	20.85
Palm Kernel Meal	0.00	10.00	20.00	30.00	40.00
Maize Offal	10.00	10.00	10.00	10.00	10.00
Rice Offal	10.00	10.00	10.00	10.00	10.00
Molasses	5.00	5.00	5.00	5.00	5.00
Bone Meal	2.50	2.50	2.50	2.50	2.50
Common Salt	0.50	0.50	0.50	0.50	0.50
Vit. Premix[a]	0.20	0.20	0.20	0.20	0.20
DL-Methionine	0.26	0.26	0.26	0.26	0.26
L-Lysine %	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00
Feed cost per tonne ₦[b]	1530	1419	1299	1179	1059
Proximate Analysis:					
C.P., %	17.71	18.27	18.84	19.39	19.96
M.E., Kcal/g[c]	3.24	3.30	3.31	3.32	3.42
Crude Fibre, %	9.63	10.38	11.08	11.38	12.82
Ether extract, %	2.28	2.38	2.80	3.50	4.06
Calcium, % d	0.84	0.84	0.83	0.83	0.82
Phosphorus, % d	0.67	0.64	0.60	0.57	0.54
Lysine, % d	0.82	0.83	0.78	0.73	0.62
Methionine, % d	0.71	0.67	0.63	0.59	0.55

[a] Roche Vitamin - Mineral Premix (VM502) contributed the following per kg of diet Vit. A, 160,000 I.U., Vit. B_3 1,600 I.U. Vit. E 20.0 I.U., Vit., K, 7.4mg, Vit. B_1 1.0mg Vit. B_2, 4.0mg, Nicotinic acid, 24mg., Calcium D-panthotenate, 14.0mg, Vit. B_6 2.0mg., Vit. B_{12} 16.0mg Folic acid, 0.4mg, Biotin, 0.05mg. Vit. C, 20.0mg, Chorine Chloride, 100mg, Zinc, 137mg Copper, 20,0mg Iodine, 0.62mg, Cobalt, 0.7mg and Selenium 0.10mg.

b Prices of feed stuffs as at May, 1988 (Table 12)

c M.E. values from Ewan, 1976.

d Calculated analysis.

All animals were dewormed with banminth prior to commencement of the trial and a month later at the rate of 25mg per kilogramme body weight. Pigs were fed at 4% of body weight and the feeding was twice daily at 0800 and 1600 hours throughout the experimental period. Unconsumed feed was collected and weighed back daily. Animals were weighed weekly and the level of feeding was adjusted to 4% of body weight daily. Water was continuously available for the animals throughout the trial period Performance of pigs was monitored in terms of feed intake, weight gain, feed to gain ratio and the cost of feed required per unit weight gain.

Proximate analysis of test diets and major feed ingredients were carried out according to the methods of A.O.A.C. (1980), table 13, The statistical analysis of the data collected was carried out using analysis of variance procedure described by Cochran and Cox (1957) and the differences between treatment means were compared using the Duncan's Multiple Range Test (Steel and Torrie, 1960).

3.1.5. RESULTS AND DISCUSSION

The results obtained from weaner pigs fed graded levels of palm kernel meal are summarised in Table 2. Weight gain of the pigs (0.34 $\pm$ 0.02kg) was not significantly ($P > 0.05$) different across treatments. This could due to the amino acid balance and adequate metabolizable energy of the PKM diets as shown in table 1. Although the first limiting amino acid in PKM is lysine followed by methionine (Oyenuga, 1968) these were balanced

Table 2: Effect of Feeding Graded Level of Palm Kernel Meal in the Diets of Young Pigs - Day Performance Data

Parameters	Levels of PKM in Diets					Mean	SE	Significant Effect
	0	10	20	30	40			
Avg. Initial weight, kg	13.75	13.67	13.78	13.61	13.61	13.69	0.19	NS
Avg. Final weight, Kg.	32.53^{a}	31.80^{b}	33.14^{a}	32.90^{a}	32.98	32.67	0.28	*
Avg. Daily Feed, Kg.	0.72	0.72	0.73	0.73	0.74	0.73	0.05	NS
Avg. Daily Gain, Kg.	0.34	0.32	0.35	0.34	0.35	.34	.02	NS
Feed Gain	3.07^{ab}	3.19^{a}	2.96^{b}	2.99^{b}	2.99^{b}	3.04	0.05	*
Feed cost per kg gain, ₦	4.83^{a}	$4,50^{a}$	3.91^{b}	3.47^{bc}	3.11^{c}	3.96	0.65	**

abc. Row means with different superscripts differ significantly

* (P/0.05)

** (P/0.01)

NS Non-Significant effect.

for in the diets. In this trial, the levels of both lysine and methionine met the minimum requirement by this class of young pigs (NRC, 1979). However, Babatunde et al. (1975) observed that a significant reduction in growth rate of weaner pigs fed 32.0 or 46.5% PKM diets could be due to reduced digestibility. This was attributed to the gritty and fibrous nature of the PKM diets compared to groundnut meal, milk powder, blood meal and fish meal diets. This result is not in agreement with the one obtained in the present trial.

