NUTRITIVE VALUE OF CASAVA PEEL MEAL FOR PIGS

By

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AUGUST 1995

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CERTIFICATION

This thesis titled "Nutritive Value of Cassava Peel Meal for Pigs", by Gideon Shaibu Bawa, meets the regulations governing the degree of Master of Science of Ahmadu Bello University and is approved for its contribution to Scientific Knowledge and literary presentation.

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DEDICATION

With love, I dedicate this work to my wife, Mrs Josephine O. Bawa, in recognition of her love, encouragement and care during the course of the programme.

ACKNOWLEDGEMENTS

In the course of this study, guidance, help, comments and encouragements were offered from many persons. The author therefore wishes to immensely thank Professor T.F. Balogun, his major supervisor and the Head of Animal Science department who supervised every stage of this research work and also carefully scrutinized the initial draft of this thesis. His personal commitment to the research work, guidance, constant encouragement, constructive criticisms, support, moral or otherwise is deeply appreciated. I am equally grateful to Professors A.O. Aduku and T.S.B. Tegbe, who were co-supervisors for the project. They criticised the initial draft of this thesis and refocused my thoughts. They also ensured that all materials submitted to them for corrections were given prompt attention.

The salient assistance periodically received from Prof. D.B. Olumeyan, Director of Division of Agricultural Colleges, Ahmadu Bello University, Zaria is highly appreciated. I wish to also commend other colleagues of the department for their numerous help and encouragement rendered both during and after the period of carrying out the experiment. In this regard, mention must be made of Dr. J.P. Alawa, Prof. N.I. Dim, Messrs G.N. Akpa, J.J. Omage, S.Duru, T.S. Olugbemi, M. Abdullahi, P.A. Iji, A. Audu, Mrs. F. Adeyinka and mrs. G.E. Jokthan.

My sincere gratitude goes to the technical field staff of the department of Animal Science especially Messrs Friday Oye-iwemeh and Sunday Bala for their valuable assistance in the

preparation of feeds and routine management of the experimental animals in the University Farm throughout the entire study. The assistance of Messrs E.O. Sanni, S. Adamu, A. Babangida and S.A. Adebayo in procuring some of the feed ingredients from the local markets for the study is equally appreciated. The assistance given by the Biochemistry Laboratory Staff of Animal Science Department, messrs C.O. Otuagbo, D. Ibrahim and I. Kwano in the proximate analysis of some of the feed ingredients and test diets used for the study deserves special mention. The active support and cooperation of Messrs E.N.C. Agusiobo, I. Adele, H. Ibrahim and O. Ocheche all of Animal by-product Laboratory in carcass analysis of the experimental animals is gratefully acknowledged. Warm appreciation is also due to Mr. M. Otitoju of Institute of Agricultural Research Data Processing Unit who helped with the computer and statistical analysis of the data. I am equally thankful to Miss Elizabeth Kolawole of Computer Room, College of Agriculture, Samaru, Zaria and Miss M. O. Ibilaiye who assisted with the typing and printing of the manuscript, respectively.

The support, moral or otherwise abundantly given by Mr and Mrs. S.A. Bello at the course of this programme to bring the realization of a dream come true is hereby gratefully acknowledged.

My deepest appreciation is also extended to the Ahmadu Bello University Board of Research for providing the fund that was used for the research. Lastly, but by no means the least, I wish to express my profound gratitude and appreciation to my wife, Mrs Josephine O. Bawa for her love, prayers and understanding

throughout the duration of this study. And to God Almighty who made all things beautiful in his time, I am grateful.

ABSTRACT

Determination of the peel content of cassava tuber, nutrient composition of cassava peel and four trials were conducted to evaluate the nutritive value of cassava peel meal in pig diets.

Cassava peels constitute 11 .80% of cassava tuber on dry matter basis. The rind on the other hand constitute 8.05% of cassava on dry matter basis. Results of the chemical analysis show that cassava peel contains 91.39% dry matter, 6.46% crude protein, 9.63% crude fibre, 1.13% ether extract, 7.16% ash and 75.80% Nitrogen Free Extract (NFE). The gross energy of cassava peel was 3978.65 Kcal/kg while the free hydrocyanic acid level was 140.90mg/kg.

In the first trial, Twenty (20) Cross-bred (Large white X Landrace) pigs of average initial liveweight of 9.4kg (range, 9.30 - 9.50kg) were fed diets formulated to contain 20% crude protein. Cassava peel meal was included in the diets at 0, 7.5, 15.0, 22.50 or 30% levels during a 42-day trial.

Average daily gain (ADG) and Feed/gain (F/G) values showed a gradual but non-significant decline as the level of CPM in the diet increased. Feed intake increased non-significantly as the level of CPM in the diet increased. Intake of crude fibre and HCN increased significantly with increasing level of CPM in the diet but the pigs showed no observable symptoms of cyanide toxicity. All the other parameters measured were not significant. The result favours the use of CPM in weaner pig diets upto the level of 30%.

In the second trial, which lasted for 49 days, twenty cross-bred (Large White X Landrace) pigs averaging 7.65kg (7.43 - 7.90kg)

were fed five iso-nitrogenous diet:: in which dried cassava peel meal was included at 0, 14.22, 28.44, 42.65 or 56.87 replacing 0, 25, 50, 75 and 100% respectively of maize in the control diet.

Average daily gain (ADG) and cost per kg gain differed significantly (P<0.05) across the treatments while the average daily feed intake and feed efficiency values were non-significant (P>0.05). The results showed that weaner pigs of the weight used can be fed up to 42.65% (43.0%) CPM in their diets.

In the third trial, the digestibility and retention of nitrogen of diets in which CPM replaced maize at 0, 25, 50, 75 or 100% levels, corresponding to CPM inclusion levels of 0, 14.22, 28.44, 42.65 and 56.87% respectively was studied using 10 crossbred (Large White X Landrace) boars with an average initial live weight of 36kg. Nitrogen digestibility was significantly depressed (P<0.05) as more of maize was replaced by CPM. There were no significant differences in nitrogen retention between the control and CPM diets up to 42.65% level of inclusion. However, there were significant depression in nitrogen intake and retention as the level of inclusion of CPM increased from 42.65 to 56.87% corresponding to 100% replacement of maize in the diet. The results suggest that CPM can be included in pig diets up to 42% but can not totally replace maize in the diet.

In the fourth trial, sixteen cross-bred pigs of average initial liveweight of 35.17 kg (range, 34.90 - 35.45kg) were fed 16% CP rations formulated to be isocaloric (3.13 Mcal/ME/kg) with the control diet. Cassava peel was included in the diets at levels

of 0, 19.10, 38.20 and 57.28%. This corresponds to replacement values of 0, 25, 75 and 100% for maize.

There were no significant differences in average feed intake, daily weight gain and feed/gain between treatments. There were also no significant differences in dressing percentage, backfat thickness, loin eye area and the prime cuts.

The results suggest that growing-finishing pigs of the weight used in this study can tolerate up to 57% level of inclusion of CPM in their diets, corresponding to 100% replacitent of maize by CPM, if the diets are formulated to be iso-nitrogenous and isocaloric with an all-maize based control diets.

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CHAPTER ONE

1.0.0 GENERAL INTRODUCTION

In Nigeria, the single most important factor militating against rapid development of the swine industry has been the increasing unavailability and consequent high cost of the conventional feeds. This has threatened the potential for increasing animal protein production which is in short supply.

In economic terms, feed cost accounts for 75 to 80 percent of the total cost of pig production in the meat herd and 60 - 65 percent in the breeding herd (Cunha, 1977, Thorton, 1978). Similarly, Sastry and Thomas (1976), documented that feed cost stands at about 67.2%, fixed cost 17.2% and other variable costs 15.6% of pig production. It is therefore imperative to find alternative and cheaper ingredients for compounding swine rations.

In swine nutrition, energy is used for provision of body heat, maintenance, growth, production and reproduction. Cereal grains such as maize, sorghum, millet and to a limited extent wheat have remained the major energy sources in diets for pigs. They are high in starch which can readily be digested by pigs but relatively low in protein and deficient in amino acids such as lysine, methionine and tryptophan. Their mineral content, notably sodium, calcium and available phosphorus is also very low. Among the cereal grains that are produced in Nigeria, maize is the most common and the major ingredient contributing about 60-80% of the total diet for pigs. In the past, most of the maize used by the feed millers was imported. The economy was still buoyant enough to sustain the importation of maize and other feed ingredients. The decision of

the Federal Government in 1984 to ban the importation of maize which was precipitated by slump in crude oil sales in the early 1980s, low foreign exchange earnings and huge external debts is widely viewed as a hinderance to the growth of the industry. Furthermore, the low level of local production of maize coupled with the effect of the ban on importation of temperate cereal grains, such as wheat and barley in 1986 has resulted in a build up of excess demand for maize, both as food and raw materials for industries like feedmills, breweries flour mills and confectionaries. This high demand for maize has resulted in the current prohibitive prices of maize leading to an unprecedented increase in the cost of pig feeds. Cognisant of this high demand for grains for human and industrial uses, Fetuga and Tewe (1985), expressed fear on the possibility of having surpluses from cereals for livestock production to meet up the protein requirement of the Nigerian populace. Reid (1970) had earlier predicted that by the year 2000 AD, there would be insufficient grains for all forms of livestock production. In view of the foregoing, the use of local by-products that are not consumed by man, available in large quantities all the year round and obtainable at the cheapest cost to substitute for the scarce grains especially maize in pig diets has been the subject of cost oriented studies by nutritionists over the years. Many workers have emphasized the need for exploitation of the agro-industrial by-products in an attempt to cut down the sky-rocketing cost of pig production especially in developing countries where such by-products abound (Babatunde and Fetuga, 1973; Devendra and Raghavan, 1978; Adebowale, 1985; Fetuga and

Tewe, 1985 and Tegbe, 1985). Cassava peel, a waste product is one of such non-conventional feed sources that could be used to replace maize as source of energy for swine diets.

Cassava peel is the skin/cortex of cassava tuber that represents a major waste during the processing of cassava root for human and animal feeding (Okeke *et al.*, 1988). it constitutes about 10-13% of the tuber by weight. It is richer in crude protein than the edible portion and is generally thrown away as waste (Oyenuga, 1968 and Adebowale, 1985). With the steady rise in the amount of the cassava tubers peeled for human and livestock consumption, industrial starch production, for making biscuits, beer, industrial alcohol and glucose, the quantity of cassava peels available for use in replacing maize as source of energy is increasing. The fact that at present these peels constitute a waste to the local cassava processing industries and do not form regular sources of dietary nutrients to man indicate that there might be considerable cost advantages if these could be used to replace sizeable portion of the grain component of the swine diet. Their utilization will also offer an opportunity of changing a potential source of pollution into a valuable resource.

Despite the enormous potential of cassava peel as a source of energy in swine diets in Nigeria, it has been relegated to the background. Although, there are some documented research findings pertaining to the suitability of cassava peel as an alternative source of energy (Obioha and Anikwe, 1982; Obioha et al, 1985) these are yet to be adopted on a commercial scale in many countries. Therefore, to renew interest in this subject, this

study was aimed at:

i. investigating the utilization of cassava peel as an alternative source of energy for various classes of pigs

ii. investigating the replacement value of cassava peels for maize and the effect of such replacement on performance characteristics of pigs.

iii. evaluating the economic potentials of replacing maize grain with cassava peel.

iv. investigating the effect of supplementation of CPM based diets with palm oil on performance and carcass characteristics of grower - finisher pigs.

CHAPTER TWO

2.0.0 LITERATURE REVIEW

Cassava (*Manihot esculenta*) accounts for about half of the root crop production in the tropics and it is also the root crop most familiar to many indigenous communities in Nigeria where it plays a prominent role in their daily culture and subsistence (Oyenuga and Amazigo, 1957). It is essentially a calorie-yielding food, capable of providing a higher yield of energy per ha when compared to maize or sorghum (Oyenuga, 1961). The 1968 world yields in 100kg per hectare for maize, millet and sorghum, and cassava were 23.7, 7.7 and 87.0 respectively (Appendix 1).

It has a high potential for being used as a source of energy to replace maize in animal feed since its production is not seasonal. FAO (1975) projected that increases in livestock production in tropical countries would depend to a greater extent on cassava production because among the other root crops, it has the greatest potential as a major world crop. Inspite of this optimism, the present high demand for cassava as a staple food by man even in areas where the cultivation of the crop is not favoured has made it unprofitable to use cassava root meal as a substitute for maize in intensive animal production. Bolton (1971) opined that where the amount of food available to the human is limited, it would be morally wrong to use acceptable human food for feeding animals.

During the process of making grated cassava meal (garri) and cassava flour for human consumption, a considerable portion of the

tuber is discarded. These include the small sized tubers which are difficult to process, the shaft obtained from the pulp after shredding as well as the peel which accounts for between 10 and 13% of the tuber by weight (Tewe *et al.* 1976). The search for an alternative source of energy to replace maize instead of the cassava flour mill brought cassava peels into focus. There is however, limited evidence in the literature that indicates the use of peels in the feeding of livestock and poultry species at certain levels of recommendation with satisfactory performance (Larsen and Amaning-Kwarteng 1976; Aregheore and Oluokun, 1989, Obioha *et al.* 1984; Obioha *et al.* 1985 and Aduku *et al.* 1991).

2.1.0 Nutritive Value of Cassava Peel

The nutritive value of any feedstuff is determined by its chemical composition in terms of dry matter, energy, protein, fibre, vitamins and minerals. Samples from the same feedstuff may have variation in their chemical compositions (Crampton and Harris, 1969). The chemical composition of cassava peel varies greatly with a number of factors important amongst which are the variety of the cassava, the type of soil on which the cassava was grown, method of processing, depth of edible pulp removed with the peel when knife is used and the accuracy and method of laboratory analysis (Oyenuga and Amazigo, 1975: Adegbola and Asaolu 1986).

Devendra (1977) reported lower nitrogen levels, higher fibre and higher soluble carbohydrates when the sweet variety of cassava was used whereas the work of Adegbola and Asaolu (1986) indicated moderate level of nitrogen, low fibre and high soluble

carbohydrates with the bitter varieties. These authors also noted that drying of cassava peel substantially increased the dry matter and ash contents with little effect on the crude protein and ether extract. A general statement on the composition of cassava peels is therefore difficult.

The nutrient composition of cassava peels from various sources is summarized in Appendix 2.

When compared with the conventional energy sources such as the cereal grains, the protein level of cassava peel is lower. Reports in the literature indicate that the crude protein content of cassava peel ranges between 5.0 and 6.8% while for maize and sorghum, the crude protein ranges from 8.0 to 11.0% and 11.0 to 13.5% respectively (Oyenuga 1968; NRC, 1979; Adebowale, 1985; Adegbola and Asaolu, 1986). Like most roots and tubers, peels of cassava root are much richer in crude protein than the edible portion (pulp). While the crude protein content of the peels ranges between 5.0 to 6.8%; that of the edible portion (pulp) ranges from 1.7 to 2.58% (Oyenuga, 1968; Devendra, 1977; Omole, 1977). When compared with yam, cocoyam, plantain and banana peels with 7.85%, 9.4%, 8.7% and 7.87% CP respectively, the crude protein level of cassava and peel is slightly lower (Oyenuga, 1968; Adebowale, 1985).

Information on the amino acid profile of cassava peels is limited. There is however, an indication from the available literature that the little protein contained in cassava peels is not only low in essential amino acids but is also deficient in the sulphur amino acids (Adegbola, 1977; Oke, 1984). Among the sulphur

amino acids, methionine is the most critical in a cassava peel-based diet and its deficiency is bound to affect the overall utilization of dietary protein either by pigs or poultry (Maner and Gomez, 1973; Job, 1975). Lysine is probably the second limiting amino acid (Oke, 1984).

Cassava peel has been described by Eshiett and Ademosun (1981) as a bulky, low energy feeding stuff. When compared with the cereal grains, the energy level of cassava peel is lower. From available literature, the energy level of cassava peel ranges from 2,030 to 2460 Kcal metabolizable energy (ME) per Kg DM, whereas for maize, sorghum and cassava flour, the energy content ranges from 3300 to 4310 Kcal ME per kg of dry matter (Oyenuga, 1968; Montila 1977 and NRC, 1979). Aduku *et al.* 1991 reported a low caloric value of 8.52 MJ/kg for cassava peels and that its inclusion at a high level in broiler diets will result in a corresponding decrease in the metabolizable energy of the diet.

Most reports evaluate the utilization of cassava peels with respect to fibre content. The crude fibre content of cassava peels ranges from 9.3 to 21.1% (Devendra, 1977; Osei and Duodu, 1988). Oyenuga (1968) and Fetuga and Tewe (1985) have also acknowledged the high fibre nature of cassava peels. They pointed out that the high crude fibre content of the peels limits their level of inclusion in monogastric rations. They concluded that cassava peel is best suited for ruminants which can handle high fibre and low energy feed better than the monogastrics. However, the results of Sonaiya and Omole (1978), Obioha *et al.* 1984 and Aduku *et al.* 1991 have shown that cassava peels can be used to advantage in non-

ruminant feeding despite the high fibre content provided the diet is supplemented with sulphur amino acids.

Oyenuga (1968) and Adegbola and Asaolu (1986) have indicated that cassava peel is fairly high in ash content and that the level of the ash substantially increases with the drying of the peels. Most workers reported a range of 5.93 to 7.90 (Oyenuga, 1968; Adebowale, 1985; Tewe and Kasali 1986; Osie and Duodu, 1988).

2.2.0 METHODS OF IMPROVING CASSAVA PEEL UTILIZATION

Inspite of the potential of cassava peel as a cheap source of energy in livestock diets, there are limitations to its usage especially in monogastric diets. According to Fetuga and Tewe (1985), Adebowale (1985) and Oke (1978) high level of hydrocyanic acid (HCN), low protein value, amino acid imbalance, high fibre content, low palatability and the physical form of the cassava peels are some of the factors militating against the efficient utilization of cassava peels in livestock rations. It is necessary therefore to improve the quality and the physical form of cassava peels if higher levels of inclusion in swine diets are desired.

Several methods of improving cassava peel utilization in swine diets have been identified. Most of these methods are centered mainly on ways of detoxifying the HCN contained in cassava peels and improving the nutritive value. Detoxification is a broad term that denotes any method or process whereby cyanide is removed from its precussors (the glucoside) in cyanogens or in bound forms in the body in any convenient way as to limit its toxicity in the body of the animals.

2.2.1 Sun drying

Sundrying of cassava peel has been described by most workers to be the most practical and effective method of removing both the HCN and glucosides contained in fresh cassava peels. Razafimahery (1953) indicated that about two-thirds of the HCN present in cassava was lost during sundrying for 7 days. About 80% of the cyanide contained in cassava peels have been reported to be lost during slow sundrying process (Akinrele, 1964). Cooke and Maduagwu (1978) opined that greater losses of HCN occured on sundrying presumably because of the longer drying time at moisture contents and temperatures at which endogenous linamarase is active. Aduku *et al*. 1991 concluded that HCN toxicity may not be the problem of well cured (sun-dried) cassava peelmeal as the HCN level after sundrying is far below the toxic levels. This view was in support of an earlier work by Sonaiya and Omole (1978).

Fast drying at higher temperatures has been proved to be less efficient in removal of HCN (Adegbola and Asaolu, 1986). During sundrying of cassava slices, Maduagwu and Adewale (1980) reported a progressive loss of HCN, most of it within the first 8hrs during which time 46-85% free and 69-74% bound cyanide disappeared from the "sweet" cultivar. They suggested that these losses could be due to optimal hydrolytic activity of the B-glucoside linamarase.

Maner (1972) indicated that crushing or chopping followed by sundrying for several days reduce the HCN level from 150 mg/Kg to 5mg/kg. Hot air drying removes free HCN and destroys the enzyme but leaves the glucosides largely intact (Creswell, 1978). Cooke and Maduagwu (1978) indicated that 29% of the bound cyanide was

removed by air-drying at 46.5°C whereas smaller losses were recorded at higher temperatures. It has also been observed that sundrying and heat treatment or preferably combination of both virtually eliminates HCN (Normanha, 1956; Larsen and Amaning-Kwarteng, 1976; Oke, 1984).

2.2.2 Fermentation

Fermentation of cassava peels has been found to remove considerable amount of cyanide and hence improve its utilization (Eka, 1986). When compared to the sun-drying and oven drying methods of processing, Tewe and Kasali (1986) pointed out that fermentation of the peels seemed to considerably reduce the HCN content than any of the two methods of processing. Maduagwu and Adewale (1980) observed that 50% of the bound cyanide in cassava peels can be removed through fermentation after 18 hours. This was in support of earlier reports of Akinrele (1964) and Oke (1965) who observed the spontaneous hydrolysis of cyanogenic glucosides into the HCN and thus detoxification during fermentation.

When discarded small tubers and cassava peels were crushed and fermented for about a week and sundried, Fetuga and Tewe (1985) reported that the hydrocyanic acid content of the peels were considerably reduced. The resultant dried meal was also less dusty than cassava flour.

2.3.2 Boiling of cassava peel

Boiling of cassava peel is another method of improving cassava peel utilization. Eka (1986) indicated that boiling destroys the

enzyme rhodenase as well as dissolving and removing the free cyanide. It was further observed that boiling of raw cassava peels for 30 minutes resulted in the elimination of about 65-85% of the HCN content.

Maner (1972) reported that boiling of cassava roots in water for 15 minutes reduced the level of cyanide from 60 to 15mg/kg while boiling for 30 minutes eliminated the cyanide entirely. The work of Maduagwu and Adewale (1980) also indicated that boiling of cassava chips for 25 minutes was enough to leach about 55% of the cyanide into the cooking water thus making it safe for consumption.

2.2.4 Ensiling

Ensiling of cassava peels has been reported as one of the ways of reducing the hydrocyanic acid levels to safe limits for animal feeding (Fetuga and Tewe, 1985). These authors also indicated that ensiling of the peels with the leaves will increase the crude protein content and that the heat produced during the process of ensiling, helps in breaking down the fibrous components of the peels and leaves.

A comparison of various methods of processing cassava peels by Okeke *et al.* 1988 has shown that a very toxic cassava peel with 1061mg/kg cyanide can be reduced to safe levels in monogastric feeds by either ensiling for 3 days, boiling for 7 minutes, roasting for 30 minutes, soaking for 15 hours or air drying for 3 days.

Adegbola and Asaolu (1986) suggested that in order to make good silage from cassava peels with the aim of improving its

utilization in swine diets, care must be taken to ensure good compaction and adequate drainage and to prevent rapid oxidation or the formation of organic acids after ensiling.

2.2.5 Pelleting

Pelleting of feed is practiced in animal feeding to improve the physical characteristics of the feed. It consists of mechanical pressing of ground feeds or mash into hard pellets. The advantages of pelleting feed as reported by Ensminger (1961) include:

a. Increasing the palatability of the diet
b. Alleviating high wastage of relatively unpalatable feeds.
c. Preventing the animal from selectively wasting ingredients likely to be high in certain dietary essentials and
d. Reducing the required storage space as the bulk of the feed is reduced by compression.

Cassava peel meal is powdery, dry, lose and bulky. Pelleting is therefore needed to reduce bulk and improve the nutrient density of the feed. Maner *et al* (1967) and Montilla (1977) pointed out that diets with high proportion of cassava peel meal were less consumed by non-ruminants due to their dry, lose, texture, powdery and bulky characteristics. Oke (1978) suggested that pelleting of cassava-based rations would result in maximum efficiency in the performance of chickens. His arguement was based on the fact that dustiness of cassava based rations would cause irritation of the respiratory tract and hence lower feed intake. Aduku *et al.* (1991) also indicated that the physical characteristics of cassava peels

may account for the decrease in the amount of feed consumed with the corresponding increase in the level of cassava peels in broiler diets.

Vogt and Penner (1963) obtained better results when cassava root meal was pelleted to arrest the excessively fine nature of the flour. Apart from reducing the problem of dustiness, the heat generated by steam treatment and high pressure during pelleting could release the cellulose from the lignin-cellulose bonds, thereby increasing the digestibility of starch and fibre (Fetuga and Tewe, 1985). Muller *et al*. (1974) pointed out that pelleting will also destroy some growth inhibitors of microbial origin (moulds, fungi and other contaminants during sun drying and storage) and probably destroy part of the glucosides as well. Pelleting of the peels may also result in increase in nutrient density, hence improving its nutritive value and digestibility of essential nutrients (Gerpacio, 1979). Nestel and Graham (1977) however pointed out that when pelleting, care must be taken to prevent the promotion of maillard reaction (Caramelization).

2.2.6 Palm oil supplementation

Palm oil has been found to play an important role in influencing the use of cassava-based diets. Olarewaju and Boszormenyi (1975) noted that commercial garri fried with palm oil contain a smaller amount of cyanide when compared to white garri that was fried without palm oil. Oke (1978)indicated that vegetable oils especially palm oil seem to be better supplements in cassava based diets than animal fat probably because of their

digestibility and metabolizable energy content.

Fomuyan *et al.* (1981) reported that the rate of hydrolysis of the cyanogenic glucosides in cassava to produce the poisonous hydrogen cyanide is greatly reduced with palm oil. They suggested that it might be necessary to feed higher levels of palm oil in order for the animals to tolerate higher levels of cassava peels as the delay in decomposition of the cassava based diets supplemented with palm oil may prevent the absorption of the cyanogenic glucoside. Improved palatability, better absorption or retention of other nutrients and reduction in the dusty nature of the cassava peel based diet has also been ascribed to the presence of palm oil in such diets.

Hutagalung (1977) reported improved live weight gains when pigs fed cassava-based diets had supplementary palm oil in their diet. The improved performance of the animals was attributed to increased energy intake of the animal due to supplementation with palm oil.

Shimada *et al.* (1971) observed that 3% palm oil was found to improve weight gain and feed conversion efficiency of pigs whether in the presence or absence of methionine especially at higher levels of cassava. Hew and Hutagalung (1972) found that a combination of oil and molasses or sugar gave better results compared to oil alone. Eshiett (1976) used 0-45% cassava with constant lysine (1.15%) and sulphur amino acid (0.77%) in chick diets. With no provision for cyanide detoxification the control diet promoted significantly faster gain and efficiency of conversion than the higher levels. However, when palm oil was

added to the ration, the rate of gain in all the treatments was similar and there was no significant differences in the amount of feed consumed and the efficiency with which the feed was utilized from 6–12 weeks of age. Omole and Onwudike (1983) carried out two trials to find out the effect of palm oil on the utilization of cassava peel meal by rabbits. The first trial consisted of six experimental diets containing 0, 10, 20, 30, 40 or 50% levels of cassava peel meal without palm oil supplementation. In the second trial, 5% of the corn fraction of each ration used in the first trial was replaced by substituting with palm oil. The results showed that without palm oil, there was a significant reduction in the rate of gain of rabbits when a level of 30% CPM was exceeded. With palm oil supplementation, the reduction in rate of gain and feed efficiency with increasing levels of cassava peels were less pronounced than with the unsupplemented diets. Without palm oil, feed intake dropped significantly above the 40% level of cassava peel, whereas with the supplemented diets, feed intake was significantly affected even with upto 50% of cassava peel. They concluded that palm oil supplementation allowed for a higher level of removal of cyanide from the animal's body than when no palm oil was used.

2.2.7 Methionine supplementation

A report from CIAT (1975) indicated that in order to detoxify the cyanide ion, it is necessary to have a dietary source of sulphur that will permit the conversion of cyanides into thiocyanates (–CN + S ------> – SCN) which will be excreted

through urine. This implies that the success of using cassava peel as a substitute for maize in swine diets will depend largely on supplementing the diet with an excellent source of sulphur, such as sulphur amino acids like methionine or cystine to serve as a readily available source of sulphur for cyanide detoxification and improving the quality of the dietary protein. Olson *et al.* (1969) pointed out that methionine seems to be more effective than cysteine. They observed that a chick diet (containing cassava) supplemented with 0.2% methionine was as good as diets supplemented with 0.4 or 0.8% cysteine. Maner and Gomez (1973) and Adegbola (1977) have suggested the use of crystalline DL-methionine as compared to other sulphur amino acids in cassava based diets. Hew and Hutagalung (1972) found that the growth depression observed in swine when cassava levels were increased in the feed could be corrected by supplementation with 0.2% methionine. A significant increase in growth rate was obtained with the cassava level as 50%. Maner and Gomez (1973) observed an increase in urinary thiocyanate in pigs fed methionine supplemented cassava based diets.

In order to assess the efficiency of several sulphur compounds, Job (1975) carried out a trial with growing pigs fed diets based on bitter cassava meal (70%) supplemented with methionine (.02%), sodium thiosulphate (0.79%) or elemental sulphur (0.2%). Supplementation with methionine gave the highest weight gain with a daily feed intake similar to that of the control. The other two sources of sulphur gave slightly lower weight gains but the feed conversion efficiency for pigs in the diet supplemented with elemental sulphur was similar to those supplemented with

methionine. It was concluded that the need for additional methionine for the purpose of detoxification can be met by the addition of other sulphur-donating compounds to the diet, although these cannot replace methionine in a diet normally deficient in the amino acid.

The high cost of supplementation particularly in the developing countries where crystalline DL-methionine is not always readily available but has to be imported may be a serious constraint to the use of DL-methionine as a source of sulphur amino acid in cassava peel based diets for swine. In such countries, Adegbola (1977) suggested that it might be cheaper to use thioshulphate, elemental sulphur or in some cases feed of high protein in the diet. Babatunde *et al.* (1976) concluded that in the Nigerian situation a high protein diet unsupplemented with methionine was more economical to feed to broilers than methionine supplemented low protein diets.

Maner *et al.* (1967) were able to use a mixture of soyabean and cottonseed meals to obtain satisfactory daily feed consumption, weight gain and feed conversion efficiency of pigs fed fresh cassava without methionine supplementation. Job (1975) found no need for supplementing a 70% cassava based diet with additional methionine, thiosulphate or elemental sulphur. Aduku *et al.* (1991) fed sesame seed which is fairly rich in methionine and soyabean (full-fat) which is low in methionine but high in lysine without DL-methionine supplementation. They reported satisfactory feed intake, feed efficiency, and weight gain even at the highest level of inclusion of cassava peel meal (37.5%) in corn-soy based diets

for broilers. No ill-health due to dietary effect was observed.

Tegbe *et al.* (1992) stated that with good manipulation of the feed ingredients, the need for synthetic amino acids can be eliminated in cassava peel meal diets and cheaper diets can be formulated for pigs. They reported that when a mixture of full-fat soyabean (boiled) and palm kernel meal (a good source of methionine) was used as sources of protein without DL--methionine supplementation, satisfactory feed intake, weight gain and feed efficiency was observed with cassava peel meal replacing up to 75% of the maize in the diet of growing pigs.

2.3.0 CASSAVA PEAL MEAL IN RABBIT/RAT DIETS

Okeke *et al.* (1986) in a trial to study the replacement value of cassava peels for maize in the diet of growing rabbits, fed forty-eight Newzealand White rabbits of average weight of 779g diet containing no cassava peel meal (Control diet) or with sundried cassava peel meal at 15, 30 or 45% or ensiled cassava peel meal at 15, 30 or 45% replacing maize. It was observed that ensiled peel meal at up to 30% or sundried peel meal at 15% increased liveweight gain compared with the controls. With sundried peel meal at more than 30% feed intake was adversely affected and serum concentrations of thiocyanide, liver weight and liver fat were also affected. It was concluded that sundried peel meal can be included at up to 15% and the ensiled peel meal at upto 30% without adverse effects on the performance of the animals. No gross or histological lesions was observed in the tissue of any of the test rabbits.

In order to study the effect of cassava peel processing on the performance, nutrient utilization and physiopathology of the African giant rat *(Cricetomys gambianus*, Water house), Tewe and Kasali (1986) fed weaning giant rats with four diets containing 31.12% of either maize (control diet) or processed cassava peel. The peel was sundried, oven dried or fermented. It was observed that performance was best on the control diet and poorest with the diet containing oven dried cassava peel meal. There were no gross or histological lesions in the tissues in any of the test rabbits.

2.4.0 CASSAVA PEEL MEAL IN POULTRY DIETS

Several investigators have reported successful use of diets containing 15 to 30% levels of cassava peel meal in trials with poultry (Pido and Adeyanju 1978; Longe and Oluyemi, 1977; Eshiett and Ademosun, 1981; Tewe, 1981; Tewe, 1984; Obioha *et al.* 1984; Osei and Duodu, 1988; Osei, 1989; Aduku *et al.* 1991; Sekoni, 1991; Agwunobi, 1991).

Pido and Adeyanju (1978) reported that when one hundred and twenty eight 7 day-old broiler chicks were given a diet based on maize and groundnut meal with fermented cassava peel at 0, 10, 20, or 30% for 9 weeks. The mean daily gain was 29.37, 26.18, 28.81 and 28.36g respectively. Feed intake was observed to be less on the diets with 10 and 20% cassava peel and greater on that with 30% than that on the control diet. It was concluded that inclusion of cassava peels at up to a level of 20% in broiler diets will promote satisfactory biological productivity.

Osei and Duodu (1988) conducted a 7-week feeding trial to

study the nutritive value of sundried cassava peel meal (CPM) using 480 day-old broiler chicks. The cassava peel meal was incorporated at 5, 10 or 15% of the diet. It was observed that feed consumption significantly ($P<0.05$) increased with the addition of sundried cassava peel meal. It was pointed out that as cassava peel (a lower energy material) replaced maize (an energy concentrate) in the rations, the metabolizable energy correspondingly decreased with increase in cassava peel meal level. Consequently, birds on the lower energy diets consumed more in an attempt to cancel out the energy deficit. Liveweights were significantly improved by the 5% CPM diet above the result of the control diet and those for the 10% or the 15% CPM diet. Feed conversion efficiency (FCE) significantly deteriorated when more than 5% CPM was incorporated into the diets. It was also observed that feeding cassava peel meal apparently had no influence on carcass quality parameters including dressing percentage (75-76%) and the weights of offals. An earlier report by Pido and Adeyanju (1978) indicated that feeding of fermented cassava peel meal had no significant effects on liveweights or carcass yield.

In another study, Osei (1989) investigated the effect on broilers of incorporating various levels of cassava peel meal (0, 5, 10, 15 and 20%) in their diets. It was observed that inclusion of cassava peel meal (CPM) in broiler diets did not significantly influence feed consumption but the conversion of feed to weight gain was significantly impaired by increasing levels of CPM. Birds fed the control diet (0% CPM) had a feed conversion efficiency of 2.59 compared with 2.72, 2.67, 2.92 and 3.10 for birds on 5, 10, 15

and 20 percent CPM diets respectively. Similarly, body weight and liveweight gains were significantly depressed by the addition of cassava peel meal.

The work of Aduku *et al.* (1991) showed that cassava peel meal can be fed at up to 15% level in maize-soyabean practical diets for broilers. It was pointed out that the bulky nature of the CPM limits feed consumption to meet energy requirements of broilers at higher levels of CPM above 15%. They indicated that the cyanide content of the diets used for the study was low enough not to be the major problem of cassava peel meal even at higher levels of inclusion (37.5%).

In order to determine the effect of feeding cassava peels to growing pullets on their subsequent laying performance, Eshiett and Ademosun (1981) fed 120 eight week-old B-Hyline commercial hybrid pullets with three isonitrogenous diets containing 0, 10 or 20% CPM for twelve weeks. At 20 weeks of age all the the birds were transfered to a standard layer mash containing no cassava peel meal. It was observed that during the growing stage, birds receiving the control diet consumed less feed and were more efficient in feed utilization than the other birds. There was no difference between the other two treatments in their efficiency of feed conversion and feed intake. The rate of body weight gain was similar in all treatments. During the laying phase, they reported that the attainment of sexual maturity, feed consumption, egg production, efficiency of feed conversion and egg weight were not significantly affected by the level of CPM fed during the growing phase. The carcass quality of the birds at the termination of the

experiment was similar for all the treatments. It was concluded that the inclusion of up to 20% CPM in growing diets for pullets had no carry-over toxic effect that would affect the subsequent laying performance of the birds.

Sekoni (1991) fed five levels of CPM (0, 10, 20, 30 and 40%) in the diets of laying birds. The result of the study indicated that the performance of the birds fed 20% CPM diet was comparable to those fed the control diet in terms of total number of eggs, % hen-day egg production and feed per dozen eggs. Average daily feed intake, egg weight and thiocyanate level of the serum were not significantly affected by dietary treatments. It was concluded that CPM can be incorporated into layer diet at up to 20% level with no adverse effect on the performance of the birds.

2.5.0 UTILIZATION OF CASSAVA PEEL IN RUMINANT DIETS

Oyenuga (1968) indicated that cassava peels are valuable waste product which could be used to feed sheep, goats and cattle in areas of high cassava production. He encouraged the use of cassava varieties that are low in prussic acid to feed ruminants. Adegbola and Asaolu (1986) observed that villages with substantial numbers of small ruminants situated near garri processing plants where cassava peel are surplus, have experienced a boom in sheep and goat production especially where adequate browse is available. Pereira (1987) pointed out that cassava peels could be used as energy source in cattle diets provided they are adequately supplemented with protein sources. Adebowale (1981) reported that the optimal level of cassava peels in the concentrate supplements of ruminants

is 20%, regardless of whether protein of animal or plant origin or non-protein nitrogen (NPN) source like urea is included. Incorporating 40% cassava peels in the diet of the West African Dwarf sheep with 0.5% dietary sulphur or 5% palm oil resulted in improved growth performance by about 30% (Tewe, 1981). In another trial, Aregheore and Oluokun (1989) used forty-eight ewe lambs (Permer X West African Dwarf) to investigate the effects of different levels of cassava peels on concentrate coefficients of some carbohydrate components. They observed that, daily dry matter intake of concentrate decreased with increase in the level of cassava peels and daily liveweight gain was highly depressed at higher levels of cassava peels. They also reported that dry matter, crude protein and crude fibre digestibilities progressively improved with increase in level of cassava peel. However, cellulose, hemicellulose and gross energy digestibilities decreased linearly at higher levels of cassava peels.

Larsen and Amaning-Kwarteng (1976) used cross-bred bullocks in 3 groups of 6 to evaluate the effect of sundried, or ensiled cassava peels with urea and molasses as supplement for grazing cattle during the dry season in Ghana. The control groups had only normal grazing and the other groups got dried or ensiled peel to provide dry matter of an average of 0.7kg/100kg liveweight each morning before grazing. It was observed that the average daily gains in 25 weeks were 0.07kg without supplement and 0.29 and 0.33kg with dried and ensiled peel. They concluded that toxicity of fresh cassava peel due to hydrocyanic acid may be eliminated by ensiling or by sundrying and that inclusion of cassava peels as

supplements to grazing cattle especially during the dry season period will result in increase in liveweight of the animals.

2.6.0 CASSAVA PEEL MEAL IN SWINE DIET

2.6.1 Effect of cassava peel meal on performance of pigs

Penuliar (1940) observed that cassava refuse meal was superior to rice bran as feed for growing and fattening pigs. He reported an increase from 50 to 75% in the efficiency of feed conversion and 45 to 60% in efficiency of weight gain of cassava refuse meal as compared with rice bran as the pig grew older.

In finishing pigs, Sonaiya and Omole (1977) fed 0, 5, 10 or 15% cassava peels in diets and observed that all the cassava peel meal diets were more efficient and promoted faster growth rate in pigs than the control diet. A 10% cassava peel meal diet induced the fastest rate of gain and highest feed conversion efficiency. They reported that high levels of cassava peel in the finishing rations of pigs produced slower rates of gain. This is probably due to the fibrous nature of the cassava peel meal. The work of Maust *et al.* (1972) and Ademosun (1977) have shown depressed growth rate and feed efficiency when fibrous feedstuffs were added to the diet of pigs.

In another study, graded levels of cassava peel meal (10, 20 and 30%) were fed in diets of growing-finishing pigs by Manikam and Gopalkrishman (1978). It was observed that total weight gain, daily weight gain and feed efficiency were almost equal up to the

20% level, but at 30%, performance was poor. They concluded that the most economic level of production based on their work was at 20% CPM in the diet.

In feeding trials with growing pigs, Tewe and Oke (1983) evaluated cassava peel meal as a possible source of energy in a 20% protein basal corn-soy diet. They observed an increase in feed intake with higher dietary cassava peel level. Body weight gain was highest on the control diet (0% CPM) and least on the CPM diet. Feed efficiency and protein efficiency ratio were observed to be poorer on diets containing cassava peel. In contrast to Tewe and Oke (1983), Sonaiya and Omole (1983) observed that growing pigs receiving diets containing cassava meal or cassava peel meal, grew slightly but non-significantly faster and were slightly more efficient in feed conversion than pigs on the control diet. Obioha and Anikwe (1982) included up to 15% level of cassava peel in diets for growing pigs and obtained good daily gain, feed intake and digestible energy when compared to those diets with 0, 5, and 10% levels of inclusion. Taylor *et al.* (1987) reported no loss in performance of growing pigs with cassava peels upto 300g/kg diet, daily feed intake and weight gain, however, decreased with increase in the level of cassava peel. Tewe (1984) reported that 30% cassava peels in diets for growing pigs decreased white blood cell count but this was corrected with 15% fish meal and 20% soyabean meal.

Tewe and Pessu (1982) evaluated the performance and nutrient utilization by growing pigs fed cassava peel diets containing different cyanide levels. The pigs were alloted to three treatment

groups which were, a maize-based control ration, cassava peel-based ration and a cassava peel + dietary KCN ration. The three diets contained 0, 96 and 400ppm cyanide levels respectively. Feed intake and growth rate were non-significantly reduced on the cassava peel-based diet. The feed efficiency and protein efficiency ratio on the cassava peel-based rations compared favourably with the control. They concluded that performance traits were negatively correlated with dietary cyanide level.

Nestel and MaCintyre (1973) pointed out that pigs fed large amounts of cassava peel meal may show slight growth depression which could be overcome by supplements of methionine or good protein. Sonaiya and Omole (1982) in experiments to study the inclusion of 15% + 15% CPM, 30% CM + 15% CPM, 15% CM + 20% CPM and 30% CM + 20% CPM in finishing diets of Large White and local pigs observed that finishing pigs on CM + CPM diets had slightly but non-significant depressed growth rate and feed efficiency when compared to the control ration that had no cassava meal and cassava peel meal. They pointed out that a combination of 15% CM + 20% CPM was consistently but nonsignificantly superior to other substituted diets. The Large White pigs used for the experiment were observed to utilize CM better than local breeds while they observed that gilts made use of both CM and CPM better than barrows at higher levels of substitution.

2.6.2 Effect of Cassava Peels on Carcass Characteristics of Pigs

Excess trimmable fat in pork is undesirable because of the problem of acceptability by consumers (Cunha, 1977). The present

trend in swine production, among other things is therefore geared towards production of lean meat which is more acceptable to pork consumers. Restricting dietary energy intake and increasing the level of fibre in swine diets are some of the ways of improving carcass quality of pigs. Eshiett and Ademosun (1981) have indicated that cassava peel is a fibrous, low energy feeding stuff and that its inclusion in swine diets as replacement for a high energy feed ingredient such as maize may improve carcass quality.

Sonaiya and Omole (1977) incorporated sundried cassava peels into finishing rations of local pigs at 0, 5, 10 and 15% levels. They observed that 15% cassava peel meal diet produced superior carcass characteristics. It was further observed that high levels of cassava peels in finishing rations of pigs produced slower rates of gain but better quality carcass in terms of backfat thickness, percent lean cuts, loin eye area, percent fat on loin than lower levels or 0% cassava peel meal.

Tewe and Oke (1983) reported that when 24 weaning Large white X Landrace race pigs were given diets based on maize and groundnut meal without or with 10, 20 or 30% cassava peel, significant differences were obtained in dressing percent, carcass length, trimmed fat, dissected fat and belly weight. Pigs on 20 and 30% cassava peel-based rations produced leaner carcasses than in other diets.

In a similar trial, Obioha *et al.* (1985) studied the effect of replacing maize with cassava peel at various levels (0, 15, 30, 45 and 60%). It was reported that the control diet (with 0% CPM) was inferior to the zero maize ration (with 60% CPM) in dressing

percent and backfat thickness. Percent liveweight, heartweight and spleen weight were slightly higher in the cassava peel meal diets than the control diet.

Sonaiya and Omole (1983) observed that the carcass quality of pigs fed various levels of cassava peels + cassava meal varied with the breed and sex of the experimental animals used. Large White carcasses were significantly superior to those of local pigs in dressing value, length, backfat thickness and loin eye area. Dressing value was highest in Large White pigs on the control diet and decreased with increasing levels of cassava peel and cassava meal.

2.6.3 Nutrient Digestibility of Cassava Peel by Pigs

Sonaiya and Omole (1977) fed cassava peel meal to finishing pigs at 0, 5, 10 and 15% levels. There were no significant differences in the digestibilities of dry matter and energy. However, there was a decline in these parameters as the levels of cassava peel meal increased in the diet.

In a later study, Sonaiya and Omole (1983) investigated the utilization of a mixture of cassava meal and cassava peel meal in finishing pig diets. It was observed that energy digestibility values were higher than dry matter digestibility and differed significantly between the diets. The cassava peel meal - cassava meal mixtures were all higher in digestibility than the control. Their results also indicated an improvement in the digestibility of nutrient when the levels of cassava meal and cassava peel meal were equal.

Knitpanit (1984) evaluated the digestibility of cassava-based diets with 3.5, 4.0, 5.0 and 6.0% crude fibre and reported no significant differences in digestibility of energy and true protein. However, it was observed that the digestibility of these parameters decreased with corresponding increase in the levels of crude fibre in the diet. It was concluded that a level of up to 6% crude fibre could be allowed in cassava-based diets without significantly affecting the digestibility of energy and protein.