Yeong et al. (1981) observed that the growth rate of broiler starters fed 0 and 15% PKM diets were superior to those on 30% PKM diets. Also Onwudike (1987b) fed PKM at 28 and 35% levels in the diets of grower chicks. He observed that the 28% PKM was optimum for this class of birds. These workers observed that the feeding of higher levels (30 and 35%) of PKM reduced the growth of young birds. But in the present trial, the feeding of up to 40% PKM diet had no adverse effect on the growth rate of young pigs.

Feed intake (0.73 $\pm$ 0.05kg) of pigs fed PKM diets was not significantly different compared to feed intake of pigs on the control diet. This might be attributed to the method feeding. The animals were fed at 4% of body weight and there was no problem of feed refusal on the high PKM diets. This system of feeding regime minimised overfeeding as obtained on ad - libitum or voluntary feeding. PKM diets were well accepted and readily consumed by young pigs in the present trial. This is contrary to the finding of Babatunde et al. (1975) who fed 32.0 and

46.5% PKM diets to weaner pigs and observed that PKM diets were least consumed compared to groundnut meal, milk powder, blood meal and fish meal diets. This, they attributed to the gritty nature of the palm kernel meal diets.

Feed to gain ratio of the pigs fed the 10% PKM diet was similar to that of pigs fed the control diet but was significantly ($P<0.05$) higher than the feed to gain ratio of the pigs on 20, 30 and 40% PKM diets. The feed required per unit gain, for the pigs fed the control diet was not significantly ($P>0.05$) different from those fed 20, 30 and 40% PKM diets. This might suggest that the utilization of feed nutrients for body weight gain in this class of pigs compared favourably with the control diet. This might be due to the adequate amino acid balance of the control and these PKM diets which must have enhanced feed conversion efficiency. Babatunde et al. (1975) fed diets containing 32.0 and 46.5% PKM and convetional protein sources to weaner pigs. They observed that the pigs on PKM diets had the poorest feed to gain ratio (6.35, 2.52, 4.01, 2.97 and 1.98) compared to those on groundnut meal, milk powder, blood meal and fish meal diets. This result differed from the one obtained in the present trial. No reasons could be attributed to the observed reduction ($P<0.05$) in feed to gain ratio of pigs fed the 10% PKM diet. Yeong et al. (1981) and Onwudike (1987b) on the other hand, observed that young chicks fed 15.0 and 28.0% PKM diets

had superior feed conversion efficiency compared to those fed 30 and 35% PKM diets. This was attributed to the poorer utilization of PKM diets by the growing birds at the higher levels (30 and 35%) of PKM.

The feeding of palm kernel meal in the diets of weaner pigs significantly ($P < 0.01$) reduced feed cost per kilogramme gain across treatments. The unit cost of the diets used in this trial (1.54, 1.42, 1.30, 1.18 and 1.06 ₦/kg) indicated a 7.80, 15.59, 23.39 and 31.19% fall in the unit prices of diets containing PKM compared to the control diet. The feed cost per kilogramme gain of 4.83, 4.50, 3.91, 3.47 and 3.11 ₦/kg indicated a 6.83, 19.05, 28.16 and 30.89% fall when 10, 20, 30 and 40% PKM diets were fed to young pigs. It is clear, therefore, that the inclusion of as much as 40% PKM in the diets of young pigs is beneficial in reducing feed cost and reducing cost of feed per unit gain. There is a drastic reduction in the feed cost and less dependence on the groundnut cake and maize which are too expensive for a profitable pig production enterprise.

In conclusion, as high as 40% PKM can be incorporated in the diets of young pigs without adverse effect on their performance. Feed cost is drastically reduced when 40% PKM is fed in the diets of weaner pigs. The inclusion of PKM in pig diets reduces the competition for groundnut cake and maize as found in this experiment.

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3.2. EXPERIMENT 2

THE REPLACEMENT VALUE OF PALM KERNEL MEAL FOR MAJOR ENERGY AND PROTEIN SOURCES IN THE DIETS OF FINISHER PIGS

3.2.1. SUMMARY

Thirty - two (32) crossbred (Large White x Hampshire) finisher pigs (16 boars and 16 gilts) of average initial weight of 41.55kg were fed diets containing 0, 20.55, 41.10 and 61.65% palm kernel meal (PKM). There were four replications, two pigs per pen and 4 treatments in a randomized block design. At the end of 64 - day trial period, results showed that feed intake was not significantly ($P>0.05$) different for pigs fed PKM and those on control. Average daily gain and final weights of the pigs fed the control and 20.55% PKM diets were not significantly different ($P>0.05$) different from one another but were significantly ($P<0.05$) higher than gains of pigs fed 41.10 and 61.65% PKM diets. Feed to gain ratio for pigs fed 61.65% PKM diet was significantly ($P<0.05$) poorer than the pigs fed 0, 20.55 and 41.10% PKM diets. The feeding of 41.10 and 61.65% PKM diets significantly reduced ($P<0.01$) feed cost per unit gain. All carcass traits measured (dressing %, percentages of ham, shoulder, loin and belly, loin-eye area and backfat thickness) did not differ significantly due to treatments. The weights of the organs (empty stomach, liver, lungs, heart, kidneys and spleen) were not significantly affected by the level of PKM fed to the pigs. It was concluded that 20.55% PKM caused weight gain in finisher diets containing no PKM. Levels of 41.10 and 61.65%

PKM caused weight gain which were significantly ($P<0.05$) lower, than those of control and 20.55% PKM diets but lower ($P<0.01$) ($P<0.05$) feed to gain ratio and feed cost per kg gain. The feeding of up to 61.65% PKM in the diets of finisher pigs has no adverse effect on the carcass characteristics of pigs. For economic reasons, these higher levels of PKM are recommended.

3.2.2. INTRODUCTION

In recent years, the rising prices of livestock feeds and the scarcity of conventional protein concentrates in the animal production industry have forced animal nutritionists to look for alternative, cheaper and readily available protein sources. Palm kernel meal (PKM) is abundant in Nigeria and many tropical countries. Palm kernel meal is obtained from the palm kernels after the extraction of the oil. In the 1960s, Nigeria was a leading world producer and exporter of palm kernels, exporting about 400,000 tonnes per annum (Oyenuga, 1968; FAO, 1975).

Palm kernel meal is a cheap protein concentrate containing 21.30% crude protein and 10.46% crude fibre. The average availability of its amino acids is 84.40% (Fetuga et al. 1977a; Nwokolo et al., 1977). Oyenuga (1968) indicated that pigs do not take readily to PKM based diets because of its fibrous, dry and gritty nature. Babatunde et al. (1975) reported that the feeding of 32% PKM in diet of finisher pigs depressed the feed intake, weight gain and feed to gain ratio compared to

other conventional protein sources. Similarly, Fetuga et al. (1977a) reported that the weight gain, feed intake and feed to gain ratio of finisher pigs fed 18.80 to 46.50% PKM diets were depressed compared with pigs fed other protein diets.

Although conventionally used as a protein source in Swine diets, PKM has high amount of residual oil depending on the method of extraction. This tends to increase the energy value of the feedstuff. NRC (1979) and Oyenuga and Fetuga (1975) reported the values of 2.88 and 3.09 Kcal/g respectively as the metabolizable energy for PKM samples PKM has not been used much in the diets of finisher pigs and where it has been used the levels appear to be very low.

3.2.3. OBJECTIVE

The objective of this study is, therefore to determine the optimum level of PKM in diets of finisher pigs. This is with a view to formulating cheap practical diets.

3.2.4. MATERIALS AND METHODS

Thirty - two (32) crossbred (Large White x Hampshire) boars and gilts of average initial liveweight of 41.55kg were used in a 64 - day trial period. The pigs were randomly assigned to pens based on initial weight-group and sex. There were 4 replications of 4 treatments in a randomized block design trial of two pigs per pen.

Cooked full-fat soybean was used as the main protein concentrate in this trial. Soybean seed was boiled for about 35 to 40 minutes in half-drum container.

The soybean was removed with a basket, the water was allowed to drain and then sun-dried for about 2 days. Thereafter the soybean was ground using a corn mill prior to inclusion in the rations.

The experimental diets (table 3) were:-

1. A 15.83% crude protein diet in which maize offal and soyabean (full-fat) were the major energy and protein sources.
2. PKM fed at 20.55% of the diet replaced 25% of the maize offal and soyabean (full-fat) in the control diet.
3. PKM fed at 41.10% of the diet replaced 50% of the maize offal and soyabean (full-fat) in the control diet.
4. PKM fed at 61.65% of the diet replaced 75% of maize offal and soyabean (full-fat) in the control diet.

All animals were dewormed prior to the start of the experiment and at monthly intervals with banminth. The dosage was 25mg per kilogramme body weight. Pigs were fed at 5% of body weight daily throughout the trial period. All the diets were offered to the animals in weighed quantities twice daily at 800 and 1600 hours throughout the trial period. Animals had free access to water. Left over feed was collected, air dried and weighed back. Pigs were weighed every week and the level of feeding was adjusted to 5% of body weight daily. The performance of the animals were monitored in terms of

Table 3: Experiment 2: Composition and Proximate Analysis of Diets in which Palm Kernel Meal Replaced major Energy and Protein Sources in Finisher Pigs

	Levels of PKM in Diets			
Ingredients %	0	20.55	41.10	61.65
Maize Offal	56.06	42.75	29.75	16.09
Boiled full fat Soyabean	26.09	18.85	11.63	4.41
Palm Kernel Meal	0.00	20.55	41.10	61.65
Rice Offal	10.00	10.00	10.00	10.00
Molasses	5.00	5.00	5.00	5.00
Bone Meal	2.00	2.00	2.00	2.00
Common Salt	0.50	0.50	0.50	0.50
Vit. Premix[a]	0.20	0.20	0.20	0.20
Methionine	0.15	0.15	0.15	0.15
Total	100.00	100.00	100.00	100.00
Feed Cost per Tonne (₦)b	1178	1023	869	714
Proximate Analysis				
Crude Protein, %	15.83	16.16	16.50	16.85
M.E. Kcal/g[e]	3.29	3.33	3.50	3.67
Crude Fibre, %	11.61	12.30	12.88	14.34
Ether Extract, %	4.96	5.84	7.38	8.38
Calcium, % d	0.67	0.72	0.75	0.78
Phosphorus, % d	0.61	0.67	0.74	0.80
Lysine, % d	0.67	0.62	0.56	0.51
Methionine, % d	0.52	0.54	0.56	0.67