2.7.0 FIBRE UTILIZATION BY THE PIG

The pig is limited in the amount of crude fibre it can use in the diet. In contrast to the complex stomachs of the ruminants and the large caecum of the horse, its digestive tract is made up of a simple stomach of relatively small capacity and relatively devoid of micro-organisms (Cunha, 1977). The digestive juice of monogastric animals does not contain the enzyme cellulase that is capable of breaking down fibre. Gohl (1975) and Fetuga (1977), thus indicated that cellulose, hemicellulose and lignin which are constituents of crude fibre are usually regarded as being unavailable to monogastric animals. Albanese (1963) had earlier stated that considerable amount of the cellulose may be utilized in cases where bacteria present in the intestines have cellulase to degrade cellulose in monogastric animals.

The bulky nature of high fibre feeds affect feed intake. Feed International (1985) reported that additional dietary fibre tends to increase the voluntary feed intake of pigs. A review by the Agricultural Research Council (1967) concluded that every percent

increase in the dietary fibre content of the diet is accompanied by an increase of approximately three percent in feed intake. At the same time, it was observed that additional dietary fibre reduced the growth rate despite the increased intake which did not appear to compensate fully for the lower digestible energy content of the diet. Hill and Dansky (1954) explained that an increase in consumption of low energy fibrous diets is an attempt by the animal to cancel out the energy deficit. Lloyd *et al.* (1978), indicated that feeds high in crude fibre content limit the weight of feed eaten by the pig and thereby placing physical limitation upon the intake of the digestive nutrients.

The inclusion of fibrous feeds in diets for pigs has been reported to affect their growth rate, feed efficiency and carcass quality. Liao (1985) observed that when a total of 24 crossbred pigs were given diets with 4, 6 or 8% crude fibre, feed conversion efficiency and average daily gain were lowest on 6 or 8% crude fibre diets but loin eye area increased compared to pigs given diets with 4% fibre. It was also observed that increasing crude fibre content of the diet tended to improve carcass quality but increased length of feeding time to attainment of market weight. This result is in agreement with an earlier report of Davidson (1964) who concluded that feeds for young pigs should not contain more than 6% crude fibre or else rate of gain and efficiency of feed conversion would be adversely affected.

Farrell and Johnson (1970) fed diets containing cellulose (wood dust) at levels of 0, 8 and 20% to finisher pigs. It was observed that pigs on the high fibre diets had slower growth rates

and higher digesta weight in the caecum. Ademosun (1976) and Maust *et al.* (1972) observed depressed growth and feed conversion efficiency when fibrous feedstuffs were added to the diet of pigs.

Lagreca (1983) in a study to investigate the effect of fibrous feeds on the performance of female and castrated male pigs reported that as dietary crude fibre increased to a maximum of 7.5%, rate of growth and efficiency of feed conversion progressively decreased with all pigs but more so with barrows than gilts. With higher levels of fibre, backfat thickness was reduced in all animals but the sex of the pigs did not affect the magnitude of change. In a similar trial, using a total of 192 growing-finishing pigs, Frank *et al.* (1983) fed 16% CP diets containing either 0, 7.5 or 15% corn cobs and observed linear decreases in both average daily gain and feed: gain ratio with increasing levels of dietary corn cobs. Average daily feed intake increased linearly but average daily digestible energy intake decreased with increasing dietary fibre level. They concluded that the ability of the pig to maintain satisfactory weight gains when fed higher than normal levels of fibre is apparently a function of the capacity to increase total feed intake in order to maintain similar intakes of digestible energy.

Bordart (1979) reported that when Belgium Landrace pigs in 3 groups of 16 were fattened from 25 to 92kg liveweight on diets with 5.8% crude fibre or with 10.7% alone or with commercial cellulose enzyme preparations at 500g/l and a mixture of dried beet, pulp, maize glutten feed, oats and lucerne meal were used as a source of crude fibre, the average daily gains were 688, 686 and 681g and

intakes were 3.33, 3.37 and 3.56 kg/kg gain respectively. Carcass quality was poorer on the diets with more fibre. De-Goey and Ewan (1975a) fed young pigs a cellulose diluent with the basal diet. The body weight gain and feed efficiency 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 the young pigs.

Babatunde *et al.* (1975) and Sonaiya and Omole (1977) reported a depression of energy and dry matter digestibility when fibrous feedstuffs were included in the diets of pigs.

Baird *et al.* (1975) conducted two feeding trials using 8 lots per test and 10 or 11 pigs per treatment. The animals were fed ration containing 14.5% crude protein and 2,866 Kcal ME/kg with fibre levels ranging from 4% to 8%, using seven different plant industrial by-products. No significant differences in performance due to level or source of fibre was observed. Similarly dry matter and crude protein digestibilities were not affected.

Just (1980) in his work to investigate the effect of crude fibre from cereals on the net energy value of diets for growing pigs concluded that the negative influence of fibre on digestibility and net energy value depended to some extent on the crude fibre source. In another trial with growing pigs, Just *et al.* (1981) fed diets containing crude fibre ranging from 3.4% in the control to 16.2%, the highest of the test diets. They observed that crude fibre exerted very important effect on the amount of gut content. They also indicated that daily gain decreased with increasing dietary fibre levels. They concluded that crude fibre

had a highly significant negative influence on the digestibility of all the nutrients except carbohydrates which was 99% digestible in all the diets.

Pond *et al.* (1981) linked fibre with increased in weight and or length of the stomach and various segments of the gastro-intestinal tracts. They stated 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 facilitated microbial digestion in the lower segment of the gut.

Breeding pigs have often been fed diets with a high content of dietary fibre. Cunha (1977) pointed out that in order to safe guard against overfatness and subsequent breeding problems, it might be necessary to feed higher levels of fibre to pigs which are going to be kept in the herd for breeding purposes. Feed International (1985) reported that digestion of dietary fibre increases during gestation and that there is potential for *ad libitum* feeding of sows on diet with high content of fibre to improve the satiety and the behaviour of sows, provided that the cost of such diet is relatively low.

Fibre utilization in swine diets has been related to the age and liveweight of the pigs. Sows can digest high fibre feeds better than the young and growing-finishing pigs respectively (Cunha, 1977).

2.8.0 THE RESPONSE OF PIGS TO VARIOUS DIETARY ENERGY LEVELS

Considerable research have been conducted regarding the response of pigs to various caloric levels in the diet.

Four diets calculated to contain 2,970, 3,356, 3,630 and 3,910 Kcal digestible energy/kg of dry matter were studied with eight Large White pigs by Cole *et al.* (1967). They observed significant difference ($P<0.001$) in daily voluntary feed intake between diets. Intake increased as digestible energy content of the diet decreased. Hale and Johnson (1970) observed that pigs fed on high-energy diets gained 13% faster, consumed 8% less feed daily and required 18% less feed per unit of weight gain than pigs fed on low-energy diets. Pigs fed on high-energy diets also have a dressing percentage 2.5% units higher and yielded carcasses 2% shorter, with more backfat than those fed on low-energy diets.

Scherer *et al.* (1972) fed 0, 3, 6, 9 or 12% fat in isocaloric diets to pigs weaned at 14 days of age. Fat level had a linear effect on average daily gain (ADG), a cubic effect on feed to gain ratio (F:G) and linear effect on average daily feed intake, indicating that young pigs can utilize diet of high caloric density efficiently. This is affirmed by McConnell *et al.* (1982) who stated that young pigs require a diet of greater caloric density than the older pigs. Cooke *et al.* (1972) reported that an increase in dietary energy level in diet of growing pigs gave linear increase in growth rate and improvement in efficiency of feed conversion (EFC), accompanied by linear decrease in lean percentage and increase in fat percentage. Ranjhan (1981) documented that the amount of the feed consumed daily by the growing-finishing pigs

allowed feed *ad libitum* is controlled principally by the energy content of the diet provided it is balanced with all the essential nutrients. The rations rich in energy are consumed less per unit of body weight than the rations poor in energy. On the other hand, Dividich and Noblet (1986) pointed out that the effect of dietary energy level on the rate of weight gain, digestible energy (DE) intake and digestible energy (DE) to gain ratio is dependent upon the environment in which the piglets were maintained. They observed that the energy diet (3.1 Mcal DE/kg feed) used in their experiment depressed digestible energy (DE) intake by 9.2% ($P<0.05$) and rate of weight gain by 5.5% ($P<0.05$) in piglets housed in cold environments when compared to the high energy diet (3.6 Mcal DE/kg feed).

Metz *et al.* (1980) reported that pigs fed less energy in the diet than recommended gained 15% less weight and retained 12% less nitrogen. Reducing the intake of energy reduced the deposition of protein by 8% and of fat by 28% in the whole body.

McConnell et al. (1982), fed corn-soyabean meal based diets containing 3,106, 3,300, 3,520 or 3,740 Kcal of metabolizable energy (ME/kg) to early-weaned pigs. A significant quadratic effect of treatment on gain was observed with gains increasing until energy density reached the 3,520 Kcal level. Average daily feed intake was lowest for pigs fed the 3,106 Kcal diet and highest for those fed the 3,300 Kcal diet but decreased as energy increased from 3,300 Kcal to 3,740 Kcal. Feed to gain ratios improved linearly as caloric density increased with improvements occuring between the 3,300 Kcal and 3,520 Kcal levels. They concluded that

the caloric requirements for maximum gains and feed efficiency in young pigs are higher than currently recommended by NRC (1979) particularly for pigs weighing 10 to 20kg.

Campbell and Dunkin (1983) used forty-two piglets to study the effects of a low, medium or high level of energy intake (1.0, 1.4, and 1.9 MJ gross energy/kg $W^{0.75}$) daily from 1.8 to 10kg liveweight and a low or high level of energy intake (1.4 and 1.8 MJ digestible energy/kg $W^{0.75}$) daily subsequent to 10kg liveweight on growth performance, body composition and cellularity of muscle and subcutaneous adipose tissue to 30kg liveweight. It was observed that raising energy intake from 1.0 to 1.9MJ in the period prior to 10kg liveweight increased growth rate, body fat content and fat cell size significantly but reduced feed conversion efficiency, body protein and water. Subsequent to 10kg liveweight, pigs previously given the lowest energy intake deposited protein and fat at a faster rate and exhibited more rapid and efficient growth ($P<0.05$) than pigs previously given the high energy feed.

Balogun *et al.* (1988) used eight littermate pigs with an average weight of 22.13kg in a 4 x 4 Latin Square design involving 18% crude protein diets containing 2.81, 2.99, 3.23 or 3.47 Mcal DE/kg to investigate the response of growing pigs to various dietary energy levels. Except for the 2.81 Mcal DE/kg diet, feed intake decreased slightly as the energy density of the diets increased, although the differences were non-significant ($P>0.05$). Pigs on diet containing 3.23 Mcal/kg diet had a better feed/gain ratio than those on the other treatments although the differences were also non significant ($P>0.05$).

Bowland and Berg (1959) stated that high energy rations resulted in increased dressing percentage and generally inferior carcasses. O'Grady and Bowland (1971) found that carcass was not influenced by the diet fed up to 25kg, beyond which the energy content of the feed gave rise to various quality differences. Vinnik and Goluslko (1983) also observed that increased levels of metabolizable energy and protein in diets of pigs did not favour economic expenditure of feed and caused large deposition of fat in carcasses.

Weldon *et al.* (1991) indicated that feeding a high level of energy during periods of rapid mammary growth in swine can impair development of the mammary gland in gilts which may subsequently decrease the amount of milk produced by the sow during lactation for nourishment of the offspring.

2.9.0 SEX: ENERGY INTERACTION

An interaction between sex of the pig and dietary energy is well documented in literature.

Bowland and Berg (1959) noted a significant sex to dietary energy interaction. They fed high energy (HE) and low energy (LE) diets to both barrows and gilts. The barrows ate more of the high energy (HE) relative to low energy (LE) diets and gained more rapidly than the gilts. A similar observation was reported by Skitso and Bowland (1969) who also fed low energy (LE) diets of 2,757 Kcal/kg DE and high energy (HE) diets of 3,652 Kcal/kg DE, to pigs of live weight range of about 57 to 82kg and observed significant differences in feed intake of the barrows as compared

to the gilts.

Davies and Lucas (1972) fed three diets separately each at 4 levels of digestible energy to gilts, castrates and boars growing from 21 to 92 kg live weight. It was observed that boars had faster growth rates and leaner carcasses than gilts which were superior to castrates. Ellis et al. (1983) showed that boars have superior growth rate, improved feed conversion and leaner carcasses than the castrates with gilts usually being intermediate in these criteria.

Balogun *et al.* (1988) observed a slight but non-significant improvement in performance by barrows over gilts in average daily gain and feed efficiency when fed diets with various levels of dietary energy. Their findings agreed with those of Wagner *et al.* (1963) who showed that barrows required less feed per unit of weight gain than gilts.

CHAPTER THREE

3.0.0 NON-ANIMAL STUDY

The non animal study consists of

a) Determination of the percentage yield of peels and rind in cassava tuber.

b) Determination of the chemical composition of cassava peels.

3.1.0 DETERMINATION OF THE PERCENTAGE YIELD OF PEELS AND RIND IN CASSAVA

3.1.1 Objectives

The main objectives of this study were to determine the percentage constituent of peels and or rind in cassava tuber and to determine the chemical composition of cassava peels.

3.1.2 Materials and Methods

Two big cassava tubers labelled A and B respectively were used for the study. They were harvested from 12 month-old cassava plants. They were peeled with a knife. The peeling process was done such that variable thickness of the edible pulp was left on the peels obtained from the tuber labelled 'A' while only the outer rind (without any edible pulp) was carefully removed from the cassava root labelled 'B'. Fresh weight of the peels and edible pulp obtained from root A were taken to enable the determination of the percentage yield of the peels on wet matter basis. Fresh rind and pulp obtained from root B were also weighed and the percentage yields on wet matter basis were determined. All the peels, rind and pulps were labelled for ease of identification and separately

dried on the concrete floor with occasional turning for 7 days and thereafter oven dried for 24 hours at 100°C and then weighed to determine the percentage yield of the peels and rind on dry matter basis. Three samples from each tuber were taken and the average values used in the calculations.

3.1.3 Results and Discussion

(A) (i) Fresh weight of peels = 100.50g

Fresh weight of edible pulp = 475.00g

Fresh weight of peels plus pulp = 100.50+475.00

= 575.50g

∴ % yield of the peels on wet basis

$$= \frac{100.50}{575.50} \times 100 = 17.48\%$$

(ii) Dried weight of peels = 20.00g
Dried weight of pulp = 149.50g

Weight of dried peels + edible pulp = 20.00 + 149.50
= 169.50g

∴ % yield of cassava peels on air dry basis

$$= \frac{20.00}{169.50} \times 100 = 11.80\%$$

(B) (i) Fresh rind weight = 80g

Fresh pulp weight = 350g

Fresh rind plus pulp weight = 80 + 350 = 430g

∴ % yield of rind on wet matter basis $= \frac{80}{}$ x 100

= 18.60%

(ii) Oven-dried rind weight = 10.50g

Oven-dried pulp weight = 120.00g

Oven-dried rind + edible pulp weight = 10.5 + 120.0g

= 130.50g

∴ % yield of cassava rind on dry matter basis

$$= \frac{10.50}{130.50} \times 100 = 8.05\%$$

The result of the percentage yield of the peels and rind from cassava tuber is shown above. The peels constituted about 17.48 and 11.80% on wet and dry matter basis respectively in cassava tuber. The rind on the other hand constituted about 18.60 and 8.05% on wet and dry matter basis.

The 11.80% cassava peel yield value on dry matter basis obtained in the present study was within the range of 10 - 13% reported by Okeke, (1988) and 15% reported by Aduku *et al.* (1991). The conformity of the result obtained in the present study and those of Okeke, (1988) and Aduku *et al.* (1991) could be due to the method of peeling process used. The result also confirmed the fact that cassava peel constitutes the major waste product of cassava processing which if utilized in feeding livestock will not only relief the pressure on the conventional feed sources but will also cut down the cost of production of pigs.

The lower percentage yield value obtained for the rind compared to the peels could be due to the variable thickness of the edible pulp left on the peels during the peeling process.

3.2.0 DETERMINATION OF CHEMICAL COMPOSITION OF CASSAVA PEELS

3.2.1 Status of the problem and objective

Information on the chemical composition of cassava peel from literature is limited. In addition, the chemical composition of cassava peels varies greatly with a number of factors amongst which are the method of processing, the depth of edible pulp removed with the peel when knife is used, the soil on which the cassava was grown, the variety of the cassava and the accuracy and method of laboratory analysis. There was therefore, the need to obtain information on the chemical composition of the cassava peels before the experimental rations for the feeding trials could be properly formulated.

The aim of the analysis was therefore to determine the nutritive composition of cassava peel as a feedstuff for swine.

3.2.2 Materials and Methods

Random dried samples of cassava peels and of maize, obtained from the ones to be used for the feeding trials were collected, thoroughly mixed and ground. Sub-samples were then taken and analyzed for dry matter (DM), ether extract (EE), crude fibre (CF), crude protein (CP), ash and nitrogen free extract (NFE) according to A.O.A.C. (1980) procedures. Nitrogen was determine by Kjeldahl method. The proximate analysis was carried out in duplicate and the mean values of the duplicate samples were calculated.

The caloric content of cassava peel meal was determined using the Adiabatic bomb calorimeter.

The Free HCN of the air dry cassava peel was determined using

the method described by Ikediobi and Fashagba (1985) .

3.2.3 Results and Discussion

The result obtained from the determination of nutrient composition of cassava peels are presented in Table 3.1. Column 3 of the table shows the calculated mean of the duplicate samples analysed. Column 4 shows the nutrient composition of maize for comparison.

The crude protein value of 6.46 obtained in this study falls within the range of 5.0 to 6.8% reported by other workers (Oyenuga, 1968; Sonaiya and Omole, 1983; Eshiett and Ademosun, 1981; Omole and Onwudike, 1983; Adebowale, 1985; Tewe and Kasali, 1986; Aduku *et al.* 1991; Sekoni, 1991 and Ogbonna and Adebowale, 1993). It was however slightly higher than 4.80%CP reported by Devandra, 1977. The crude protein content obtained from the present study is in support of other reports that cassava peel is of very low protein content.

The mean crude fibre content of 9.62% was in accord with those of Sonaiya and Omole, (1983); Eshiett and Ademosun, (1981), Omole and Onwudike, (1983), Adebowale, (1985), Tewe and Kasali, (1986); Osei and Duodu, (1988); Aregheore and Oluokun, (1989) and Aduku *et al.* (1991) who reported a range of 9.30 - 10.60% CF. The 9.62% CF value obtained in the present study was however lower than those obtained by Oyenuga, (1968), Devendra, (1977), Sekoni, (1991) and Ogbonna and Adebowale, (1993) who reported a range of 16.70 to 21.10% CF. The crude fibre results confirmed the fact that cassava peel is high in fibre which may have an effect on the growth

Table 3.1 Chemical anaysis of sundried Cassava peel meal (CPM) and Maize

	Sample Replicate I	Sample Replicate II	Means of the result of the 2 samples	Maize
Drymatter (%)	91.99	90.78	91.39	91.80
Crude protein	6.31	6.63	6.46	8.96
Crude fibre (%)	9.89	9.34	9.62	2.46
Ether extract (%)	1.04	1.22	1.13	3.18
Ash (%)	7.55	6.76	7.16	1.65
Nitrogen free extract (%)*	75.21	76.38	75.80	83.75
Gross Energy (Kcal/kg)	3950.12	4007.18	3978.65	4430
Free HCN (mg/kg)	142.30	139.50	140.90	-

* Calculated

performance of monogastric animals especially when fed at higher levels.

The mean ether extract value of 1.13% obtained from the present study was almost the same with the range of 1.0 to 1.20% reported by Oyenuga (1968); Devendra (1977); Sonaiya and Omole (1983); Omole and Onwudike (1983); Aregheore and Oluokun (1989); Osei (1989) and Ogbonna and Adebowale (1993). The ether extract (EE) values of 3.5, 6.5 and 5.8% reported by Adegbola and Asaolu (1986); Osei and Duodu (1988) and Aduku *et al.* (1991) respectively were higher than the value obtained in the present study. The differences in the ether extract values could be due to the variation in the method and degree of accuracy of the laboratory analyses of the CPM. It could also be due to differences in variety.

The ash (mineral) value of 7.16% obtained in the present study was within the range of those of Eshiett and Ademosun (1981); Tewe and Kasali (1986). Osei and Duodu (1988); Osei (1989) and Aduku *et al.* (1991) who reported ash values of 7.0, 7.2, 7.4, 7.10 and 7.20% respectively. It was however higher than 4.2% reported by Devendra (1977) and lower than 15.5% reported by Adegbola and Asaolu (1986).

The NFE values of 75.80% obtained in the present study was very close to 76.20% reported by Osei (1989). A slightly lower NFE values of 66.63, 68.60, 69.30, 66.63 and 67.50% were however reported by Oyenuga (1968); Devendra (1977), Osei and Duodu (1988); Aregheore and Oluokun (1989) and Ogbonna and Adebowale (1993). Since NFE is usually determined by difference, the slight differences in the NFE values obtained by other workers and in the

present study could be due to the differences in the values of the other nutrients obtained by these workers.

The percentage dry matter value of 91.39% obtained in the present study was close to that of Tewe and Kasali; (1986), Osei and Duodu (1988); Osei (1989) and Sekoni (1991) who reported DM value of 90.10, 92.10, 92.00 and 94.29% respectively. It was however higher than that of Adegbola and Asaolu (1986) who reported 66.25% DM. The slight difference in the DM value observed in the present study and that of Adegbola and Asaolu (1986) could be due to the season of harvest of cassava, and the number of days the peels was exposed to the sun for the drying process.

The gross energy value of 3978.65 Kcal/kg obtained in the present study was close to 3950 and 4001.20 Kcal/kg reported by Sonaiya and Omole (1983) and Eshiett and Ademosun (1981) respectively. The caloric value was however lower than 4430 Kcal/kg obtained for maize.

The free hydrocyanic acid (HCN) value of 140.90 mg/kg obtained for the cassava peels analysed in the present study was close to 148.00 mg/kg reported by Tewe and Kasali (1986) but higher than 47.65 and 50.0 mg/kg reported by Eshiett and Ademosun (1981) and Osei (1989) respectively. The difference in the level of HCN observed in the cassava peel could be due to the variety of the cassava from which the peels were obtained and the method of processing the cassava peels.