[a]Roche Vit-Mineral Premix (VM501) contributed the following per kg of diet; Vit. A. 9,600 I.U., Vit. D_3 1,600 I.U., Vit. E 12. I.U., Vit. K, 1.6mg. Vit. B_1 0.8mg., Vit B_2 3.2mg, Nicotinic Acid, 12.0mg, Calcium D-Panthotenate, 6.4mg, Vit. B_6 1.6mg Vit. B_{12} 8.0mg, Folic Acid, 0.4mg., Biotin, 0.6mg, Choline Chloride, 160mg. Manganese, 8.0mg., Iron, 4.0mg, Zinc, 46.8mg Copper 8.0mg, Iodine, 0.48mg, Cobalt, 0.28mg and Selenium, 0.01mg.

b Prices of Feedstuffs as at December, 1988 (Table 12)

c M.E. Values from Ewan, 1976.

d Calculated analysis.

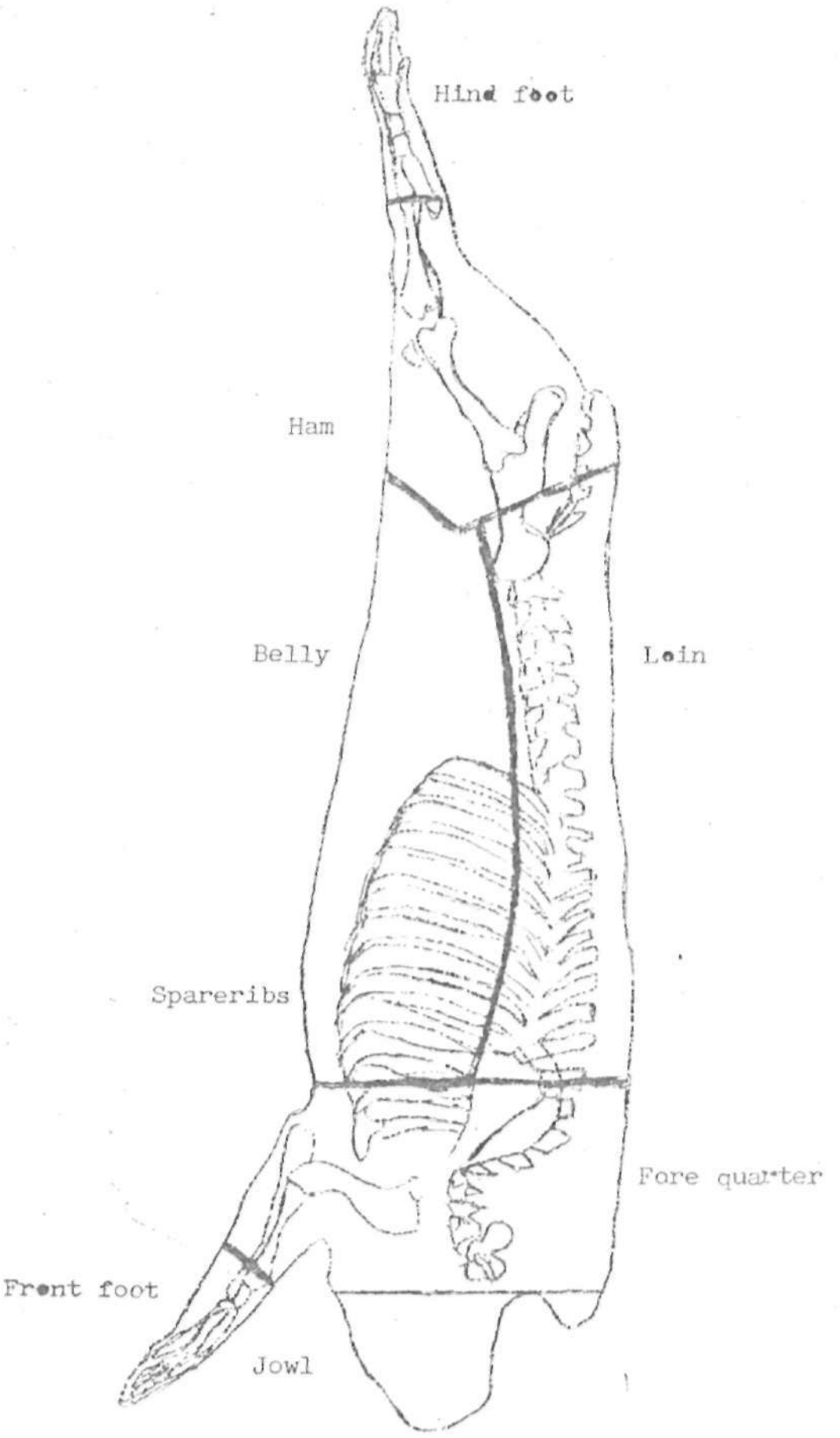


Figure (1). Skeletal diagram of a pork carcass to illustrate the anatomical references for cutting the wholesale (primal) cuts.

feed consumption, weight gain and feed to gain ratio throughout the 64 - day trial period. At the end of the feeding period, the cost analysis of the project was carried out.

Sixteen (16) animals (8 boars and 8 gilts) were selected based on final weight across the replications, that is, one pig from each pen. These were slaughtered to evaluate the carcass quality. Prior to slaughtering, pigs were fasted overnight but had access to water. The carcasses were processed for data collection according to the procedure of Eusebio (1980).

The hind foot was removed from the hind legs 1.5cm above the hock joint perpendicular to the shank line. The fore foot was removed slightly (1.5cm) above knee joint perpendicular to the line of the shank. The ham was removed by a cut between 2nd and 3rd saeral vertebrae along the axis of the shank. The shoulder was removed by a cut between the 2nd and 3rd ribe (thoracic vertebrae) and perpendicular to the backline. The loin was removed by cutting across the 10th and 11th ribs.

The belly was removed by separating the loin through a cut of the tender loin 4cm, from the backbone following the back bone. Back fat thickness was measured apposite the rib, 10th rib and the junction between the 2nd and 3rd lumbar vartebrae. Loin-eye area was measured by a tracing of a cross-section of the right and left longissimus muscles posterior to the junction of the 10th rib (thoracic vertebra) counting from the anterior end of the carcass (fig 1).

Proximate analysis of test diets and major feed ingredients were carried out according to the methods of A.O.A.C. (1980), Table 14. Gross energy was determined by Gallenkamp automatic bomb calorimeter. The data collected were statistically analysed using analysis of variance method by Cochran and Cox (1957). Treatment means were compared using Duncan's Multiple Range Test (Steel and Torrie, 1960).

Table 4: Experiment 2: The Effect of Feeding Palm Kernel Meal Diets on Performance Characteristices of Finishing Pigs

Parameters	Levels of PKM in Diets 0	20.55	41.10	61.65	Mean	S.E.	Significant Effect
Avg. Initial Weight, kg	41.59	41.19	41.65	41.55	41.55	0.94	NS
Avg. Final Weight, kg	85.39[a]	89.35[a]	83.08[b]	80.14[b]	84.49	2.70	*
Avg. Daily Feed, kg.	2.59	2.75	2.49	2.44	2.57	0.12	NS
Avg. Daily Gain, kg	0.68[a]	0.74[a]	0.64[b]	0.58[b]	0.66	0.03	*
Feed Gain Ratio	3.62[a]	3.22[a]	3.69[a]	4.20[b]	3.91	0.11	*
Feed Cost/kg Gain (₦)	4.26[a]	3.81[a]	3.21[b]	3.00[b]	3.57	0.11	**

a,b., Row means with different superscripts are significantly different * (P/0.05) ** (P/0.01).

N. S., Non-significant difference among treatment means.

3.2.5. RESULTS AND DISCUSSION

The results obtained from finisher pigs fed PKM diets are presented in Table 4. The average final weight and weight gain of pigs fed the control and 20.55% PKM diets were not significantly different. Both however, produced significantly better gain ($P < 0.05$) than the diets containing 41.10 and 61.65% PKM diets. This could be attributed to the lower lysine content at those higher levels of PKM. The lysine levels were 0.67 and 0.62% at 0 and 20.55% in contrast to 0.51% at 61.65% PKM levels. Babatunde et al (1975) investigated the inclusion of PKM at 33 and 49.0% levels in finisher diets in terms of its growth promotion ability. They observed that the pigs fed PKM diets gained at a rate (0.20, 0.49, 0.35, 0.38 and 0.38kg) significantly lower ($P < 0.05$) than those on diets containing groundnut cake, milk powder, blood meal and fish meal. This result is in agreement with those obtained in this work as their level of PKM of 33% was above 20.55% used here. Babatunde et al (1975) attributed this low performance to deficiencies of lysine, leucine, threonine and phenylalanine levels in PKM diets.

Feed intake (2.57 ± 0.12kg) of pigs was not significantly different ($P > 0.05$) across treatments. This could be attributed to the method of feeding. Pigs were fed at 5% body weight daily and where left over feed was available, this was weighed. This system of feeding management did not allow the animals to overfeed as obtained on ad - libitum or voluntary feeding.

Fetuga et al. (1977a) fed diets containing between 18.8 and 46.5% PKM and 2.5% cane molasses. They observed non-significant difference in feed intake (2.12 ± 0.12kg) of the pigs. They attributed this trend to the incorporation of cane molasses which improved the palatability of the diets. This is in agreement with the present trial in which 5% cane molasses was incorporated in the diets.