Conclusion

It was concluded from the non-animal study that:

i. Cassava peels constitute about 17.48% and 11.80% on wet and dry matter basis respectively of cassava tuber.

ii. The rind (without the edible pulp) constitutes about 18.60 and 8.05% on wet and dry matter basis respectively of cassava tuber.

iii. Cassava peel constitutes the major waste product of cassava processing which could be channelled to livestock feed.

iv. CPM is of lower nutritional value than maize

v. CPM is high in crude fibre and ash which comparatively are higher than those of maize.

vi. CPM has lower caloric value compared to maize.

vii. Because of the possible variation in quality of CPM from different sources, especially for the crude protein, ether extract and crude fibre, it is advisable to determine the chemical composition of CPM before formulating rations for pigs.

CHAPTER FOUR

4.0.0 EFFECT OF DIETARY LEVEL OF CPM ON PERFORMANCE OF WEANER PIGS

4.0.1 Introduction

The subsistence of pigs on non-conventional feedstuffs has been reported by Babatunde *et al.* (1975); Adebowale, (1985) and Tegbe, (1985) among other workers. Cassava peel, which constitutes the major waste product of cassava processing can serve as a good component of pig diets despite its low protein and its hydrocyanic (HCN) acid content. Iyayi (1990) indicated that though low in protein, the admirable energy level of the by product makes it a favourable replacement for maize in swine feeding. Longe and Oluyemi (1977) reported the metabolizable energy of cassava peels (rind alone) to be 1.52 Kcal/g; Tewe (1984) however, reported the value for peels from garri producing factories to be 2.16 Kcal/g (1 Cal = 4.19J). The value of Tewe (1984) was reported to be higher because of the additional small tubers and the pulp that adheres to the peel during peeling.

Cassava peel feeding has been associated with substantial feed cost savings (Tegbe *et al.* 1992, Obioha *et al.* 1985; and Aduku *et al* 1991). Levels of inclusion of 30% (Tewe, 1984), 43.9% (Obioha and Anikwe, 1982); 60% (Obioha *et al.* 1985), 40% (Tewe and Pessu, 1982, Tewe and Oke 1983) of cassava peel in pig diets have been reported with satisfactory performance. The diets were however, supplemented with either fishmeal or synthetic DL – Methionine for cyanide detoxification and improving the quality of dietary protein.

The present high cost of supplementation particularly in developing countries where crystalline DL - Methionine is not always readily available but has to be imported may pose a serious constraint to the use of DL - Methionine as a source of sulphur amino acid in cassava peel based diets for swine. Babatunde *et al.* (1976) concluded that in the Nigeria situation a high protein diet unsupplemented with methionine was more economical to feed to broilers than methionine supplemented low protein diets. Tegbe *et al.* (1992) indicated that with good manipulation of the feed ingredients, the need for synthetic amino acids can be eliminated in cassava peel meal diets and cheaper diets can be formulated for pigs.

The main objectives of this study are therefore:

i) to investigate the effect of dietary inclusion of cassava peel meal on performance of weaner pigs. This is with the view to determining the extent to which maize can be replaced by cassava peels without DL - Methionine supplementation in swine diets.

ii) to find out the extent to which the use of cassava peels can affect the overall feed cost.

4.2.0 MATERIALS AND METHODS

4.2.1 Source and Method of Processing Cassava peel Meal

The cassava peels used in this trial were obtained as a by-product of garri processing industry in Lokoja, Kogi State. The fresh peels were removed with knives such that variable thickness of edible pulp was left on the peels. They were dried in the sun

to about 10% moisture content on cemented floor where they were turned daily with rake for about seven days. This was with the view to reducing the cyanide level of the peels and also for preservation. The dried peels were then bagged and transported to Ahmadu Bello University, Farm where the experiment was carried out. The dried cassava peels were subsequently milled using hammer mill at National Animal Production Research Institute (NAPRI), Shika into flour and later on incorporated into the experimental diets.

4.2.2 Source of the Experimental Animals

The twenty (20) weaner pigs used in this experiment were obtained from two sows that farrowed at about the same time (four days interval) at the Ahmadu Bello University Farm, Zaria. The experimental animals were weaned on the same day (when they were 8 weeks old) and were used for the study.

4.2.3 Experimental Design and Housing

The 42-day growth trial including adjustment period involved the use of 20 crossbred (Large White x Landrace) gilts and boars with an average initial live weight of 9.35 ± 0.23kg. The pigs were weighed and randomly alloted on the basis of sex and initial liveweights to the five dietary treatments in a randomized design. There were four replicates per treatment. Each treatment comprised of two boars and two gilts. The animals were held in individual concrete floor pens measuring 2.75 by 2.50 metres. Each of the pen was equipped with a concrete watering trough and feeder. The entire house was roofed with asbestos sheets with a lintel type

configuration.

4.2.4 Experimental Diets

The composition and the calculated analysis of the diets are shown in Table 4.1. Proximate analysis of the diets and some of the major ingredients are shown in Tables 4.2 and Appendix III, respectively. The experimental diets are:

Diet 1. A 20% basal maize - soybean meal diet as control.

Diet 2. Cassava peel meal was fed at 7.50% of the diet and replaced some maize in the diet.

Diet 3. Cassava peel meal was fed at 15% of the diet.

Diet 4. Cassava peel meal was fed at 22.5% of the diet.

Diet 5. The cassava peel meal was fed at 30% level in the diet.

4.2.5 Management of the animals and data collection

A week to the commencement of the experiment, all the animals were held in quarantine during which the animals were treated against intestinal parasites using piperazine dewormer. The animals were also washed with Asuntol solution against external parasites. They were earnotched for easy identification. Before the experiment was started, all the animals were fed the same diet for a period of one week after which they were weighed and assigned to dietary treatments. The pigs were fed twice daily at 8.00a.m and 4.00p.m throughout the trial period. The pigs were fed the experimental diet ad libitum, and necessary precautions were taken to guide against feed wastage. All feeds not consumed were removed, weighed and recorded at the end of each week to enable

Table 4.1: Composition of diets used in Experiment 1

Ingredients	Levels of cassava peel meal				
	0.00	7.50	15.00	22.50	30.00
Maize	56.87	48.53	40.18	31.79	23.46
Cassava peel meal	0.00	7.5	15.00	22.50	30.00
Soyabean (full fat)	20.48	21.32	22.17	23.06	23.89
Bloodmeal	5.00	5.00	5.00	5.00	5.00
Wheat offal	10.00	10.00	10.00	10.00	10.00
Cotton seed cake	5.00	5.00	5.00	5.00	5.00
Bone meal	1.50	1.50	1.50	1.50	1.50
Limestone	0.50	0.50	0.50	0.50	0.50
Salt	0.50	0.50	0.50	0.50	0.50
Vit. Premix[a]	0.15	0.15	0.15	0.15	0.15
Total	100.00	100.008	100.00	100.00	100.00
Cost per kg of feed (N)	6.12	5.94	5.78	5.58	5.40
Cost per tone of feed (N)	6120	5940	5780	5580	5400
Calculated Nutrient Levels:					
Crude protein (%)	20.10	20.10	20.10	10.10	10.10
metabolizable Energy (ME/Kcal/kg)	2906	2822	2739	2654	2571
Calcium (%)	1.14	1.15	1.15	1.15	1.15
Phosphorus (%)	0.70	0.69	0.68	0.68	0.67
Ca : P	1.63	1.67	1.69	1.71	1.75
Crude fibre (%)	4.39	5.03	5.64	6.27	6.89
Lysine	1.18	1.19	1.19	1.19	1.19
Meth + Cystine	0.64	0.62	0.60	0.58	0.56
HCN (mg/kg)	-	11.10	22.20	33.30	44.40

[a]Roche VM502 contributed the following per kg of diet: Vitamin A, 12,000 I.U; Vit. D_3, 1,200 I.U; Vit. E. 3.6 I.U; Vit. K., 1.8mg; Vit. B_2, 3.6mg, Nicotinate, Calcium-d-Panthothenate, 9.6mg; Biotin, 0.36mg; Vit. B_{12} 0.012mg Choline Chloride, 120mg, Chlortetracycline, 48mg Manganese, 24 mg; Iron, 48mg, Zinc, 96mg, copper, 60mg; iodine, 1.8mg, Cobalt 0.48mg.

Table 4.2: Proximate Analysis of Experiment Diets (Dry matter basis)

	Levels of CPM in the Diet				
	0.00	7.50	15.00	22.50	30.00
Dry matter %	91.98	91.75	91.62	92.09	90.53
Crude protein (%)	20.94	21.44	21.23	21.00	19.13
Crude fibre (%)	2.06	4.26	4.32	5.43	6.27
Ether extract (%)	9.56	7.30	7.43	6.38	7.64
Ash (%)	5.12	5.19	6.80	7.11	7.54
Nitrogen free extract (NFE) (%)*	62.32	61.81	60.22	59.88	59.42

* Determined by difference

calculations of weekly intake of feed. Water was offered ad libitum.

The pigs were weighed weekly through out the experimental period. At the end of every week, average daily feed intake, average daily gain, feed conversion efficiency and cost per kg gain were calculated.

4.2.6 Proximate analysis

Proximate analysis of test diets and major feed ingredients were carried out according to the method outlined by A.O.A.C.(1980) described in 3.2.2.

4.2.7 Statistical analysis

Data collected was subjected to ANOVA using the model for completely randomized design (Snedecor and Cochran, 1980) and differences between treatment means were compared using Ducan's multiple Range Test (Steel and Torrie, 1960).

4.3.0 RESULTS

Table 4.3 presents results of average daily gain (ADG), average daily feed intake (ADFI), Feed conversion ratio (F/G), protein efficiency ratio (PER), hydrogen cyanide intake (Mg HCN/day), crude fibre intake, energy intake (Kcal ME day^{-1}). While Table 4.4 shows the relative costs of the experimental diets.

There was a general trend of slight but insignificant increase in feed intake as the level of cassava peel meal in the diet increased from 0 to 30%. The highest feed intake per day of 1272g

Table 4.3: Effects of dietary levels of CPM on performance of weaner pigs

	Cassava peel meal levels						Level of
	0.00	0.75	15.00	22.50	30.00	S.E.M	Significance
Average initial weight (kg)	9.48	9.30	9.35	9.38	9.25	1.98	NS
Average final weight (kg)	33.10	32.70	32.70	32.30	32.00	3.89	NS
Average daily feed intake g, day	1234	1240	1251	1266	1272	0.12	NS
Average daily wt. gain, g, day	562	557	555	553	547	0.06	NS
Feed efficiency, F/G	2.22	2.25	2.26	2.30	2.32	0.15	NS
Average daily energy intake, (Mcal ME day^{-1})	3589	3500	3427	3359	3271	0.310	NS
Protein efficiency ratio (PER)	2.27	2.24	2.19	2.18	2.14	0.13	NS
Average daily crude protein intake g, day^{-1}	248	249	254	254	256	0.023	NS
Average crude fibre intake, g/day	56^{b}	63^{ab}	71^{ab}	78^{ab}	88^{a}	0.07	*
Hydrogen cyanide intake (MgHCN/day)	-	13.71^{b}	27.77^{ab}	42.16^{a}	56.48^{a}	0.19	*

NS = Non Significant difference ($P>0.05$)

* = ($P<0.05$)

a,b,c Means separated by different letters are significantly different at 5% level.

Tabel 4.4 Relative costs of experimental diets and cost per kg gain.

Factor	Cassava peel replacement levels				
	0.00	7.5	15.00	22.50	30.00
Cost/kg feed (N)	6.12	5.94	5.78	5.88	5.40
Feed cost (N/ton)	6120	5840	5780	5550	5400
Cost of feed consumed (N)	317.44	309.36	303.69	296.70	288.09
Relatuve Cost of feed consumed (N)	100.00	97.45	95.67	93.47	90.88
Feed cost per kg gain (N)	13.63	13.16	12.95	12.95	11.14

was obtained from diet 5 followed by diets 4, 3, 2 and 1 with 1266, 1251, 1240 and 1230g per day respectively. This observed trend agreed to the general observation that pigs consume more of low energy diets in an attempt to cancel out the energy deficit.

Results of the average daily weight gain showed that pigs on the control diet had the highest gain, although the differences were not ($P > 0.05$) significant. There was a trend towards depressed weight gain as the level of CPM in the diet increased from 0 to 30%. The maize reference diet had a slight but non-significant superiority over the CPM diets. Pigs fed the control diet gained an average of 562g per day while those on treatments 2, 3, 4 and 5 recorded 557, 555, 553 and 547g per day respectively. The average daily weight gain values were observed to be statistically identical.

Feed: gain ratio (F/G) was not significantly ($P>0.05$) affected by CPM level in the diets. Feed: gain ratio results shows that pigs on the control diet (0% CPM) were most efficient with a trend towards poorer feed efficiency as the level of CPM increased from 0 to 30%. The control diet gave a feed efficiency ratio of 2.22 which was comparable to 2.25, 2.26, 2.30 and 2.32 for diets 2, 3, 4 and 5 respectively.

The highest final liveweight of 33.10kg was obtained from the control diet followed by diets 2, 3, 4 and 5 with 32.70, 32.70, 32.30 and 32.0 respectively. The final liveweight of the pigs were comparable ($P>0.05$) as the level of CPM increases from 0 to 30%.

Protein efficiency ratio (weight gain per unit protein intake) decreased with increase in the inclusion level of cassava peels in

the diet. The differences was however not statistically significant (P > 0.05) between treatments. While the control diet gave a protein efficiency ratio of 2.27, diets 2, 3, 4 and 5 recorded 2.24, 2.19, 2.18 and 2.14 respectively.

Although average daily feed intakes were comparable across treatments, the daily energy intakes dropped by 2.48, 4.51, 7.30 and 8.80% (3589 Vs 3500 Vs 3427 Vs 3359 Vs 3271 ME Kcal/day) for diets 2, 3, 4 and 5 respectively. Pigs on diet 1 recorded the highest energy intake followed by diets 2, 3, 4 and 5. The differences were however not statistically significant (P > 0.05). The dietary energy level of the diets decreased with increase in the level of CPM.

The highest crude protein intake of 256g/day was obtained for diet 5 followed by diets 4, 3, 2 and 1 with 254, 254, 249 and 248 g/day respectively. With increase in the level of cassava peel in the diets, there was a corresponding increase in feed intake values (Table 4.1) which may account for the observed trend in average daily crude protein intake.

Weaner pigs fed different levels of cassava peel meal showed significant differences (P<0.05) in crude fibre intake. The level of crude fibre in the diets increased with increase in the level of cassava peel meal (4.39 Vs 5.03 Vs 5.64 Vs 6.27% for diets 1, 2, 3, 4 and 5 respectively). The highest level of crude fibre, (88g/day) was consumed by pigs fed diet 5. The pigs on other diets consumed significantly comparable levels (P>0.05) of crude fibre, but the CF intake of diet 5 was significantly higher (P > 0.05) than that of the control diet (88g/day vs 56g/day).

There were significant differences (P<0.05) in the average daily cyanide intake of pigs fed different levels of cassava peels. The highest daily cyanide intake of 56.48 mg HCN/day was recorded with pigs on diet 5 with 30% CPM level. This value was closely followed by the cyanide intake of pigs on diet 4 with average daily cyanide intake of 42.16 mgHCN/day. Pigs on diet 3 with 15% level of cassava peel had an average cyanide intake of 27.77 mgHCN. Increasing the level of cassava peel in the diet resulted in increased HCN intake. The HCN intake for diets 4 and 5 were significantly (P < 0.05) higher than for diet 2.

The costs of the diets used in this trial indicated a 3.45, 4.77, 4.99 and 16.07% fall in prices of feed as the inclusion level of CPM increased in the diets (6.12 Vs 5.94 Vs 5.78 Vs 5.58 Vs 5.40 N/kg for 0, 7.5, 15 22.5 and 30% CPM diets respectively. Similarly, the highest cost of feed per tonne of N6120.00 was obtained for the control diet. The cheapest diet per tonne comes from diet 5 which was N5500.00 per tonne, followed by diets 4, 3 and 2 with 5580, 5780 and 5940 N/ton respectively.

Comparing the cost of feed required per unit gain in weight (13.63 Vs 13.16 Vs 12.98 Vs 12.95 Vs 11.44 N/kg gain for treatment 1, 2, 3, 4 and 5 respectively) no difference in production costs could be discerned. The cheapest cost of producing a unit of weight gain (N11.44 per kg) was obtained when 30% of cassava peel meal was fed in the diet. The cost of feed per kg gain was decreased by 9.12% at the highest level of inclusion of CPM.

4.4.0 DISCUSSION OF RESULTS

Evidence is provided from the present study that it is possible to use up to 30% level of CPM in diets of weaner pigs and still maintain reasonable productive performance that is comparable to the control diet. The uniformity in initial liveweight of the animals suggests that the experimental animals were adequately balanced for age, sex and size. The absence of significant differences in any of the performance characteristics further suggests that the five dietary treatments had equivalent nutritional attributes. The absence of deficiency symptoms or mortality also suggests that the diets were adequately balanced and supplemented.

The increased feed intake of the CPM diets over the control could be explained by the fact that as the level of CPM increased from 0 to 30%, there were corresponding increases in the level of dietary crude fibre (4.39, 5.03, 5.64, 6.27 and 6.89% for diets 1, 2, 3, 4 and 5 respectively). It has been documented that additional dietary fibre tends to increase the voluntary feed intake of pigs (Feed International, 1985). ARC (1967) concluded that every one percent increase in the dietary fibre content of the diet is accompanied by an increase of approximately three percent in feed intake. Although the crude fibre levels of the diet increased from 4.39% for the control diet to 6.89% for the 30% CPM level (Table 4.1), the differences in feed intake were non-significant. This result is in agreement with the result of Tewe and Oke (1983) who had earlier observed a non-statistically significant increase in feed intake with higher dietary, cassava

peel levels by grower pigs upto a level of 20%.

The increase in the amount of feed intake with increase in the level of cassava peel meal in the diets could also be explained based on the fact that with increase in CPM and crude fibre levels in the diets, there was a corresponding decrease in energy concentration of the diet. The substitution of CPM for maize in the diets for pigs consistently lowered the metabolizable energy concentration. The metabolizable energy of CPM ranges from 1.52 to 2.16 Kcal/g, compared with 3.4 Kcal/g for maize (Tewe and Pessu, 1982). That voluntary feed intake appears to be controlled by energy intake has been reported by Owen and Ridgemen (1968). Because pigs eat primarily to satisfy their energy requirements, more feed was consumed on the CPM diets. Ranjhan (1981) had earlier documented that the amount of the feed consumed daily by the growing - finishing pigs allowed feed *ad libitum* is controlled principally by the energy content of the diet provided it is balanced with all the essential nutrients. The diets rich in energy are consumed less per unit of body weight than the diets poor in energy.

The slightly depressed weight gain as the level of cassava peel meal increased in the diet in this trial is in agreement with the observations of other workers (Nestel and Macintyre, 1973); Obioha *et al.* (1975) and Manikam and Gopalkrishman (1978). Nestel and Macintyre (1973) observed a slight depression in weight gains of growing pigs fed cassava peel diets. Obioha *et al.* (1988) fed growing pigs (22.50±3.82kg) with 0, 15, 30, 45 and 60% CPM and reported no differences in growth rate of pigs fed the diets (0.51

Vs 0.41 Vs 0.40 Vs 0.41 Vs 0.41 kg/day). On the other hand, Manikam and Golpalkrishman (1978) observed that daily weight gains of growing pigs (15 - 55kg) fed 0, 10, 20 and 30% CPM in diets were almost equal up to the 20% level but at 30%, performance was poor.

The generally slight depression (562 Vs 557 Vs 555 Vs 553 Vs 547 g/day) as the level of cassava peel increased in the diet in the present study could also be explained in terms of dietary intakes of the pigs. Vanschoubrek *et al.* (1967) illustrated from literature that on the average a 15.5% energy restriction from growing pigs resulted in a 12.5% reduction in average daily gains. Davies and Lucas (1972) reported that a 5, 15 and 25% energy restriction from optimum growing pigs requirement caused daily gains to deteriorate by 5, 15 and 34% respectively. In the present study, energy restrictions were at about 2.9, 5.7, 8.7 and 16% which may account for the slight depression in weight gain with increased level of CPM. Lloyd *et al.* (1978) observed that reduced energy content in high fibre diets is the main reason for decreased gains. In this experiment, energy intakes decreased with increasing level of CPM in the diet (3589 Vs 3500 Vs 3427 Vs 3359 Vs 3271 ME Kcal day^{-1}) which may account for the decrease in weight gains.

The fibre level of diets has also been reported to be responsible for depression in growth rate of pigs. Relatively higher levels of dietary fibre have been reported to depress growth rate (Kornegay, 1978; Kennelly and Aherne, 1980; Frank *et al.* 1983). Maust *et al.* 1972 and Ademosun 1976 have indicated depressed growth and feed efficiency when fibrous feedstuff (rice

bran) were added to the diets of pigs. In the present trial, the increased dietary fibre level with increase in the level of CPM may be the cause of the slight depression in weight gain. It is noteworthy that the nonsignificant differences across the treatments in rate of gain is an indication that the fibre level of the diets even at the highest level of inclusion of cassava peel (30%) was within the range of what the animals can handle without any deleterious effect on weight gain.

The similarity in weight gain values across the treatments (562 vs 557 vs 555 Vs 553 Vs 547) is also an indication that the residual HCN had no depressing effect on weight gain. This observation is in conformity with those of Obioha *et al*. 1985 who reported no depression in average daily gain due to HCN intake when grower pigs (22.50 ± 3.82kg) were fed with graded levels (0, 15, 30, 45 and 60%) of CPM.

Sitompul (1977) reported that weight gain depressions as a result of HCN occurs at 100ppm level or above. The similarity in the weight gain values in the present study might suggest that the sundrying method of processing cassava peels for 7days was adequate to reduce HCN levels below the critical depression levels. Akinrele, (1964) had earlier indicated that about 80% of the cyanide contained in cassava peel is lost during sundrying process. Aduku *et al*. (1991) concluded that HCN toxicity may not be the problem of well cured (sun dried) cassava peel as the HCN level after sundrying is far below the toxic levels.

The feed efficiency (F/G) result shows that pigs on the control diet were most efficient with a trend towards a slight but

non-significant decline as the level of CPM in the diet increased from 0 to 30%. This suggests poorer conversion of CPM diet to weight gain compared to maize based diet. This is in conformity with the work of Tegbe *et al.* (1992) who observed no significant increase in feed to gain ratio (2.59 Vs 2.66 Vs 2.75 Vs 2.77) when 0, 12.50, 25.00 and 37.5% graded levels of CPM were fed to growing pigs. The result from the present study is probably associated with the lower calorie content of the feed as the level of CPM was increased from 0 to 30%. Pigs had to consume more of the low energy feeds in order to satisfy their nutrient requirements (Troelsen and Bell, 1962). The lower fibre levels and apparently, better diet digestibilities on the lower CPM treatments may also explain this observations. Osei (1989) attributed reduced feed conversion efficiency to the presence of hydrocyanic acid in cassava and its by-products. In the present study, the consumption of HCN rose from zero to 13.71, 27.77, 42.16, 56.48 and 46.71 mg/day for pigs on 0, 7.5, 15, 22.5 and 30% CPM diets respectively. Although there was a significant difference in the average daily HCN intake, the feed efficiency values shows that the cyanide level of the diets even at the highest level of inclusion was not enough to affect the utilization of feed nutrients for body weight gain.