Feed to gain ratio was not significantly different when up to 41.10% PKM was fed to the finisher pigs. There was however, a significant increase ($P<0.05$) in feed to gain ratio at the highest level of PKM (61.65%). This may be due to the reduction in the digestibility. The feeding of 33.0 or 49.0% PKM to finisher pigs by Babatunde et al (1975) resulted in significant decline in the growth rate and feed conversion. This was attributed to the dry, gritty and fibrous nature of the high PKM diets which reduced their digestibility. The significant reduction in feed to gain ratio of the pigs fed the diet containing 49% PKM in their results is in agreement with the result obtained in the present trial. However, Fetuga et al. (1977b) observed improved weight gain and feed efficiency with the addition of 10.0 to 30.0% cane molasses to diets containing 33.0 or 38% PKM. They observed poor performance of the pigs fed higher levels of PKM in their trial and attributed this performance to the impaired protein digestion resulting from an encrusting effect of fibre on the proteinaceous material. Fetuga et al. (1977b). also stated that higher fibre induced a more rapid passage of the digesta through the gastro - intestinal tract. This would lead to a reduction of the available amino

Table 5: Experiment 2: The Effect of Feeding Palm Kernel Meal Diets on Performance Characteristics of Boars and Gilts

Parameters	Sex		Mean	S.E.
	Boars	Gilts		
Initial Weight, kg	41.97	41.13	41.13	0.94 NS
Final Weight, kg	82.86	82.12	84.49	2.70 *
Avg. Daily Feed kg.	2.55	2. 59	2.57	0.12 NS
Avg. Daily Gain, kg.	0.69	0.63	0.66	0.03 *
Feed Gain Ratio	3.71	4.11	3.91	0.11 **
Feed Cost per kg Gain(₦)	3.47	3.88	3.57	0.11

* = Significant at (P/0.05)

** = Significant at (P/0.01)

NS = Not significant.

acids at absorption site. This situation tends to be more serious as the level of PKM increased in the diets. Babatunde et al. (1975) and Ehle et al. (1982) observed that the reduction in the digestibility of nutrients in fibrous feeds arose from the shorter time of feed retention in the gastro-intestinal tract.

Boars had significantly ($P<0.05$) higher weight gain and lower feed to gain ratio compared to gilts even though feed intake was not significantly different for both sexes (table 5). Fast growing animals tend to lay down more muscle as component of their gain compared to show growing ones. Perhaps some of the gain put on by the gilts is composed of intracellular fat. Newell and Bowland (1972) also observed in significant difference in feed intake of male and female pigs and that boars gained significantly more weight than gilts. Hale et al. (1968) on the other hand, observed no sex difference in body weight gain of individually fed pigs.

The feed cost per kalogramme gain of pigs fed the control and 20.55% PKM diets were not significantly different. (Table 4). However, these were significantly higher ($P<0.01$) compared to those pigs fed 41.10 and 61.65% PKM diets. The feed cost is reduced as the level of PKM in the diets increases. The least cost diet is at the highest level of PKM in the diet. This feed cost of ₦3.00 per kg body weight gain compared to the current sale value of ₦7.00 per kg liveweight of pig is very entruising. With the trend in the inflationary rates , the prices of conventional feed ingredients in pig diets

Table 6: Experiment 2: The Effect of Feeding Palm Kernel Meal Diets on Carcass Quality of Finisher Pigs

Parameters[1]	Levels of PKM in Diets				Mean	S.E.	Significant Effect
	0	20.55	41.10	61.65			
Slaughter weight, kg.	85.39[a]	89.35[a]	83.08[b]	80.14[b]	84.49	2.70	*
Carcass weight, kg.	64.04[a]	65.03[a]	62.00[b]	62.38[b]	63.37	1.10	*
Dressing, %	77.12	76.35	76.38	76.45	76.58	0.72	NS
Ham, %	22.05	22.19	22.02	22.64	22.64	0.51	NS
Shoulder, %	25.02	25.49	25.64	25.11	25.82	0.72	NS
Loin, %	18.05	18.25	17.27	17.48	17.76	0.94	NS
Loin-eye area, cm^2	23.38	23.39	23.30	23.30	23.57	0.52	NS
Backfat Thickness, cm	2.55	2.68	2.61	2.60	2.61	0.22	NS
Belly, %	15.31	16.31	16.39	16.23	16.22	0.74	NS

a,b., Row means with different superscripts differ significantly

* Significant at ($P/0.05$)

NS Not significant

1 Carcass measurements expressed as % live-weight at slaughter.

Table 7: Experiment 2: The Effect of Feeding Palm Kernel Meal Diets on Organ Weights of Finisher Pigs

Parameters	Levels of PKM in Diets				Mean	S.E.	Significant Effect
	0	20.55	41.10	61.65			
Empty Stomach, g	608	683	641	663	649.19	32.43	NS
Liver, g	1408.75	1475.00	1480.00	1571.25	1483.75	69.17	NS
Lungs, g	658.50	630.00	647.50	670.00	658.13	56.09	NS
Meart, g	290.50	307.25	281.25	294.25	293.38	18.19	NS
Kidneys g	241.75	255.00	253.00	235.00	246.38	14.81	NS
Spleen, g	145.50	160.50	145.50	155.00	152.60	15.46	NS

are always on the increase. The feeding of 61.65% PKM diet to fattening pigs is highly beneficial and cost saving. In a fattening scheme designed to attain 45kg liveweight gain, the waiting period between using the control and the 61.65% PKM diets is only about 12 days. This period is equivalent to a saving of about ₦56.70 on each pig fattened. These findings are in line with those of Babatunde et al. (1975) who fed diets containing 33.0 to 46.5% PKM. They observed that it was more economical to use the higher level of PKM in finisher diets.

All the carcass measurements taken (dressing %, percentages of ham, shoulder, loin and belly, loin-eye area and backfat thickness) were not significantly different across treatments (Table 6). This might be due to the adequacy of the amino acid profile and the metabolizable energy of the control and the PKM diets. In the present trial, the limiting amino acids, lysine and methionine, in PKM and control diets appeared to meet the minimum requirement by this class of pigs (NRC, 1979). Thus the amino acids must have produced similar muscle growth and development of these pigs and hence the carcass traits measured. The result of this trial are in line with the findings by Babatunde et al. (1975) and Fetuga et al. (1977a). They fed diets containing 18.8 to 46.5% PKM to finisher pigs and observed no significant differences in the above carcass traits compared to conventional protein diets.

The weight of the organs (empty stomach, liver, lungs, heart, kidneys and spleen) were not statistically

significant (P>0.05) across treatments (Table 7). Apparently, no reasons can be aduced to for this trend. However, Jesen et al. (1976) reported that increased dietary fibre resulted in depressed liver lipid content with a decrease in liver weight. Also Bohman et al. (1953), Cunha (1977) and Pond et al. (1981) have all observed that there were increases in gut dimensions (both linear and mass) as the level of fibre increased in the diets of pigs. Such increases were not observed in the present trial.

It can be concluded from this trial that, the optimum level of PKM in finisher diets is 20.55%. The feed cost per unit gain is lowest at 61.65% PKM producing 0.58kg gain daily. This results in a saving of ₦56.70 per animal over the control and 20.55% PKM diets. This level however, lengthens the period of fattening by 12 days. The feeding of up to 61.65% PKM in the diets of finisher pigs has no adverse effect on the carcass characteristics of the pigs.

4. CHAPTER FOUR

4.1. GENERAL SUMMARY AND CONCLUSION

The results obtained from this study suggest that inclusion of palm kernel meal in swine diets is beneficial. In the diets of young pigs, 40% PKM inclusion rate has no deterimental effect on the growth rate and feed intake of the pigs. Feed cost per kilogramme gain decreases as PKM level increases in the diet. The feeding of PKM in the diets of weaner pigs is cost saving.

With finisher pigs, the results indicate that the performance characteristics of the pigs are not adversely affected by feeding low levels of PKM in the diets. The feeding of 41.10 and 61.65% PKM diets significantly depresses ($P < 0.05$) the growth rate of the pigs. The feeding of up to 61.65% PKM diet has no effect on the carcass characteristics of finisher pigs.

In conclusion, up to 40% PKM diets can be fed to young pigs. The optimum level of PKM in finisher diets is 20.55%. The feeding of up to 61.65% PKM diet to finisher pigs has no adverse effect on their carcass characteristics. The inclusion of PKM in swine diets is very economical and the competition for groundnut cake and maize in swine diets between man and swine will be reduced considerably thereby providing more food for the increasing human population.

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4.3. APPENDICES

Appendix 1
Table 8: Palm Kernel Production by Some leading world Producers (in 1,000 tonnes)

Countries	1964	1965	1966	1967	1968
Cameroun	35	38	37	38	49
Ivory Coast	15	16	17	18	21
Congo Kinshasa	110	75	80	95	105
Nigeria	408	462	435	250	225
Siera Leone	53	50	56	-	66
Indonesia	33	34	33	39	42
Malasia	31	36	44	51	63

Source: Ng. (1972).

Appendix 2:

Table 9: Proximate and Chemical Composition of Palm Kernel Meal by Various Authors

	DM	GE	DE	ME (Swine)	ME (Poultry)	MEn (Swine)	CP	CF	EE	Ash	NFE	Cellulose	NDF	NDL	Ca	P
				Kcal/g	Kcal/g	Kcal/g	%	%	%	%	%	%	%	%	%	%
NRC, 1964	93.0	-	3.20	2.88	-	-	18.5	12.0	7.1	3.9	50.5	-	-	-	0.20	0.70
Owusu-Domfeh et al.(1970)	90.81	4.28	-	-	-	-	18.62	-	1.71	4.46	38.19	37.02	-	-	0.31	0.44
Fetuga et al. (1973a)	90.43	4.42	-	-	-	-	18.70	10.30	6.74	4.22	49.61	-	-	-	0.28	0.74
Oyenuga and Fetuga(1975)	89.70	4.34	3.28	3.09	-	3.00	19.30	11.4	6.70	4.80	58.80	-	-	-	0.20	0.72
Oluyemi et al. (1976)	-	4.68	-	-	2.74	-	18.70	12.96	6.48	4.80	57.06	-	-	-	0.18	0.74
Nwokolo et al. (1977)	-	4.68	-	-	2.80	-	21.30	-	-	-	-	-	43.7	21.3	0.36	0.80
Fetuga et al. (1977a)	90.89	-	-	-	-	-	18.58	10.46	6.77	4.22	59.98	-	-	-	0.20	0.74
Onwudike (1987a)	91.20	4.37	-	-	2.65	-	19.20	11.20	7.94	5.12	47.80	-	-	-	-	-

Appendix 3:

Table 10. Amino Acid Profile of Palm Kernel Meal by various authors (g/16gN).