The use of CPM up to a level of 30% in this trial has resulted in cost effectiveness. Tegbe *et al.* (1992) reported a saving of 12.4, 23.4 and 36.8% per tonne of feed respectively when 12.50, 25.0 and 37.50% levels of CPM were used to replace maize in the diet of growing pigs. Obioha *et al.* (1985) also observed a substantial cost reduction with increase in level of CPM in diets

of growing pigs. The use of CPM in the present study has resulted in a 3.45, 4.77, 4.99 and N16.07 fall in the unit prices of feed when 7.5, 15.0, 22.50 and 30% CPM levels were used to replace maize in the diets respectively. This correspond to a saving of 2.9, 5.6, 8.8 and 11.8% per tonne of feed respectively.

It is noteworthy that although there are no significant differences ($P<0.05$) among the treatment means in the cost per kg gain in weight, the cost to produce unit gain in body weight of the pigs decreased with increase in levels of CPM, but this advantage can only be significantly realised on a very large-scale operation. The decrease in cost per kg of weight gain without significant effect on the performance of the animals is of particular importance in situations where maize is scarce due to heavy demand as human food or simply not available for livestock feed. The main advantage however is that there would be a reduced input of humanly useful maize in pigs diet which will reduce the competition between the livestock subsector and the human populace for cereal grains.

It is interesting to note that earlier workers (Tewe, 1984; Obioha and Anikwe, 1982; Oke 1983 and Obioha *et al*. 1985) have recommended the use of synthetic DL - methionine or fish meal to improve the quality of the diet and also for cyanide detoxification in CPM diets, satisfactory performance of the animals were achieved in the present study without inclusion of these expensive and unavailable ingredients in the diets. This suggests that with good manipulation of the feed ingredients, the need for synthetic amino acids can be eliminated in cassava peel meal diets. This is

in conformity with the works of Maner *et al.* (1976) Aduku *et al.* (1991) and Tegbe *et al.* (1992).

The conclusions drawn from this study therefore are that:

1. As high as 30% level of CPM can be included in diets of weaner pigs without significant effect on their performance;
2. The sundrying method of processing cassava peels is an effective means of reducing the cyanide levels of cassava peels.
3. The cyanide level of the diets even at the higher levels of inclusion (30%) was low enough not to be the major problem of cassava peel;
4. There is cost benefit effect of using cassava peel to replace maize in swine diets;
5. It is feasible to formulate a practical diet with upto 30% level of inclusion of CPM without the use of DL - methionine and still obtain a good performance of the animals

CHAPTER FIVE

5.0.0 REPLACEMENT VALUE OF CPM FOR MAIZE IN THE DIET OF WEANER PIGS

5.1.0 Introduction

Nigeria, like most other developing countries, suffers greatly from a constant shortage and rise in cost of livestock feeds especially those supplying protein and energy. This situation tends to be highly magnified of recent due to two main reasons. First, the very high competition existing between stock and human population for the same source of food particularly energy feeds such as maize, sorghum, wheat and cassava on one hand, and the protein feeds such as soyabean and fish meal on the other. Whereas these sources of feeds form the basic constituents of most livestock rations particularly for the non-ruminants, they also form the major source of human food. The choice therefore has to be made between feeding human population for bare survival or feeding pigs, poultry or dairy cows to enhance meat and milk production. Second, the existence of uncertain weather conditions in the grain producing areas of the country with frequent periods of drought and in some instances, occurence of flood has become a major cause of constant food deficit. There is therefore the urgent need for livestock producers to explore ways and means of utilizing those cheaper feed resources that have little direct competition for human food. Cassava peels is one of the feedstuffs that can appropriately fit into this category especially in developing countries that can ill afford the luxury of feeding only maize or sorghum to the monogastrics as the main source of energy.

Obioha and Anikwe (1982) indicated that the attraction of incorporating cassava peels in livestock feeds rests heavily on cost savings. Unlike the feeding of whole cassava root, the peels are not subject to any competition arising from demand for human consumption but rather complement human utilization of food cassava. As a waste product from cassava processing, peels do constitute a nuisance from point of view of refuse disposal. Their large scale use therefore would undoubtedly recycle such wastes into utilizable feed for pigs. The main objective of this study was therefore to:

i) Assess the response of weaner pigs to diets in which cassava peels (sun dried) replaced 0, 25, 50, 75 and 100% of maize in the basal diet. This is with the view to determining the extent to which cassava peels can substitute for maize in weaner pig diets.

ii) Evaluate the cost benefit effect of replacing up to 100% of maize with CPM in diets of weaner pigs.

5.2.0 MATERIALS AND METHODS

5.2.1 Source and Method of processing cassava peel

The cassava peels used in this study were collected from garri grating depots in Lafia, Plateau State and were spread out on a concrete floor under the sun. Stumps and roots were sorted out and the mass was turned everyday for seven days. After sun drying, the peels were bagged, transported to Ahmadu Bello University Teaching and Research Farm and later on grounded into meal before incorporation into the experimental diets.

5.2.2 Source and general conditions of the experimental animals

Twenty (20) weaner pigs used in this study were purchased from Samaru village. The animals were obtained from two sows that had the same level of management. The weaner pigs were farrowed and weaned about the same time and were in good condition of health at the time they were procurred for the experiment.

5.2.3 Experimental design and housing

Twenty (20) weaner pigs averaging 7.65±0.51kg were assigned to 5 experimental diets in such a way that age, sex and group weights were balanced as far as possible. They were fed five diets, corrsponding to five treatments with four pigs per treatment in a randomized design. All the experimental animals were held individually in standard open-sided concrete floor pens equipped with feeding and watering troughs. The experiment was carried out at the Ahmadu Bello University Teaching and Research Farm and it lasted for six (6) weeks. There was an intial adjustment period of 7 days.

5.2.4 Experimental diets

The composition and calculated analysis of the test diets are as presented in Table 5.1. Proximate analysis of the diets is also as shown in Table 5.2.

Ground cassava peels and maize were used as main energy sources in formulating five isonitrogenous test diets. The caloric value of the experimental diets varied as the cassava peel replaced maize in the diets. The control diet (Diet 1) contained 2906 Kcal

Table 5.1: Composition and calculated analysis of the test diets

Ingredient	D 1	I 2	E 3	T 4	S 5
Maize	56.87	40.69	25.20	9.37	0.00
Cassava peel meal	0.00	14.22	28.44	42.65	56.87
Soyabean (full fat)	20.48	22.44	23.71	25.33	20.48
Blood meal	5.00	5.00	5.00	5.00	5.00
Wheat offal	10.00	10.00	10.00	10.00	10.00
Cotton seed meal	5.00	5.00	5.00	5.00	5.00
Bone meal	1.50	1.50	1.50	1.50	1.50
Limestone	0.50	0.50	0.50	0.50	0.50
Salt	0.50	0.50	0.50	0.50	0.50
Vit. Premix[a]	0.15	0.15	0.15	0.15	0.15
Total	100.00	100.00	100.00	100.00	100.00
Cost per kg feed (N)	6.14	5.63	5.07	4.54	3.54
Calculated chemical composition:					
Crude protein (%)	20.10	20.20	20.10	20.10	18.22
Metabolizable energy (ME/Kcal/kg)	2906	2744	2588	2430	2332
Calcium (%)	1.4	1.15	1.17	1.18	1.18
Phosphorus (%)	0.70	0.69	0.67	0.65	0.51
Ca: P	1.63	1.67	1.75	1.82	2.31
Crude fibre	4.39	5.58	6.67	7.97	8.94
Lysine	1.18	1.19	1.19	1.19	1.04
Metth. + Cystine	0.64	0.61	0.57	0.53	0.45
HCN mg/kg	-	21.05	42.09	63.12	84.17

[a]Roche VM502 Contributed the following per kg of diet: Vitamin A, 12,000 I.U; Vitamin D_3 1,200I.U; Vitamin E, 3.6 I.U; Vitmain K, 1.8 mg; Vitamin B_2 3.6 mg; Nicotinate, 18mg, Calcium-d-Pantothenate, 9.6 mg; Biotin, 0.36 mg; Vitamin B_{12} 012 mg; Choline chloride 120mg; Chlortetracycline, 4.8mg, Manganese, 24mg; Iron, 48mg; Zinc, 96mg; Copper, 60mg; Iodine, 1.8mg Cobalt, 48mg.

Table 5.2: Proximate Analysis of Diets on Drymatter Basis

	D I E T S				
	1	2	3	4	5
Drymatter (%)	89.46	90.18	90.29	91.11	90.96
Crude protein (%)	20.94	23.44	20.25	22.00	19.13
Ether extract (%)	8.33	7.34	6.28	7.07	5.78
Ash (%)	5.07	5.93	7.61	10.52	11.54
Crude fibre (%)	3.20	5.21	6.70	8.50	12.00
Nitrogen free extract (%)	62.46	60.16	59.16	51.91	51.55

ME/kg while 2744, 2588, 2430 and 2332 Kcal ME/kg were recorded for diets 2, 3, 4 and 5 respectively. The dietary treatments were:

Diet 1 - A 20% CP basal maize - soyabean diet

Diet 2 - Cassava peel meal (CPM) replaced 25% of maize in the basal diet which correspond to 14.22% level of CPM in the diet

Diet 3 - CPM replaced 50% of maize in the basal diet which correspond to 28.44% level of CPM in the diet.

Diet 4 - CPM replaced 75% of maize in the basal diet which correspond to 42.65% level of CPM in the diet.

Diet 5 - CPM replaced 100% of maize in the basal diet which correspond to 56.87% level of CPM in the diet.

All the dietary treatments were balanced with respect to minerals and vitamins as recommended by ARC, (1967).

5.2.5 Management of the experimental animals and data collection

The management of the experimental animals and performance data collection in this study followed the same procedure as outlined under items 4:2.5 and 6.2.5 in chapters 4 and 6 respectively.

5.2.6 Proximate analysis

The proximate analysis of the test diets were carried out according to the method outlined by A.O.A.C. (1980) at the Biochemistry Laboratory of Animal Science Department, Ahmadu Bello University, Zaria.

Table 5.3: Effect of replacement value of cpm for maize in the diet of weaner pigs.

Parameters	DIETS 1	2	3	4	5	S.E. of Means	Level of pigs
Average initial weight (kg)	7.93	7.43	7.45	7.42	7.90	1.27	NS
Average final weight (Kg)	30.63a	27.92ab	26.68ab	24.73b	23.73b	1.17	*
Average Daily Feed intake g/day	1108.00	1040.00	1003.00	968.00	918.00	10.19	NS
Average Daily Weight gain g/day	470.00a	425.60ab	372.00ab	351.50ab	322.0b	23.91	*
Feed Efficiency (F/G)	2.20	2.40	2.70	2.75	2.85	0.91	*
Av. daily crude protein intake g/day	222.50a	205.00ab	201.50ab	194.50ab	167.30b	21.03	*
Protein efficiency ratio (PER)	2.39	2.09	1.85	1.82	1.94	0.24	NS
Av. daily energy intake ME Mca/kg/day	3.22a	2.85a	2.60a	2.35a	2.14b	0.29	*
Av. daily crude fibre intake g/day	48.50a	57.00ab	68.00b	77.00b	82.00b	5.19	*
Cost per kg live wt. gain (N)	14.87a	13.92ab	13.66ab	12.50b	10.06b	0.57	*
Average cost of feed consumed (N)	333.20a	286.90b	249.10bc	215.00bc	159.10c	29.58	*
Hydrogen cyarnide intake (mg HCN/day)	0.000	21.90d	42.20c	61.10b	77.20a	3.99	*

a,b,c = Means seperated by different letters are significantly different at 5% level
NS = Not significant (P > 0.05)
* = P > 0.05

5.2.7 Statistical analysis

The data obtained from this experiment were subjected to Analysis of Variance and correlation analysis using the model for completely randomized design (Snedecor and Cochran (1980). Treatment means that were significantly different were separated using Ducan's Multiple Range test as described by Steel and Torrie (1960).

5.3.0 RESULTS

Results of final liveweight, average daily feed consumed, average daily gain (ADG), feed conversion efficiency, protein efficiency ratio (PER), energy intake (Kcal ME day^{-1}), crude fibre intake and hydrogen cyanide (HCN) intake are presented in (Table 5.3). Correlation analysis of performance parameters is shown in Table 5.4.

The final liveweight result indicated a significant ($P<0.05$) linear decrease as the level of cassava peel in the diets increased. Pigs fed the control diet had the highest final liveweight of 30.63kg and it differed significantly ($P < 0.05$) from the maize substituted (CPM) diets. A final liveweight of 27.92kg was obtained from pigs fed diet 2 and it was comparable to the value obtained for pigs fed diet 3. The 100% maize replacement diet gave significantly lower final liveweight value which differed ($P<0.05$) from pigs fed the control but was similar to results obtained for pigs fed diets 2, 3 and 4.

The average daily feed consumed was not significantly different across the treatment. There was a trend towards decrease

Table 5.4: Matrix of Correlation Between Daily Feed Intake, Energy Intake, Crude Fibre Intake, Hydrogen Cyanide Intake and Performance.

	Average initial weight	Average Final Weight	Average Daily Feed Intake	Average Weight Gain	Feed Efficiency	Average Daily Crude Protein Intake	Protein Efficiency Ratio	Average Daily Energy Intake	Average Daily Crude Fibre Intake	Cost Per Kg. Gain	Hydrogen Cyanide Intake
Average Initial Weight	1.000										
Average Final Weight	0.4308	1.0000									
Average Daily Feed Intake	0.3706	0.5409*	1.0000								
Average Weight Gain	0.1368	0.8432	0.6684*	1.0000							
Feed Efficiency	0.2747	-0.4139	*	-4959*	1.0000						
Average Daily Crude Protein Intake	0.3042	0.5628*	0.3001	0.7136*	0.2109	1.0000					
Protein Efficiency Ratio	- 0.2260	* 0.3520	0.9800* *	* 0.3493*	-0.9151** 0.0149	-03963 0.9579*	1.0000 0.1972	1.0000			
Average Daily Energy Intake	0.3312	0.7120*	-0.4352	*	0.8779**	*	-0.7296	-0.0898	1.0000		
Average Daily Crude Fibre Intake	0.1618	*	0.9459	0.8388*	0.3218	0.1337	0.1493	0.6852*	-	1.000	
Cost Per Kg. Gain	0.1001	-	0.2372	*	-0.1734	0.6115*	0.0526	0.9688*	0.5158*	0	1.0000
Hydrogen Cyanide Intake	0.2668	0.4606*	0.5031*	-		*			-0.3027	0.810	
		0.6871* *	0.3480* *	0.4535*		0.8985* *				7	
		0.7641		0.7174*							
				0.8905* *							

* = Significant at P 0.05
** = Highly significant at P 0.01

in the amount of feed consumed per day as the level of CPM increased in the diets. The best feed consumed per day was obtained from pigs fed the control diet with 1108g/day whereas the lowest feed consumption figure of 918g/day was recorded from pigs fed diet 5 (with 100% maize replacement). Pigs fed diets 2, 3 and 4 had feed intake values of 1040, 1003 and 968g/day respectively.

The average daily weight gain data revealed a significant difference ($P< 0.05$) between diet 1 and diet 5. The average daily weight gain results followed the same trend with those of the average daily feed intake. The pigs raised on diet 1 had the best gain while those on diet 5 (with 100% maize replacement) had the least weight gain although the value was not significantly different from those on diets 2, 3 and 4.

There were no significant differences in the efficiency of feed utilization across the treatments. The best converters of feed were pigs on diet 1, closely followed by the pigs on diets 2, 3, 4 and 5 with 2.20, 2.40, 2.70, 2.75 and 2.85 respectively. The poorest feed efficiency value was obtained from pigs fed the 100% maize replacement diet (Diet 5), but it was not statistically significant when compared to pigs fed the other treatments.

The average crude protein intake value generally decreased with corresponding increase in the level of CPM in the diets. Pigs fed the control diet had the highest amount of crude protein intake per day and was similar to those of pigs fed diets 2, 3 and 4. The least amount of CP consumed was recorded by pigs fed diet 5 and was significantly ($P < 0.05$) less than those obtained for the control diet. However, it was similar to protein intake of pigs fed diets

2, 3 and 4. Pigs raised on diets 1, 2, 3, 4 and 5 had average crude protein intake values of 222.50, 205.00, 201.50, 194.50 and 167.30g/day respectively.

The data obtained for protein efficiency ratio revealed that weight gain per unit protein intake decreased with increase in the level of CPM in the diets. The differences were however not statistically significant. The best converters of dietary protein were pigs fed diet 1 closely followed by the pigs on diets 2, 5, 3 and 4 with 2.39, 2.09, 1.85, 1.82 and 1.94 respectively.

The average daily energy consumption data revealed a decrease with increasing level of CPM in the diets. Pigs fed CPM diets progressively consumed less of energy than the pigs fed the control diet. The highest amount of energy consumed (3.22 Mcal ME per day) was obtained from pigs fed the control diet. This value was followed by pigs fed diets 2, 3, 4 and 5 with 2.85, 2.60, 2.35 and 2.14 Mcal ME per day respectively. Except for pigs fed diet 5 that had significantly ($P<0.05$) depressed energy intake, values obtained for pigs fed diets 1, 2, 3 and 4 were similar.

The amount of crude fibre consumed increased linearly as the level of CPM increased in the diets. The highest crude fibre intake of 82.0g/day was recorded for pigs fed diet 5. This value was statistically comparable to those obtained for pigs fed diets 2, 3 and 4 but differed significantly ($P<0.05$) from pigs fed the control diet. Pigs on diets 1, 2, 3, 4 and 5 had crude fibre intake of 48.50, 57.00, 68.00, 77.00 and 82.00 g per day respectively.

HCN intake increased linearly ($P < 0.05$) with increased CPM

levels. The highest daily cyanide intake of 77.2 mgHCN per day was recorded with pigs on diet 5 (100% maize replacement). This value significantly differed from all other dietary treatments. The least amount of HCN intake on the CPM diets was obtained from pigs fed the 25% maize replacement diet and it differed significantly from other dietary treatments. The control diet had no CPM and therefore animals fed the control diet were assumed to consume no cyanide.

The cost of producing a unit gain in body weight of the pigs decreased linearly ($P<0.05$) with increased level of CPM in the diets. The most expensive cost of N14.87 per Kg liveweight gain was recorded from pigs fed the control diet and was significantly different ($P < 0.05$) from treatment 4 and 5 but similar to treatments 2 and 3. Pigs fed diet 4 and 5 had cost per unit gain that was similar to the values recorded for those fed diets 2 and 3. The least expensive cost of gain of N10.06 per kg was obtained from pigs fed diet 5. Pigs fed diets 1, 2, 3, 4 and 5 had an average cost per kg gain of N14.87, 13.92, 13.66, 12.50 and 10.06 respectively.

The feed consumed by the pigs fed the control diet was generally more expensive than the CPM diets. The costs decreased by 13.90, 25.24, 35.47 and 52.25% for diets 2, 3, 4 and 5 respectively compared to the control diet.

5.4.0 DISCUSSION OF RESULTS

The observed non-significant ($P>0.05$) depression in feed intake as the level of CPM increased in the diets is in agreement

with the reports of Sonaiya and Omole (1977), Omole and Sonaiya (1981), Obioha and Anikwe (1982) and Obioha *et al* (1987) but does not conform with the results obtained by Longe (1980), Longe and Oluyemi (1980). Fessu (1981) and Maust *et al* (1972) who reported significant depression in feed intake arising from increasing levels of cassava peels in the diet. A few plausible explanations could be advanced for the non conformity of the feed intake results obtained from the present study and those of some of the earlier workers. While Longe (1980), Longe and Oluyemi, (1980) and Maust *et al*. (1972) worked with poultry and reported significant depression in feed intake, the feed intake from the present study and those of Sonaiya and Omole (1977), Omole and Sonaiya (1981), Obioha and Anikwe (1982) Obioha *et al*. (1985) and Tailor *et al*. (1987) were obtained from pigs. This results suggest that pigs can tolerate higher levels of CPM in their diets than poultry despite the fact that both of them are single stomach animals. Besides, the level of dietary cyanide depends on the variety of the cassava from which the peels were obtained and the various method used in the processing of the peels. It also depends on the different levels of supplementation in the diet.

The superiority of the pigs fed the control diet as compared to those fed the CPM-based diets in feed intake could be due to lower palatability of cassava peels compared to maize and the dustiness occassioned by the use of ground cassava peels (Oke, 1978). Dustiness of cassava peels could cause irritation of the eyes and respiratory organs thereby decreasing feed intake (Muller and Nah, 1974). Maust *et al*. (1972) and Maner *et al*. (1972)

attributed depressed feed intake in CPM diets to HCN factor. It is therefore most likely that the increase in the level of the dietary cyanide with increase in the level of CPM in the diets in the present study was responsible for the linear decrease in the amount of feed consumed.

The weight gain pattern obtained from this study closely followed that of the feed intake. This suggests that higher feed consumption enhanced better growth. It could be inferred from the differences observed across the treatment means that energy restrictions as a result of dilution of high energy diets with CPM especially at higher level of inclusion would have a negative effect on the growth of pigs. The Metabolizhble Energy Value of cassava peels ranges from 2,030 to 2460 Kcal ME per kg, whereas for maize the ME value ranges from 3,300 to 4310 Kcal ME per kg of dry matter (Oyenuga, 1968, Montila, 1977 and NRC, 1979). Besides, the inclusion of CPM in pig diet in the present study has not only revealed a linear decrease in the dietary energy but also showed a significant depression ($P<0.05$) in energy intake at the highest level of inclusion. The net effect of reduced feed intake (although not statistically significant) and the low energy density of the CPM diets observed in the present study is responsbile for the significantly depressed ($P<0.05$) weight gain by pigs fed the high level of CPM diet. The rate of gain result obtained here is in support of Cooke *et al.* (1972), Metz *et al.* (1980), Campbell and Dunkin (1983) and Tewe (1986) who reported increased weight gain with increasing levels of dietary energy.

A major limitation in the use of CPM in diets of young pigs is

its high fibre content (Eshiett and Ademosun, 1981) and this has been attributed to their inadequate digestive enzyme development (Pond *et al.* 1971). Kondra *et al.* (1974) observed that feed efficiency and digestibility decreased as dietary fibre increased. Gear *et al.* (1981) explained that such decrease in nutrient digestibility, was due to the fast movement of the ingested feed through the gastro intestinal tract. In the present study, pigs fed the CPM diets significantly ($P<0.05$) consumed more of the dietary fibre than the maize control diet. It is therefore most likely that high fibre especially at the highest level of cassava peel inclusion hindered the efficient utilization of the dietary nutrients for body building.

Feed to gain ratio values showed that pigs on the control diet (0% CPM) were most efficient with a trend towards poorer feed efficiency as the level of cassava peels increased in the diet. This suggests poorer conversion of the CPM diets to weight gain than the maize control diet. The result is in consonance with the observations made by Obioha and Anikwe (1982); Obioha *et al.* (1984) and Aduku *et al.* (1991) and could be attributed to either decreasing caloric density of the diets with increasing level of CPM or the increase in the level of dietary fibre with corresponding increase in the level of CPM.

The values for protein efficiency ratio (PER) (Table 5.3) showed the same trend as the other production parameters. The protein efficiency ratio values were poorer at high levels of CPM and this is in agreement with the findings of Obioha and Anikwe (1982), Obioha *et al.* (1984) Tewe (1986), Omole *et al.* (1978) and

Umoh *et al.* (1979). Tupynamba and Vieira (1979) had earlier reported low PER values of cassava based diets especially when not adequately supplemented with amino acids.

The non-significant difference ($P>0.05$) in the values of PER could be due to the presence of blood meal (an animal protein source) that was used to beef-up the nutrient profile of the diets. Oke (1969) indicated that animal protein contains vitamin B_{12} which helps in the detoxification of cyanide and thereby sparing the use of methionine for detoxification. It is therefore most likely that the use of blood meal at the same level of inclusion (5%) in all the dietary treatments in the present study resulted in the provision of vitamin B_{12} which had an ameliorating effect on the anti-nutritional factor (HCN) of cassava peels thereby sparing the methionine provided by soyabeans and cotton seed meals for body building. This in effect may be responsible for the non-significant differences in the PER values.

The cost analysis in this study indicated enormous cost benefits associated with CPM inclusion in pig diets. It is well known that feed cost represents the major cost of producing pigs (Cunha, 1977). Lowering the cost of producing a unit of the product will therefore create the major impetus for increased pork production in the country, especially in areas where cheap and abundant agro-industrial by-products exist. The significant decrease ($P<0.05$) in the cost of producing unit gain at each level of replacing maize with CPM in the diets is of interest in this study. The percentage decrease in feed cost per kilogramme gain were 6.39, 8.14, 12.50 and 32.35% for diets 2, 3, 4 and 5

respectively compare to cost of the basal diet. This reduction in cost will undoubtedly contribute to lowering the cost of production on a larger scale and at the same time relieve competition that exist between man and livestock in the use of scarce grains. The cost per kg of diet (Table 5.1) and average cost of feed consumed (Table 5.3) were observed to be highest with the control diet and least with the 100% maize replacement diet. The cost considerations suggest that while diets 2 and 3 appeared to promote equal performance with the control diet in most respects, diets 4 and 5 promoted acceptable levels of production at least cost. This suggest that where maximum feed cost savings are desired and provided that lowered performance is compensated by feed cost savings, 100% maize replacement with cassava peels is an important practical options that need to be considered especially in situations where maize cost or nonavailability make high level of maize diets impracticable. The cost analysis result of this study is consistent with earlier cassava peels studies (Obioha and Anikwe, 1982, Obioha *et al.* 1983, Obioha *et al.* 1984 and Tewe, 1986).

When average daily feed intake was correlated with the performance parameters (Table 5.4), there was a highly significant positive correlation ($P<0.01$) between the amount of feed intake and the rate of weight gain, average daily crude protein, energy and hydrogen cyanide intake. This result confirmed that higher feed consumption promoted faster growth in this study and this could be attributed to the corresponding increase in the amount of protein and energy intake as the amount of feed intake increased. In the

same vein, the depressed feed intake which could be due to the dustiness of the cassava peel meal diets might be responsible for the depressed growth compared to the control diet. The feed intake data also correlated significantly ($P < 0.05$) with the final live weight and the cost of producing a unit gain in weight. The correlation between the feed intake and feed efficiency and protein efficiency ratio were non significant ($P > 0.05$).

Energy intake correlated positively and significantly ($P < 0.05$) with weight gain, final live weight, crude protein and average daily feed intake. It could be inferred that the low caloric value associated with cassava peel utilization in livestock diets does not only affect the amount of feed consumed but also the final live weight and the rate at which the animals gain weight.

Crude fibre intake data correlated positively and significantly ($P < 0.01$) with the rate of feed conversion efficiency. A significant negative correlation ($P < 0.05$) of $r = -0.4606$ and -0.4535 was also observed when dietary crude fibre intake was correlated with average weight gain and final live weight respectively. This result shows that high level of dietary fibre commonly associated with cassava peels depressed the utilization of other dietary nutrients hence the significant depression on the growth performance especially at the high level of CPM inclusion. The correlation of crude fibre intake with protein efficiency ratio is highly negatively correlated and non significant ($P > 0.05$).

Correlation coefficients between HCN consumption and production parameters showed highly significant positive

correlations ($P < 0.01$) ($r = 0.3460$, 0.8905 and 0.0895) with average daily feed intake, liveweight gain and crude protein intake respectively. Correlation coefficient between HCN intake and feed efficiency, protein efficiency ratio and cost per unit gain in weight were non significant ($P > 0.05$).

The general trend in matrix of correlation for the results of this study seems to suggest that the poor performance of the animals fed high CPM diet compared to the control could be due to the combined effect of cyanide, high level of fibre and low caloric value of cassava peels.

It is concluded that:

1 the expensive maize fraction of the diets of weaner pigs can be replaced by as high as 75% by CPM without deleterious effect on their performance.

2 Increasing the CPM content of the diet to replace maize at a higher level may result to increase in length of feeding time to reach the market weight.

3 Poor performances of pigs on diets containing high CPM levels could be attributed to combined effect of hydrogen cyanide, high crude fibre, low caloric value and dustiness(which might depressed the food intake).

4 There is cost benefit effect of replacing maize with cassava peel in swine diets.

CHAPTER SIX

6.0.0 EXPERIMENT III: THE EFFECT OF DIETARY REPLACEMENT OF MAIZE WITH CPM ON NITROGEN DIGESTIBILITY AND RETENTION BY GROWING PIGS

6.1.0 Introduction

The swine industry in Nigeria, as well as in many African Countries is faced with the problem of rising feed prices. Babatunde *et al.* (1975) opined that inclusion of feed sources that are not consumed directly by man and are available all the year round in pig diets could be one of the means of cheapening the cost of pig feed. One of such by-products is cassava peel. Its only cost is the collection and processing and is available throughout the year. Apart from the admirable metabolizable energy level of 2.16 Kcal/g contained in cassava peels as reported by Tewe (1984), substantial cost reduction with inclusion of cassava peels in diets of pigs has been noted by Obioha *et al.* (1985). However, unlike in ruminants where the inclusion of cassava peels in their diets has resulted in improved dry matter, crude protein, crude fibre and other nutrients digestibilities (Aregheore and Oluokun, 1989) it is poorly digested by the non-ruminant which in the long run depresses the digestibilities and utilization of other nutrients (Tewe and Pessu, (1982), Tewe and Oke (1983) and Sonaiya and Omole (1977). Although the presence of high amounts of fibre and HCN in CPM is known to depress the digestibilities of many of the nutrients, the level at which this happens is not yet clearly defined with the monogastrics. Apart from that, there is paucity of information on

the digestion and utilization of CPM diets by pigs.

The study reported here, was therefore designed to investigate the digestibility and retention of nitrogen of practical diets in which CPM replaced maize at graded levels (up to 100%) with a view to explaining the response pattern observed when pigs are fed high CPM diets.

6.2.0 EXPERIMENTAL PROCEDURES

6.2.1 Experimental design and housing

Ten (10) crossbred (Large White X Landrace) boars of an average initial weight of 36.40kg were randomly assigned to metabolism crates. There were five dietary treatments replicated two times in a randomized block design with faecal and urinary collection period as the blocking factor.

The pigs were housed individually in metal metabolism crates measuring 71.5 x 131.5 x 150.0 cm^3 with slated metal floor to allow for separate collection of faeces and urine. The metabolic crates have provision for feeding and watering. The experiment was conducted at the Ahmadu Bello University Farm, Shika which is about 6km away from Samaru.

6.2.2 Experimental diet

The composition and the calculated analysis of the test diets are presented in Table 6.1 while Table 6.2 shows the proximate analysis of the experimental diets.

The dietary treatments were:

Diet 1 - A 20% CP basal maize-soyabean diet;

Table 6.1: Composition and calculated analysis of the test diets

Ingredient	D I E T S 1	2	3	4	5
Maize	56.87	40.69	25.20	9.37	0.00
Cassava peel meal	0.00	14.22	28.44	42.65	56.87
Soyabean (full fat)	20.48	22.44	23.71	25.33	20.48
Blood meal	5.00	5.00	5.00	5.00	5.00
Wheat offal	10.00	10.00	10.00	10.00	10.00
Cotton seed meal	5.00	5.00	5.00	5.00	5.00
Bone meal	1.50	1.50	1.50	1.50	1.50
Limestone	0.50	0.50	0.50	0.50	0.50
Salt	0.50	0.50	0.50	0.50	0.50
Vit. Premix[a]	0.15	0.15	0.15	0.15	0.15
Total	100.00	100.00	100.00	100.00	100.00
Cost per kg feed (N)	6.14	5.63	5.07	4.54	3.54
Calculated chemical composition:					
Crude protein (%)	20.10	20.20	20.10	20.10	18.22
Metabolizable energy (ME/Kcal/kg)	2906	2744	2588	2430	2332
Calcium (%)	1.4	1.15	1.17	1.18	1.18
Phosphorus (%)	0.70	0.69	0.67	0.65	0.51
Ca: P	1.63	1.67	1.75	1.82	2.31
Crude fibre	4.39	5.58	6.67	7.97	8.94
Lysine	1.18	1.19	1.19	1.19	1.04
Metth. + Cystine	0.64	0.61	0.57	0.53	0.45
HCN mg/kg	-	21.05	42.09	63.12	84.17

[a]Roche VM502 Contributed the following per kg of diet: Vitamin A, 12,000 I.U; Vitamin D_3 1,200I.U; Vitamin E, 3.6 I.U; Vitmain K, 1.8 mg; Vitamin B_2 3.6 mg; Nicotinate, 18mg, Calcium-d-Pantothenate, 9.6 mg; Biotin, 0.36 mg; Vitamin B_{12} 012 mg; Choline chloride 120mg; Chlortetracycline, 4.8mg, Manganese, 24mg; Iron, 48mg; Zinc, 96mg; Copper, 60mg; Iodine, 1.8mg Cobalt, 48mg.

Table 6.2: Proximate Analysis of Diets on Drymatter Basis

	D I E T S				
	1	2	3	4	5
	0	25	50	75	100
Dry matter (%)	89.46	90.18	90.29	91.11	90.96
Crude protein (%)	20.94	23.44	20.25	22.00	19.13
Ether extract (%)	8.33	7.34	6.28	7.07	5.78
Ash (%)	5.07	5.93	7.61	10.52	11.54
Crude fibre (%)	3.20	5.21	6.70	8.50	12.00
Nitrogen free extract (%)	62.46	60.16	59.16	51.91	51.55

Diet 2 – Cassava peel meal (CPM) replaced 25% maize in the basal diet which corresponds to 14.22% level of CPM in the diet.

Diet 3 – Cassava peel meal (CPM) replaced 50% of maize in the basal diet which corresponds to 28.44% level of CPM in the diet;

Diet 4 – Cassava peel meal (CPM) replaced 75% of maize in the basal diet which corresponds to 42.65% level of CPM in the diet, and

Diet 5 – Cassava peel meal (CPM) replaced 100% of maize in basal diet.

The diets were adequately fortified with minerals and vitamins. Handmixing of the experimental feeds on concrete floor was done throughout the experimental period.

6.2.3 Management of the animals and data collection

Before the start of the experiment, all the animals used for the study were held in quarantine for one week during which time they were treated for intestinal parasites using piperazine dewormer. The animals were also dipped in Asuntol solution against external parasites. They were earnotched for identification. The pigs were randomly alloted to their metabolic cages and also randomly assigned to their experimental diets. During the first pre-test period which lasted for five days, the pigs were fed *ad libitum* with the view to determining the average amount of feed intake per animal per day. It was established that on the average each animal consumed approximately 1.50kg of feed per day.

Subsequently, the pigs were fed 1.50kg of feed twice daily one-half of the ration at 8.00 Hrs and the other half at 1600 Hrs throughout the experimental period. Water was also offered to the pigs *ad libitum* .

The trial had three collection periods of five days each and an adjustment period of five days between each collection period. At the end of each collection period, the pigs were reassigned to different treatments in a randomized manner. Ferric oxide powder was used as an innert maker to identify the beginning and end of each faecal collection period (Schneider and Flatt, 1975). The feed allowance for succeeding periods was increased to take care of the growth of the animals.

Faeces were collected from the slatted metal floor of the cage and from the two metal trays fitted below the slatted floor. Faeces were collected daily for each period in plastic bags and stored in a deep freezer. Total collection for a period was dried in an oven at 105°C, cooled and then weighed. It was then milled using GallenKamp medium size mill, equipped with mesh screen. The milled sample was mixed thoroughly and subsamples taken for laboratory analysis. This procedure was repeated for the other periods with the pigs realloted at the beginning of each period to the dietary treatments on a random basis.

Urine was collected daily in plastic buckets to which 15ml of concentrated HCl was previously added. Each daily urine collection was diluted to a constant volume of 4 litres. 100ml aliquot was taken from each day's collection and stored in a refrigerator until analysed for nitrogen.

Refused feed was collected daily and pooled for each phase. It was sundried and then weighed to determine the amount of feed intake.

6.2.4 Chemical analysis

Representative samples of the experimental diets were analysed in duplicate for dry matter, ash, nitrogen, crude fibre and ether extract according to (AOAC, 1989). Faecal samples and Urine were also analysed for nitrogen according to the procedure of AOAC (1980) using kjeldahl method. The chemical analysis was carried out at the Biochemistry laboratory of Animal Science Department, Ahmadu Bello University, Zaria.

6.2.5 Statistical analysis

Statistical analysis of data generated from this study were carried out using analysis of variance procedure as outlined by Snedecor and Cochram (1980) and differences between treatment means were compared using the Duncan's Multiple Range test (Steel and Torrie, 1960).

6.3.0 RESULTS AND DISCUSSION

The highest daily nitrogen intake (66.50g) was recorded by pigs on diet 2. This value was similar to those of pigs on other diets except diet 5 which gave a value of 57.10g and was significantly different ($P<0.05$) from diet 1, 2, 3 and 4 with 63.40, 66.50 and 63.10g nitrogen per day respectively (Table 6.3).

A general linear increase in faecal nitrogen was observed as

Table 6.3: Nitrogen intake, digestibility, Excretion and retention by growing pigs fed diets in which cassava peels replaced maize

Parameters	DIETS 1	2	3	4	5	S.E. of Means	Level of Significance
Nitrogen intake, gN/day	63.40[a]	66.50[a]	61.50[a]	63.10[a]	57.10[b]	2.19	*
Nitrogen intake as percentage of feed intake (%)	51.30[a]	49.10[a]	44.50[a]	42.00[a]	29.70[b]	29.70	*
Nitrogen digested, gN/day	50.17[a]	49.91[a]	49.91[a]	42.25[a]	37.37[b]	3.40	*
Faecal nitrogen, gN/day	13.22[b]	15.94[ab]	17.51[ab]	20.55[a]	21.72[a]	1.72	*
Urinary nitrogen, gN/day	17.70	17.20	16.70	15.80	15.10	3.58	NS
Nitrogen retention, gN/day	32.90[a]	32.70[a]	27.30[a]	26.40[a]	17.30[b]	4.65	*
Nitrogen retention as percentage of digested (%)	64.80	65.80	62.50	62.80	45.80	9.64	NS
Apparent nitrogen digestibility (%)	79.31[a]	74.99[a]	71.72[ab]	66.91[b]	65.38[b]	2.65	NS

a, b, c.....Means on the same row with different superscripts are significantly different

* = $P<0.05$

** = $P<0.01$

NS = Not significant ($P>0.05$)

the level of CPM in the diets increased. The highest faecal nitrogen of 21.72 g/day was obtained from pigs fed diet 5. This value was similar to the other treatments but significantly ($P < 0.01$) higher than the control diet which gave the least value of 13.22 g/day. The control diet had a faecal nitrogen that was significantly different ($P<0.01$) from diets 4 and 5. The use of CPM in pig diets tend to enhance higher loss of nitrogen through the faeces.

Urinary nitrogen excretion data revealed a non-significant difference ($P<0.05$) across the treatments. The highest urinary nitrogen output of 17.20g/day was obtained from pigs fed diets 1 and 2.

Nitrogen retention by the control pigs was the highest at 32.90g/day. This value was however similar to those of diets 2, 3 and 4 which retained 32.70, 27.30 and 26.40gN/day respectively. Significant differences ($P<0.05$) however exist between diets 5 which retained 17.30g of nitrogen compared to the pigs fed the other diets.

Nitrogen digestibility decreased with increased level of CPM in the diet. The control diet had the highest apparent nitrogen digestibility value of 79.31% which was significantly different from those fed diets 4 and 5 with 66.91 and 65.35% respectively but similar to those obtained from animals fed diets 2 and 3 which had apparent nitrogen digestibility of 74.99 and 71.72% respectively.

The significant ($P<0.05$) depression in the amount of nitrogen intake for pigs fed diet 5 (100% maize replacement) compared to the

other dietary treatments could be an indication of the lower crude protein content of that diet. With the total replacement of maize with CPM, it was not possible to get a 20% CP diet. The diet was therefore slightly lower in CP, although, it meets the NRC (1988) requirement for the weight of pigs used. It could also be due to the effect of high fibre on feed intake. Loosli et al 1954 fed rice tusk diets to pigs and reported a linear decline in the amount of nitrogen consumed with increased level of fibre. The differences in the present study and the report of Loosli et al (1954) might be due to the more bulky and more fibrous nature of cassava peels and rice husk respectively. Rice husk is not only bulky but is more fibrous than cassava peel meal and this would have more significant influence on the amount of feed intake. Frank *et al.* (1983) opined that differences in daily nitrogen intake by growing pigs was largely due to differences in daily feed intake.

The faecal nitrogen output increased linearly with increased CPM levels fed to the pigs. This result is in support of Malmlof and Hakanssan (1984) who indicated that the fermentation of fibre in the hindgut of the pig is effected by a proliferation of bacteria, which retain nitrogen during their growth and are passed out in faeces resulting in faecal nitrogen loss. Low (1985) reported that fibre increases nitrogen output in faeces. Morgan and Whittemore (1988) reported a significant ($P<0.05$) increase in faecal nitrogen as the level of crude fibre in the diets of pigs increased. The general linear trend in increase in faecal nitrogen output in this trial as the level of CPM increased in the diets could be due to increase in the level of fibre in the CPM

based diets which might have promoted faecal nitrogen excretion owing to increased output of bacteria.

Nitrogen digested decreased linearly with increased CPM levels fed to the pigs. This result is due to the fact that the higher CPM levels contained more crude fibre which had a negative effect on the digestibility of nitrogen.

The pigs fed the control diet excreted more nitrogen in the urine than pigs fed CPM diets. Increasing fibre in the diet usually result in decreased urinary nitrogen output. Malmlof and Hakanssan (1984) concluded that dietary fibre suppressed ammonia liberation in the colon, through the activity of the microflora, thereby reducing urinary nitrogen excretion. Morgan and Whittemore (1988) reported that urinary nitrogen output, expressed as a proportion of nitrogen intake, decreased significantly ($P<0.01$) with increase in the level of fibre. Although there is paucity of information concerning the digestive and metabolic utilization of nutrients by pigs fed CPM diets for comparison, the linear increase in urinary nitrogen output which is due to the increase in the level of fibre as the level of CPM increased in the diets is in conformity with the reports of Malmlof and Hakanssan (1984) and Morgan and Whittemore (1988). It could be inferred from the result of this study that the inclusion of cassava peels in pigs diets especially at the higher levels may result in higher loss of nitrogen through the faeces than urine.

Nitrogen retention was highest for pigs fed the control diet compared to pigs fed the CPM diets. This result could be attributed to the fibrous nature of the cassava peel meal diets

which might have contributed to poor digestibility of the dietary protein, more excretion of nitrogen through the faeces and thus less retention of nitrogen by the pigs. Kornegay (1973), Babatunde *et al.* (1975) and Yaakugh *et al.* (1988) working with brewer's dried grain (BDG), a fibrous material reported a linear decrease in nitrogen retention as the level of brewer's dried grain increased in the diets. However, Morgan and Whittemore (1988) reported results that indicated a significant ($P<0.01$) linear increase in nitrogen retention as the levels of sugar-beet pulp, (a fibrous material) were increased in the diets of pigs. This they suggested might be explained in terms of the fact that dietary fibre has the tendency of suppressing ammonia liberation in the colon, through the activity of the microflora, thereby reducing urinary nitrogen excretion thus promoting nitrogen retention. They further opined that the increased nitrogen retention could be due to a greater effectiveness of internal nitrogen metabolism with high fibre diets. They concluded that, it was possible that the removal of nitrogen waste products, via the faeces, and the suppression of ammonia release reduces the loading on the nitrogen metabolism process and increases nitrogen retention through a greater efficiency. There is usually an interplay between cyanide in CPM diets and S-amino acids. At hihger level of CPM inclusion, some of the amino acids are utilized for detoxification of hydrocyanic acid to thiocyanate at the expense of their been retained for the growth of the animals (Iyayi and Ngodigha 1991). It is thus possible that the low profile of the amino acids in CPM coupled with the fact that some of them were used for detoxification of the hydrocyanic

acid might be responsible for the decline in nitrogen retained in the pig body as the level of cassava peels increased in the diets.

Apparent nitrogen digestibility coefficient (Table 6.5) decreased linearly ($P<0.01$) with increased level of CPM in the diets. This result could be due to the fact that high fibre diets fed to the pigs increased metabolic faecal nitrogen excretion as also observed by Just (1980). Morgan and Whittemore (1988) reported that fibre often reduces the digestibility of nitrogen by increasing faecal nitrogen output. Frank *et al.* (1984) reported linear decreases in nitrogen digestibility with increased dietary cell wall material. Though the intakes of nitrogen across the treatments were almost similar in the present study, the quantities voided out in faeces by pigs on the CPM test diets were more than those on the control diet hence the decline in apparent nitrogen digestibility. The significant difference ($P<0.01$) observed at the highest level of CPM inclusion in this trial could be due to the increased fibre and bulky nature of that diet which might have reduced the retention time of that diet in the gut thus indirectly affecting the digestibility of the dietary nitrogen. Babatunde *et al.* (1975) and Yaakugh *et al.* (1988) reported a similar trend of result with growing pigs fed Brewer's dried grain (BDG).