	1	2	3	4	5	6
Alaninine	4.2	4.30	3.92	4.60	4.05	3.96
Arginine	14.0	12.81	14.90	10.90	13.40	13.80
Aspartic Acid	8.5	8.40	9.52	7.75	8.45	8.95
Glutamic Acid	18.8	20.05	12.82	15.75	18.10	20.90
Glycine	4.8	4.67	4.91	4.15	4.55	4.81
Histidine	1.8	1.83	2.34	1.45	2.05	2.18
Isoleucine	3.6	3.27	3.28	3.10	3.00	3.25
Leucine	6.7	0.10	6.35	5.55	6.15	6.24
Lysine	3.5	3.12	3.82	2.95	3.45	3.56
Methionine	2.3	1.22	1.74	1.50	2.35	1.69
Cystine	1.9	0.90	1.44	1.00	-	-
Phenylalanine	3.8	3.84	3.87	3.65	4.10	3.88
Proline	3.8	-	3.78	3.15	2.50	3.24
Serine	4.7	4.63	5.31	3.45	4.50	4.82
Threonine	3.2	3.52	3.73	2.75	3.30	3.54
Tryptophan	1.0	-	1.14	0.85	-	-
Tyrosine	2.6	2.30	2.93	1.90	2.90	2.96
Valine	5.4	4.77	5.22	4.65	2.15	4.57

Sources:- 1) Oyenuga (1968)
2) Owusu-Domfeh et al. (1970)
3) Fetuga et al. (1973a)
4) Yeong (1983)
5) Nwckolo et al. (1977)
6) Onwudike (1987a)

Appendix 4:

Table 11. The Amino Acid Availability in Palm Kernel meal by Some Authors

Amino Acids	% Availability 1	2	3
Alanine	85.5	66.7	83.0
Arginine	93.2	87.0	92.7
Aspartic Acid	87.6	64.4	85.3
Glutamic Acid	90.1	74.4	88.6
Glycine	63.3	25.8	52.1
Histicine	90.1	66.8	88.7
Isoleucine	86.1	64.9	87.5
Leucine	88.5	66.7	90.6
Lysine	90.0	58.6	88.9
Methionine	91.4	72.1	92.1
Cystine	-	-	-
Phenylalanine	90.5	70.4	91.6
Proline	68.0	55.0	64.2
Serine	88.7	65.6	85.4
Threonine	86.5	60.7	85.3
Tryptophan	-	-	-
Tyrosine	85.0	65.7	89.9
Valine	68.4	62.8	66.7
Mean	84.4	64.4	83.3

Sources: 1) Nwokolo *et al.* (1977)
2) Yeong 1983)
3) Onudike (1987)

Appendix 5:

Table 12: Prices of feed ingredients at the time of conducting the experiments (May - December 1988).

Feed Ingredients	Price Per Kg (₦)
Maize	1.75
Groundut Cake	1.50
Soyabean meal	1.30
Palm Kernel Meal	0.50
Maize Offal	0.50
Rice Offal	0.20
Molasses	0.75
Bone Meal	0.35
Salt	1.00
Premix	3.00
Lysine	35.20
Methionine	34.00

Table 13: Experiment 1: Chemical Analyses of Diets and the Major Feed Ingredients in the Diets (% DM Basis)

Items	Levels of PKM in Diets					Maize	Groundnut cake	Palm Kernel Meal	Maize Offal	Rice Offal
	0	10	20	30	40					
Dry Matter, %	88.71	88.50	89.35	88.81	89.13	91.13	92.52	88.10	89.11	91.30
Gross Energy Kcal/g	4.10	4.18	4.19	4.20	4.34	4.43	4.81	4.69	4.09	3.76
Crude Protein, %	17.98	17.98	18.81	18.56	18.04	8.75	43.88	21.38	7.25	6.19
Crude Fibre, %	9.63	10.38	11.08	11.38	12.02	2.05	4.20	11.62	10.66	38.46
Ether Extract, %	2.28	2.38	2.80	3.50	4.06	3.06	5.50	14.33	1.26	1.79
Ash, %	5.91	6.03	5.98	6.42	6.55	6.68	4.20	4.20	1.08	1.22

Table 14 Analysed Proximate Composition of Diets and Major Feed Ingredients in the Finisher Diets (% DM Basis)

Items	Levels of PKM in Diets				Maize Offal	Full fat Soyabean	Palm Kernel Meal	Rice Offal
	0	20.55	41.10	61.65				
Gross Energy, Kcal/g	4.17	4.22	4.43	4.65	4.09	5.12	4.69	3.76
Dry Matter, %	80.40	91.04	89.35	90.71	89.11	92.57	88.10	91.30
Crude Protein %	15.83	16.61	16.50	16.85	7.25	42.75	21.38	6.19
Crude Fibre, %	11.61	12.30	12.88	14.34	10.66	5.64	11.62	38.62
Ether Extract, %	4.94	5.84	7.38	8.38	1.26	10.48*	10.33	1.79
Ash, %	4.90	5.98	6.51	6.55	6.08	6.06	4.20	1.22

* Low value is obtained here compared to the literature values of between 15 - 18%.