It is concluded from this study that:-

1. The replacement of up to 50% of dietary maize by CPM in corn-soy diets was optimum for growing pigs.
2. In view of the fact that there were no significant differences in the digestibility nitrogen by animals fed 50% and 75% maize replacement diets, higher levels of upto 75% maize replacement

(which correspond to 42.28% CPM level) are feasible.

3. Nitrogen digestibility and perhaps utilization by growing pigs may not be significantly depressed when up to 75% of maize in the basal diet was replaced by CPM.

4. Higher levels of maize replacement by cassava peels beyond 75% in practical diets would result in significant depression in the digestibilities of most of the nutrients especially nitrogen.

CHAPTER SEVEN

EXPERIMENT IV

7.0.0 THE EFFECT OF PALM OIL ON CASSAVA PEEL UTILIZATION IN GROWER-FINISHER PIG DIETS

7.1.0 Introduction

With the inadequate supply of the conventional feed resources and the shortage of foreign exchange to facilitate importation, efforts in recent times are geared towards harnessing and utilizing the abundant non-conventional feed resources in Nigeria for livestock feeding. Despite the enormous potential of these non-conventional feed resources in the country, their use as sources of energy or protein especially in monogastric diets has not been remarkable. This is probably because of their high crude fibre content, low caloric and protein value, unpalatability, gritty or dusty nature, presence of some noxious substances that might have deleterious effect on the performance of the animals and lack of adequate informations on their chemical composition. Cassava peel is one of such non-conventional feed sources. Its inclusion in monogastric diets is usually associated with high levels of fibre (Eshiett and Ademosun, 1981) dustiness (Maner *et al.* 1967) low energy value (Sonaiya and Omole, 1977) and high HCN levels (Maust *et al.* 1972). The extent to which it could be included in monogastric diets will therefore depend on measures taken to correct the afore-mentioned factors that are associated with cassava peel utilization in livestock feeds.

In the past, the use of synthetic DL-methionine was always

advocated whenever CPM was to be included in livestock diets. Apart from its function as an essential amino acid, methionine also acts as a sulphur donor for detoxification of cyanide. In view of the non-availability of this product and the current hyperinflation, the prospect of its inclusion in CPM based diets to improve the performance of the animals is blique. A review of the literature has shown that palm oil may play an important role in influencing the use of cassava peel based diets provided such diets are well supplemented with protein sources. In addition to serving as detoxifying agents in CPM diets (Olarewaju and Boszormenyi, 1975, Formuyan *et al.* 1981 and Omole and Onwudike, 1983) and helping to reduce dustiness of cassava peel diets (Tewe, 1975), palm oil serves as a source of essential fatty acids to facilitate supply and absorption of fat soluble vitamins and increase the energy profile of the diet.

While the inclusion of palm oil at higher levels of dietary CPM for pigs may seem attractive, it is necessary to consider its level of inclusion as it may affect the carcass quality of the pig. Shimada *et al.* (1971), Hutagalung (1977) and Balogun *et al.* (1988) have reported improved performance of pigs fed diets supplemented with palm oil. These authors however did not report the effect of palm oil supplementation on the carcass quality of the animals. In a chick study, Edwards (1971) and Edwards and Hart (1971) indicated that when the dietary oil is at a high level, the composition of the body fat of the chick reflected that of the diet. This implies that the use of palm oil especially at the higher level in CPM diets for pigs may have a positive correlation with the body fat of

the pig which may not be in the interest of the pork consumers.

Considering the current market price of palm oil (N450/tin), its use in CPM based diets can only be justified only when the feed efficiency, body weight gain, feed cost per unit weight gain and carcass quality/yield of pigs fed diets supplemented with palm oil are superior or equal to those fed maize reference diets without palm oil.

With the dearth of information on the optimum level of cassava peel and palm oil supplementation adequate for grower-finisher pigs, the objectives of this study therefore were to:-

1. Investigate whether there is actually a requirement for palm oil in CPM-based diets for grower-finisher pigs;
2. Assess the optimum level of CPM and palm oil adequate for grower-finisher pig vis-a-vis the carcass quality,
3. Evaluate the cost benefit of using palm oil in CPM based diets for grower-finisher pigs and
4. provide basis for further research into the effect of using palm oil on the performance and carcass quality of various farm animals fed cassava peel based diets.

7.2.0 MATERIALS AND METHODS

7.2.1 Source and method of processing cassava peel meal

The source and method of processing cassava peel used in this trial were the same as reported in Chapter 3 under item 4:2:1.

7.2.2 Source and general conditions of the experimental animals

The sixteen (16) grower-finisher pigs (12 boars and 4 gilts) used in this study were obtained from the Ahmadu Bello University Farm, Zaria. All the animals were in good health at the time they were procured for the study.

7.2.3 Experimental design and housing

Sixteen (16) grower-finisher pigs used in this study were started on the experiment at an average initial weight of 35.17±0.28kg. The animals were randomly divided into four groups and assigned to four isocaloric and isonitrogenous diets on the basis of initial body weight and sex. Each dietary treatment was replicated in a randomized manner. All the pigs were held individually in a standard open-sided concrete floor pens equipped with watering troughs and feeders. The pig house had asbestors roof. The experiment was carried out at the Ahmadu Bello University Teaching and Research Farm, Zaria.

7.2.4 Experimental diets

The composition and the calculated analysis of the experimental diets are presented in Table 7.1. Proximate analysis of the test diets is shown in Table 7.2. With the exception of cotton seed cake (CSC) and palm oil, the feed ingredients used for this study were the same as in experiments 1 to 3 (chapter 3 to 5) and were obtained from local dealers. The four experimental diets as shown in Table 7.1 were formulated to be isocaloric ($\simeq$ 3130 Kcal ME/kg) and Iso-nitrogenous (16%CP). Proximate analysis of test

Table 7.1: Composition and calculated analysis of the diets fed in Experiment 4

Ingredients	D 1	I 2	E 3	T 4	S
Maize	76.39	51.68	26.80	2.11	
CPM	0	19.10	38.20	57.29	
SBM (full fat)	2.96	5.94	8.97	11.95	
Bloodmeal	8.00	8.00	8.00	8.00	
Wheat offal	10.00	10.00	10.00	10.00	
Palm oil	-	2.63	5.38	8.00	
Bone meal	1.50	1.50	1.50	1.50	
Limestone	0.50	0.50	0.50	0.50	
Salt	0.50	0.50	0.50	0.50	
Vit. Premix[a]	0.15	0.15	0.15	0.15	
Total	100.00	100.00	100.00	100.00	
Calculated analysis					
Crude protein (%)	16	16	16	16	
DE (Mcal/kg)	3.13	3.13	3.13	3.13	
Calcium (%)	0.88	0.90	0.92	0.94	
Phosphorus (%)	0.56	0.53	0.51	0.50	
Ca :P	1.52	1.70	1.80	1.88	
Crude fibre	2.76	4.32	5.88	7.45	
Lysine	0.91	0.93	0.94	0.95	
Methionine	0.26	0.24	0.21	0.18	
Cystine	0.28	0.25	0.23	0.20	
Meth. & cystine	0.54	0.49	0.44	0.38	
HCN Cmg/kg	-				
Cost of diet, N/kg	4.64	4.90	5.20	5.80	

[a]Roche VM502 contributed the following per kg of diet:
Vitamin A, 12,000 I.U; Vitamin D_3, 1,200I.U; Vitamin E, 3.6 I.U; Vitamin K, 1.8mg; Vitamin B_2 3.6mg; Nicotinate, 18mg; Calcium-d-Pantothenate, 9.6mg, Biotin, 0.36mg; Vitamin B_{12} 0.012mg; Choline Chloride 120mg chlortetracycline, 48mg; Manganese, 24mg, Iron, 48mg; Zinc, 96mg; Copper, 60mg; Iodine, 1.8mg; Cobalt 0.48mg.

Table 7.2: Proximate Analysis of Diets on Drymatter Basis

	D I E T S			
	1	2	3	4
Dry matter (%)	91.98	91.75	91.62	90.52
Crude protein (%)	16.18	16.20	16.48	16.05
Ether extract (%)	6.32	8.78	10.70	11.69
Ash (%)	9.18	10.07	11.89	13.56
Crude fibre (%)	2.90	4.89	6.20	7.98
Nitrogen free extract (%)	65.42	60.06	54.73	50.72
Metabolizable Energy (Kcal ME/kg)[1]	3130	3130	3130	3130

[1]Calculated value

diets were carried out according to the method outlined by A.O.A.C. (1980) at the Biochemistry Laboratory of Animal Science Department, Ahmadu Bello University, Zaria.

Diet 1 served as control and was not supplemented with palm oil. The control diet contained 3130 Kcal ME/kg diet, while palm oil was used to raise the dietary energy in diets 2, 3 and 4 to 3130 Kcal ME/kg diets corresponding to palm oil levels of 2.63, 5.38 and 8.0% respectively.

The dietary treatments were:-

Diet 1 - A 16% CP basal maize - soyabean diet;

Diet 2 - Cassava peel meal (CPM) replaced 25% of maize in the basal diet which correspond to 19.10% level of CPM in the diet.

Diet 3 - CPM replaced 50% of maize in the basal diet which correspond to 38.20% of CPM in the diet.

Diet 4 - CPM replaced 75% of maize in the basal diet which correspond to 57.29% level of CPM in the diet.

All the diets were fortified with minerals and vitamins. The feed was handmixed on concrete floor forthnightly to minimise the problem of rancidity which might arise as a result of long storage of oil-containing feed.

7.2.5 Management of the experimental animals and performance data collection:

All the pens were washed and disinfected a week before the start of the experiment. Thereafter, they were cleaned of faecal materials and urine every morning throughout the experimental period. As part of the routine management, pigs were dewormed

using piperazine dewormer solution before the start of the experiment. The pigs were also dipped in Asuntol solution against external parasites. All the animals were earnotched for the purpose of identification. Before the commencement of the experiment, all the animals were fed the same diet for a period of one week. They were all allowed adjustment period of five days on their test diets. Thereafter, they were weighed to mark the beginning of the experiment. The animals were fed once daily at 8.00 a.m throughout the experimental period. Feeding and watering were done *ad-libitum*. All necessary measures were taken to prevent feed wastage and unnecessary water spillage. All feeds not consumed were removed, weighed and recorded at the end of each week to enable calculations of weekly intake of feed.

Pigs were weighed at the beginning and at the end of the experiment as well as at weekly intervals. At the end of every week, performance data such as average daily feed intake, average daily gain, feed efficiency, protein efficiency ratio and cost per kg gain in weight were computed as presented in Table 7.3. The final liveweights of the animals were also recorded.

7.2.6 Carcass evaluation

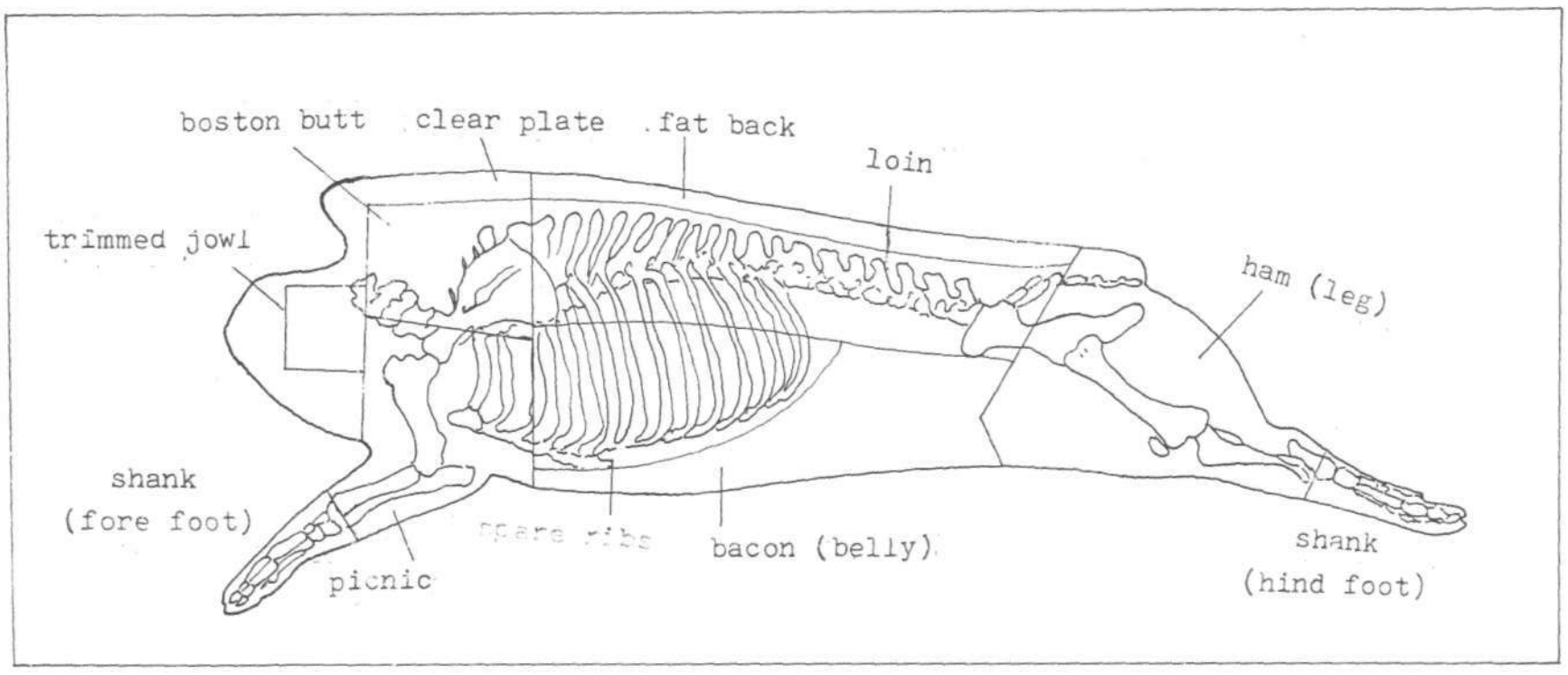
At the end of the 42 days trial, three pigs from each treatment making a total of 12 pigs were selected on the basis of averagae final liveweight for each treatment and were taking to the Ahmadu Bello University Meat Processing Laboratory (Meat Lab.) for carcass evaluation. The carcass analysis was carried out according to the procedure of Arganosa (1972) and Eusebio (1980).

All the pigs earmarked for the carcass study were starved for 18 hours and were weighed to obtain the liveweights at slaughter. They were individually stunned and immediately bled by severing their jugular veins just below the head. The bled carcasses were scalded using hot water of 80°C for five minutes and then dehaired using the dehairing machine available in the meat laboratory. Evisceration was then carried out. The spleen, lungs, heart, kidney and the liver were excised and weighed and the weights expressed as percentages of body weight. The length of the cleaned intestines were measured using Tailor's measuring tape. The carcasses after the stomach; intestines and the soft organs had been removed were then chilled at 5°C for 24 hours. The chilled carcasses were splitted into two longitudinal halves. On both halves, the carcass length, average backfat thickness and loin eye area were determined. Carcass length was measured from the anterior edge of the first rib adjacent to the vertebra to the aitch bone and the average length of both halves were recorded.

Backfat thickness was measured at the first rib, 10th rib and the junction between the second and the third lumbar vertebra on both halves and the average was recorded.

Area of longissimus dorsi muscle (eye muscle) was determined by a planimeter measurement from a tracing of a cross section of the right longitudinal dorsi cut perpendicular to the linear axis at a point immediately posterior to the junction of the 10th rib and the 10th thoracic vertebra counting from the anterior end of the carcass.

The carcass was then cut into: ham between the second and the



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

third lumbar vertebrae and perpendicular to the back line. Shoulder - between the second and the third ribs. The trotters were separated from both the front and hind legs. The head was severed from the carcass. These various cuts (Fig. 1) were weighed and expressed as percentages of the liveweight.

All carcass yield trimmed and untrimmed were weighed and calculated as percentage of liveweight. Trimmed cuts were obtained by maximally removing fat thickness plus the skin and weighed. Dressing percentage was based on liveweight after 18 hours of fasting.

7.2.7 Statistical analysis

Results obtained from this study were analysed by the analysis of variance (ANOVA) technique of Cochran and Cox (1957). Differences between paired means were assessed by the least significant difference (LSD) method.

7.3.0 RESULTS

The results of final liveweight, average daily gain (ADG), feed intake, feed/gain ratio, protein efficiency ratio (PER) crude fibre intake, energy intake (Kcal ME day^{-1}), average HCN intake, cost per kg gain in weight and carcass evaluation are presented in Tables 7.3, 7.4, 7.5 and 7.6 respectively.

With the exception of pigs fed diet 4, pigs fed cassava peel meal based diets supplemented with palm oil gave a better final liveweight than the control, although the differences were non-significant. Diet 3 with 38.20% CPM supplemented with 5.38% CPM

Table 7.3: Effect of CPM on performance of growing-finishing pigs

Parameters	D I E T S				S.E. of Means	Level of Significance
	1	2	3	4		
Average initial weight (kg)	35.30	35.45	34.90	35.03	55.80	NS
Average final live weight (Kg)	52.90	53.10	54.73	50.90	5.94	NS
Average Daily Feed intake g/day	1630.00	1646.00	1839.00	1728.00	152.40	NS
Average Daily Weight gain g/day	436.00	452.00	503	402	83.20	NS
Feed Efficiency Ratio (F/G)	3.74	3.66	3.64	5.30	1.69	NS
Daily Crude Protein intake g/day	251.68	263.30	294.00	276.50	0.56	NS
Protein Efficiency ratio (PER)	1.60	1.74	1.70	1.40	0.66	NS
Average Daily Energy Intake, ME Kcal/kg/day	4.92	5.15	5.75	5.49	0.51	NS
Average Daily Crude Fibre Intake g/day	49.00^{c}	71.00^{b}	108.00^{a}	128.50^{a}	8.28	**
Average Daily HCN Intake mg/day	0^{d}	46.52^{c}	103.95^{b}	146.50^{a}	8.34	**
Average Cost/kg Weight gain (N)	19.12	19.14	19.18	26.55	3.67	NS

NS = Non Significant difference (P>0.05).

** = Row means with different superscripts **are sig**nificantly different (P>0.01).

Table 7.4: Carcass characteristics of growing-finishing pigs fed cassava peel meal diets

	DIETS				S.E. of Means	Level of Significance
	1	2	3	4		
Average slaughter weight (kg)	48.67	51.33	53.33	48.67	7.45	NS
Average warm carcass weight (kg)	33.97	35.03	41.76	32.47	5.80	NS
Average warm carcass yield (%)	69.56b	68.05b	77.96a	67.13b	2.196	**
Average chilled carcass weight (kg)	33.03	34.23	37.83	31.97	5.57	NS
Average chilled carcass yield (%)	67.67	6.65	70.48	66.17	2.723	NS
Average carcass length (cm)	66.00	66.92	68.33	63.72	2.514	NS
Average Back fat thickness (cm)	1.48	1.89	2.01	2.08	0.895	NS
Average Area of longissimus dorsi (cm2)	9.50	8.83	7.58	7.33	1.407	NS
Average chilled Ham yield (%)	17.55	17.17	17.91	17.62	1.237	NS
Average chilled shouldar yield (%)	17.55b	17.73b	20.99a	17.91b	0.731	**
Averaged chilled boston Butt yield (%)	8.33	7.44	7.67	5.31	1.253	NS
Average Head yield (%)	7.22	7.09	7.58	7.41	0.708	NS
Average feet (trotters) yield (%)	3.01	2.99	3.32	3.05	0.1190	NS

NS = Non Significant difference (P>0.05).

** = Row means with different superscripts **are significantly different (P > 0.01)**

Table 7.5: The effect of feeding cassava peel meal on length of intestines, stomach weight and soft-organs weight of growing-finishing pigs

	DIETS				S.E. of Means	Level of Significance
	1	2	3	4		
Average length of small intestine (cm)	1634.00	1833.33	2085.00	2118.33	376.10	NS
Average length of large intestine (cm)	401.33	412.33	417.00	452.33	31.90	NS
Average liver weight (g)	1060.00	1127.00	1283.00	1313.00	215.40	NS
Average lungs weight (g)	773.00	750.00	764.00	787.00	167.70	NS
Average heart weight (g)	233.00	240.00	210.00	218.00	56.30	NS
Average kidney weight (g)	180.00	181.00	220.00	253.00	61.30	NS
Average spleen weight (g)	108.00	92.00	108.00	120.00	23.59	NS
Average empty stomach weight (g)	502.00	587.00	624.00	505.00	69.60	NS

NS = Non Significant difference (P>0.05).

Table 7.6: The effect of feeding cassava peel meal on percentage yield of the intestines, stomach and soft organ offals of growing - finishing pigs

	D I E T S				S.E. of Means	Level of Significance
	1	2	3	4		
Small and large intestine average yield (%)	6.53	5.03	4.90	5.84	0.754	NS
Empty stomach average yield(%)	1.02	1.15	1.18	1.04	1.1079	NS
Liver average yield (%)	2.20	1.90	2.49	2.72	0.02824	NS
Lung average yield (%)	1.58	1.42	1.51	1.71	0.418	NS
Heart average yield (%)	0.49	0.35	0.45	0.48	0.1223	NS
Average Chilled kidney yield (%)	0.38	0.37	0.43	0.50	0.1044	NS
Average Spleen yield (%)	0.23	0.18	0.21	0.25	0.0508	NS
Average edible offals yield (%)	19.64	18.09	18.13	19.94	1.519	NS
Average Warm Carcass and Edible offal yield (%)	89.21	86.18	96.05	88.70	3.83	NS

NS = Non Significant difference (P>0.05).

oil recorded the highest final liveweight of 54.73kg. This was comparable (P>0.05) with diets 2, 1 and 4 which recorded 53.10, 52.90 and 50.90kg respectively. Diet 4 with 57.29% CPM and 8.0% palm oil gave the lowest final liveweight.

The amount of feed consumed was similar (P>0.05) for all treatments. Highest feed intake per day of 1839.0g was obtained from diet 3 followed by diets 4, 2 and 1 with 1728, 1646.00 and 1630 g/day respectively. These differences were however non-significant.

Average daily gain was highest with pigs on diet 3 supplemented with 5.38% palm oil. They grew faster than pigs fed diets 1, 2 and 4 by 10.93, 10.14 and 20.08% respectively. Increasing the levels of CPM and palm oil induced enhanced rate of gain upto the 38.20CPM inclusion level (50% maize replacement) after which a slight decrease in the daily gain was noticed. All differences in dietary means were however not significant (P>0.05). Pigs on diet 3 gained an average of 503 g per day while those on diet 2, 1 and 4 recorded 452, 436 and 402 g per day respectively.

Efficiency of feed conversion revealed that with the exception of diet 4 (which had 57.29% CPM level supplemented with 8.0% palm oil) there appeared to be an improvement on the rate of feed conversion on the CPM based diets over the control diet. Diet 2 was the most efficiently utilized being 1.38, 13.19 and 45.66% more efficient than diet 3, 1 and 4 respectively. While the control diet gave a feed efficiency ratio of 3.74, diets 2, 3 and 4 recorded 3.64, 3.69 and 5.30 respectively. The difference between treatment means were however not statistically significant

(P>0.05).

The weight gain per unit protein intake was statistically comparable (P>0.05) across all the treatment means. No particular trend was however observed in protein efficiency ratio. While the control diet gave a protein efficiency ratio of 1.60, diets 2, 3 and 4 recorded 1.74, 1.70 and 1.40 respectively. It is interesting to note that except for pigs fed diet 4, protein utilization appeared to be more efficient on CPM diets supplemented with palm oil than the control diet.

The cost to produce a unit gain in body weight of the pigs increased with increased level of CPM and palm oil in the diets. The least expensive gain of N19.12 per kg body weight gain was obtained from the control diet. This was not statistically different (P>0.05) from diets 2, 3 and 4 which cost N19.14, 19.18 and 26.55 per kilogramme gain respectively. The most expensive weight gain of N26.55 per kilogramme gain was recorded for diet 4 which had the highest level of CPM (57.29%) and palm oil (8%) inclusion.

The summaries of data on the carcass evaluation of grower-finisher pigs fed CPM-based diets supplemented with palm oil are presented in Tables 7.4, 7.5 and 7.6. The parameters included slaughter weight, dressed weight, warm and chilled carcass yield(%) carcass length, ham yield(%) shoulder yield(%) Boston butt yield(%), Backfat thickness, Area of longissimus dorsi (cm^2), head yield(%), trotters yield(%); length of the small and large intestine, weight and yield of vital organs such as liver, lungs, heart, kidney, spleen and the empty stomach.

With the exception of warm carcass yield and chilled shoulder yield which showed significant differences ($P<0.01$) between means, the other parameters recorded no significant differences among treatment means. Pigs fed diet 3 recorded the highest slaughter and warm dressed weights of 53.33 and 41.76kg respectively. These were however comparable with diets 1, 2 and 4 with 48.67, 51.33, 48.67kg slaughter weight and 33.97, 35.03 and 32.76kg dressed weights respectively. There were no significant differences in the chilled carcass weight of the pigs that received the different treatments. In terms of warm carcass yield, pigs on diet 3 had the highest carcass yield of 77.96% which was significantly different ($P<.01$) from treatments 1, 2 and 4 with 69.56, 68.05 and 67.13% carcass yield respectively.

The chilled carcass yield (dressing percentage) of pigs fed the experimental diets were similar ($P > 0.05$). Pigs on diet 3 however had the highest chilled carcass yield of 70.48 compared to diets 1, 2 and 4 with chilled carcass yield of 67.67, 66.65 and 66.17% respectively. Lowest weights and yield of all the above parameters were obtained from pigs fed diet 4 where 75% of maize in the basal diet was replaced with CPM and 8% palm oil added to the diet.

The result for the carcass length, backfat thickness and area of longissimus dorsi are presented in Table 7.4. The carcass length of the animals increased with corresponding increase in the level of CPM, and palm oil supplementation. The carcass length however was least for those pigs fed diet 4. The highest carcass length was obtained from pigs on treatment 3 with 68.33cm followed

by pigs fed diets 2, 1 and 4 with 66.92, 66.00 and 63.72 cm respectively. The treatment means were however similar for all the treatments.

The results for the average backfat thickness did not show any statistical differences (P>0.05) between the treatment means. However, the back fat thickness increased with increasing level of CPM and palm oil in the diets. The highest backfat thickness was obtained from pigs fed treatment 4 with 2.08cm, then followed by pigs fed diets 3, 2 and 1 with 2.01, 1.89 and 1.48cm respectively. The loin-eye area (cm^2) decreased with corresponding increase in levels of CPM in the diets. Mean loin-eye area was highest for pigs fed the control diet and closely followed by those pigs fed diets 2, 3 and 4 (9.50 Vs 8.83 Vs 7.58 Vs 7.33 cm^2) respectively. However, the differences between the treatment means were not significant (P>0.05).

The chilled ham yield showed non-significant differences (P>0.05) between the treatment means. Shoulder yield showed significant differences (P<0.01) among the pigs fed different levels of CPM and palm oil. Chilled shoulder yield was highest (P<0.01) at 20.99% from pigs that were fed diet 3. However, chilled shoulder yield of pigs fed diets 4 and 2 were similar to that of the control.

The control diet recorded the highest yield (%) of boston butt which was similar (P>0.05) to those pigs fed diets 3, 2 and 4 (8.33 Vs 7.44 Vs 7.67 Vs 5.31%) respectively.

The data obtained in this trial revealed that there were no significant differences (P>0.05) between treatment means for the

percent yield of head and feet (trotters).

The intestinal linear measurement data (Table 7.5) showed that the length of the small intestine increased insignificantly ($P>0.05$) with increase in the replacement level of CPM. Pigs fed diet 4 with 57.29% CPM level and 8.0% palm oil gave the highest linear measurement of 2188.33cm. This was followed by treatments 3, 2 and 1 with values of 2085.00, 1833.33 and 1634.00cm respectively. The linear measurement of the large intestine followed the same trend with that of the small intestine. The shortest length was recorded from pigs fed the control diet, followed by treatment 2, 3 and 4 (401.33 Vs 412.33 Vs 417.00 Vs 452.33cm) respectively. In all cases an increase in the linear measurement of the intestine with corresponding increase in the level of CPM was observed.

The average liver, heart and spleen weights are presented in Table 7.5. Liver average weight showed no significant differences ($P>0.05$) among treatment means. Liver weights increased as the level of CPM and palm oil level in the diet increased. Pigs fed the control diet which had no CPM and palm oil had the least weight of 1060g when compared to the CPM based diets. Pigs fed diet 4 recorded the highest average liver weight (1313g). This was followed by those pigs fed diets 3, 2 and 1 which weighed 1283, 1127 and 1060 respectively.

There was no defined trend for the average heart weights. Average heart weight was highest for pigs fed diet 2 with 240g. This was followed by those fed diet 1, 4 and 3 (233 Vs 218 Vs 210g) respectively. The differences between treatment means were however

not significant (P>0.05).

The differences in spleen weights were inconsistent and are statistically non-significant (P>0.05) between treatment means. Highest spleen weight of 120.0g was obtained from pigs fed diet 4 with the highest level of CPM inclusion. This was followed by treatments 1 and 3 (168 Vs 108 g). The lowest spleen weight (92.0g) was observed for pigs fed diet 2.

Pigs fed the CPM diets with palm oil had heavier kidney weight compared to those pigs on the control diets. The least liver weight was obtained from pigs fed the control diet and it was comparable (P>0.05) to those pigs fed diets 2, 3 and 4 with 180, 181, 220 and 253 g respectively.

The results show no significant differences (P>0.05) among treatment means. Treatment 4 gave the highest lung weights (787.00) which were comparable (P>0.05) to treatments 1, 3 and 2 with 773, 764 and 750.0g respectively.

The empty stomachs of pigs fed diets containing CPM were inisignificantly heavier (P>0.05) than those fed the control diet. The empty stomach average weight was highest (624.0g) in pigs that were fed diet 3. This was followed by those fed diets 2, 4 and 1 with 587, 505 and 502g respectively.

The differences in percentage yield of the liver was statistically insignificant (P>0.05) for all the tested diets (Table 7.6).

Diet 3 gave the highest liver yield (2.49%) and this was comparable to percentage values obtained from treatments 4, 1 and 2 with 2.72, 2.20 and 1.90% yield respectively. The average heart

yield slightly decreased in the cassava peel meal fed diets. The difference in percentage yield were however not statistically significant (P>0.05) between the control and the CPM – based diets. The lowest percentage heart yield (0.49%) was obtained from pigs fed diet 2 followed by those fed diets 3, 4 and 1 with 0.45, 0.48 and 0.49% yield respectively.

There was a similarity in the means of percentage yield of the spleen (P>0.05). The highest yield of the spleen (0.25%) was recorded on diet 4 which was closely followed by those fed diets 1, 3 and 2 with 0.23, 0.18 and 0.21% respectively.

Treatment 4 gave the highest lungs yield (1.71%) which was comparable (P>0.05) to other dietary treatments. The lowest average lung yield (1.42%) came from diet 2 which was closely followed by treatments 3 and 1 with 1.51 and 1.58% respectively.

A similar trend was observed for kidney yield. With the exception of average kidney yield (0.37%) obtained from treatment 2, a progressive insignificant (P>0.05) increase in the CPM based diets with palm oil was observed (0.37 Vs 0.43 Vs 0.50).

The gut yield which consist of intestine and empty stomach yield is presented in Table 7.6. The control diet gave the highest intestinal yield as compared to the CPM based diets (6.53 Vs 5.03 Vs 4.90 Vs 5.84%). The lowest intestinal yield (4.9%) was obtained from pigs fed diets 3 and was closely followed by those fed diets 2 and 4 with 5.03 and 5.84% yield respectively. The difference between the treatment means of all the tested diets were however not statistically significant (P>0.05).

The results for the average empty stomach yield did not show

any statistical difference (P>0.05) between the treatment means. Diet 3 gave the highest yield (1.18%) and it was comparable (P>0.05) to those pigs fed diets 2, 4 and 1 with 1.15, 1.04 and 1.02% yield respectively.

The results for the edible offal yield and warm carcass and edible offal yield (%) are presented in Table 7.6. Treatment 4 gave the highest edible offal (19.94%) which was closely followed by treatments 1, 3 and 2 with 19.64, 18.13 and 18.09% respectively.

In terms of warm carcass yield plus the edible offal yield, diet 3 had the best yield (95%). This was followed by pigs fed treatments 1, 4 and 2 with 89.21, 88.70 and 86.18% respectively.

7.4.0 DISCUSSION

Results of this study show the nutritive value of cassava peel in diets of grower-finisher pigs. Though cassava peel is low in protein and is a respository of cyanide, it is a potential source of energy in the diets of grower-finisher pigs when supplemented with adequate protein, minerals and vitamins.

The similarities in initial and final liveweight of the pigs observed in the present trial is an indication that the experimental animals were adequately balanced for age, sex and size. The superiority of the CPM based diets fed upto the level of 38.20% supplemented with palm oil when compared to the maize reference diet further suggests that inclusion of palm oil in CPM based diets fed to pigs has the tendency of reducing the time that will be taken to finish them. Beyond 38.20% level of CPM inclusion, it will take a longer time to finish the pigs despite

the palm-oil supplementation to balance for energy. A further study in which the pigs are raised up to 90kg and above using the same diets above might be necessary to confirm this assertion. Suffice to mention that apart from increasing the time to finish the pigs, raising pigs on diet 4 will not be economical since it is the most expensive diet because of the level of the very expensive palm oil suplementation.

The feed intake data obtained from this study have confirmed the advantages of supplementing palm oil in cassava peel meal based diets. Obioha *et al.* (1985) using 0 to 60% CPM inclusion in growing-finishing diets for pig, formulated to be isocaloric and isonitrogenous, reported that the maize reference diet maintained a considerable though non-significant superiority over the CPM - based diets in terms of feed intake. Taylor *et al.* (1987) also observed a decrease in the amount of feed consumed with increase in the level of CPM. The result of this study however revealed that more of the CPM - based diets were consumed compared to the maize diet. The difference in the trend of result obtained from the present study and that of Obioha *et al.* (1985) and Taylor *et al.* (1987) may be attributed to palm oil supplementation. While attempts was made to make the experimental diets isocaloric and isonitrogenous by addition of palm oil in the present study, such supplementation was not done by Obioha *et al.* (1985) and Taylor *et al*, (1987). Formuyan *et al.* (1981) had earlier reported improved palatability and reduction in dustiness of the CPM based-diets with the addition of palm oil which may account for the non-significant superiority of the CPM based diets over the control diets in this

study.

Sonaiya and Omole (1977) using 0 to 15% CPM inclusion rates in finishing pig diets reported that the amount of feed consumed was similar on all the treatments (0.89 Vs 0.89 Vs 0.89 Vs 0.89kg) for 0, 5, 10 and 15% CPM inclusion rates respectively. In the present trial, a progressive non-significant increase in the amount of feed consumed was observed with increase in the level of CPM. Apart from the fact that the added palm oil might have enhanced feed consumption, the method of feeding used in the present trial was different from that of Sonaiya and Omole, (1977). While the animals were fed a restricted amount of feed which they completely consumed as reported by Sonaiya and Omole, (1977), feed were offered *ad libitum* in the present study.

Inclusion of CPM at higher levels in monogastric diets is usually associated with high level of fibre (Eshiett and Ademosun, 1981) which tends to increase the voluntary feed intake of the pigs (Feed International, 1985). In the present study, the crude fibre increased from 2.76% on the control diet to 4.32, 5.88 and 7.45% in diets 2, 3 and 4 respectively and might be responsible for the increase in feed intake as the level of CPM increased in the diet. This is also in agreement with ARC (1967).

Davidson (1964) reported that feeds for growing pigs should not contain more than 6% of crude fibre or else feed intake might be depressed. In the present study, there was a slight depression in the amount of feed consumed in diet 4 with 7.45% crude fibre as compared to diet 3 with 5.88% crude fibre. The drop in feed intake as revealed in diet 4 is in support of Davidson, (1964). The

research findings of Lloyd *et al.* (1978) also give an appropriate explanations to the drop in feed intake in pigs fed diet 4 with the highest level of fibre. These workers reported that feeds high in crude fibre content can limit the weight of feed consumed by the pig.

Bohman *et al.* (1963) and Pond *et al.* (1981) linked the bulky nature of high fibre diets with increase in weight/volume of the stomach and various segments of the gastro-intestinal tracts which may result in increased capacity of the gastro-intestinal tracts to accommodate more or large quantities of bulky feed materials. Although the data collected on stomach weights and intestinal lengths showed no significant ($P>0.05$) increase in the gut measurement, the slight but non-significant increases observed in the present study (Table 6.3) may partially account for the linear increase in feed intake upto the 50% maize replacement level. Above this level, the drop in feed intake could be due to other factors related to palatability.

Growth data revealed that the dietary inclusion of CPM upto 38.20% (50% maize replacement) non-significantly ($P>0.05$) improved the rate of weight gain compared to the control diet. However at the highest level of CPM inclusion (57.29%) growth performance dropped slightly. Sonaiya and Omole (1977) fed CPM at 0 to 15% in diets of finishing pigs and reported that all the CPM diets promoted faster rate of growth in pigs than the control diet. The 15% inclusion rates however, produced slower rate of gain compared to the other CPM - based diets. Manikam and Gopalkrishman (1978) fed CPM at 0 to 30% in diets of growing-finishing pigs and observed

that the rate of gains were almost equal at the 20% level of inclusion but at 30%, rate of gain was depressed. Nestel and Macintyre (1973) had earlier reported a slight growth depression at a higher levels of inclusion. In the other hand, Tewe and Oke (1983) and Obioha *et al.* (1985) have reported that the body weight gain was highest on the control diet compared to the CPM based diets fed to growing-finishing pigs.

The trend of results obtained from this study is in agreement with those of Sonaiya and Omole (1977); Manikam and Gopalkrishman (1978) and Nestei and Macintyre (1973). Higher levels of CPM was however tolerated by the pigs in the present study compared to these workers' findings. The increased growth rate of pigs fed upto 38.20% CPM level as compared to the growth performance of the pigs fed the control diet could be attributed to the palm oil supplementation in attempt to offset the energy imbalance of the CPM based diets. Gear *et al.* (1981) reported that the use of CPM which is usually associated with high level of fibre normally result in more rapid transit times of diet through the gastro intestinal tract. Apart from palm oil serving to reduce the dustiness of CPM diets and serving as a source of essential fatty acids to facilitate supply and absorption of fat soluble vitamins, it exerts an extra metabolic effect on energy metabolism by slowing down the rate of passage of diet through the digestive tract (Mateos and Sell (1981). A situation as this will allow longer contact with the digestive enzymes and possibly microorganisms necessary for fermentation of indigestible fraction of the feed like the fibre. Boenker *et al.* (1969) explained that fibre has a

low nutrient value in it self, decreases apparent dry matter digestibilities, contributes little if any digestible nutrients and also makes other nutrients less available for growth. Just (1980) reported that the presence of high levels of fibre in the diets increased metabolic faecal nitrogen excretion by impairing the digestibilities of growth promoting nutrients such as nitrogen and Nitrogen Free Extract. It is interesting to note that although the crude fibre intake data obtained from the present study revealed significant differences ($P<0.01$) for pigs fed up to 57.28% CPM in their diets, an improvement in growth performance of pigs fed up to 38.20% CPM compared to the control diet was observed. This could be due to the prolongation of transit time of the ingested feed in the gastro intestinal tract which allowed longer contact with the digestive enzymes and microorganisms necessary for fermentation as a result of the palm oil supplementation. This in turn promote effective utilization of dietary nutrients for body building.

Hale and Johnson (1970) and Cooke *et al.* (1972) observed that pigs fed on high energy diet gained 13% faster than pigs fed on low-energy diets. Metz *et al.* (1980) reported that reduced energy intake of the diet can result in reduction in the deposition of protein by 8% and of fat by 28% in the whole body. This implies that feeding a suboptimal level of energy in diets of pigs may have a negative influence on the weight gain. In the present trial, all the test diets were isocaloric and the energy intake data across the treatments were comparable ($P>0.05$). This is an indication that the slight differences in growth rate observed may not be attributed to either the energy status of the diet or the energy

intake but rather to other factors like fibre, hydrocyanic acid and palm oil supplementation.

Sitompul (1977) reported that weight gain depression as a result of the HCN occurs at 100 ppm or above. In this trial, the HCN intake at 57.28% CPM level of inclusion rose to 146.50 mg/kg and was statistically significant ($P<0.01$) when compared to other CPM, diets. The drop in weight gain data when 57.28% CPM level was fed to the pigs in the present study may be attributed to the interplay between cyanide in the diet and sulphur amino acids. At such high levels of CPM inclusion there is the tendency for some of the amino acids to be used for the detoxification of hydrocyanic acid to thiocyanate at the expense of growth of the animals. It is also most likely that although the 75% maize replacement diet (57.28% CPM level) had higher protein contribution from soyabean, that was not enough to overide the effect of dietary cyanide, bearing in mind the absence of supplemented methionine in the CPM based diets. The result for the protein efficiency ratio (PER) indicated a poorer conversion of the dietary protein to weight gain as the level of CPM increased in the diet. The lowest value of 1.40 was recorded for those pigs fed diet 4 as compared to 1.78, 1.74 and 1.70 for diets 1, 2 and 3 respectively. The trend of the protein efficiency ratio results obtained in the present study seem to support the fact that the depressed growth rate at the 57.28% CPM level of inclusion was probably because of the high fibre which might have impaired protein digestibility and the presence of high level of HCN which resulted in some amino acids in the diet been used for detoxification of HCN to thiocyanate at the expense of

growth of the animals.

Judging from the improved growth performance of pigs fed diets 2 and 3 compared to those fed the control diet (0% CPM diet) in the current study, it can be inferred that cassava peels can constitute up to 40% of the compounded diet of grower pigs without having a negative influence on the rate of growth provided it is supplemented with palm oil. Tewe and Pessu (1982) and Tewe and Oke (1983) had earlier reported the use of up to 40% CPM level of inclusion in grower-finisher pig's diet without significant effect on the performance of the animals. In the same vein, experimenting with rabbit a level of 5% (Omole and Onwudike, 1983) and 1.5% palm oil (Iyayi and Ngodigha, 1991) have revealed linear improved growth performance of rabbit fed diets of up to 50% CPM inclusion.

The results obtained from this study indicate similarities in the amount of feed required per unit weight gain across the treatments. Sonaiya and Omole (1977) and Obioha and Anikwe (1982) obtained similar results when finishing pigs were fed up to 15% CPM in the diets. Other workers (Tewe and Oke (1983) and Obioha *et al.* (1985) have also reported a non-significant ($P>0.05$) increase in quantity of feed required per unit weight gain when up to 30% and 60% CPM were fed in finisher pig diets respectively.

Generally, the inclusion of fibrous feedstuff in pig diet often leads to depressed feed efficiency. Liao (1985) reported that over 60% fibre in finisher pig diets resulted in poorer feed conversion efficiency. Other workers have shown that dietary fibre levels of 4-13% did not significantly affect feed conversion efficiency in finishing pigs (Babatunde *et al.* 1975, Pond *et al.*

1981 and Drewry *et al.* 1981).

The dietary fibre levels in the present study ranged from 2.76 to 7.45% and were thus within a range that would not cause significant variation in feed conversion ratios.

It is of interest to note the slight but non-significant improvement on feed conversion of pigs fed the CPM diets up to 38.20% CPM inclusion level as compared to the control diet. Fats are known to improve utilization of dietary nutrients (Mai Orino *et al.* 1986). Shimada *et al.* (1971) reported that 3% palm oil in higher levels of cassava meal diets either in presence or absence of methionine resulted in improved feed conversion efficiency in pigs. Omole and Onwudike (1983) and Iyayi and Ngodigha (1991) also observed an improvement in feed conversion efficiency of rabbits fed CPM diets with palm oil. The linear improvement on the feed to gain ratio of pigs fed upto 38.20% CPM levels with palm oil as compared to the control diet in the present study is in support of Shimada *et al.* (1971), Omole and Onwudike (1983) and Iyayi and Ngodigha (1991).

The use of cassava peels which normally cost little or nothing to obtain is usually associated with reduction in unit cost of pig and poultry diets (Obioha *et al.* 1985; Tewe, 1986; Aduku *et al.* 1991 and Tegbe *et al.* 1992). This enormous savings in cost of feed and economy of gain is usually due to the price differential between maize and cassava peel. In the present trial, the economic performance of the pigs (measured by feedcost per kilogramme gain in weight) on cassava peel diets were inferior (>P0.05) to the performance of those fed the control diet. Contrary to the reports

of Obioha *et al.* (1985); Tewe (1986); Aduku *et al.* (1991) and Tegbe *et al.* (1992), a linear increase in the unit cost of feed and the cost of feed per kilogramme weight gain was observed. The difference between the results reported by these earlier workers and the present study could be due to the addition of palm oil to the diets. Whereas palm oil was used in the present study in attempt to make all the experimental diets isocaloric, such supplementations was not done by these other workers. The replacement of substantial amount of maize with cassava peels at a higher level of inclusion resulted in the use of more palm oil to beef up the energy level. The current price of palm oil is more than that of maize. Whereas maize cost N6.00 per kg. palm oil costs about N14 per kg. This implies that the cost of compounded diets for pigs will increase with the corresponding increase in the level of palm oil in the diet. Tewe (1986) experimenting with layers had earlier reported that the supplementation of palm oil in CPM diets resulted in an increase in the price of feed per unit weight gain and had resulted in reducing the cost benefit of using cassava peel to the producer. Palm oil supplementation in the present study resulted in a 5.60, 12.60 and 25% rise in unit price of feed fed at 19.10, 38.20 and 57.29% CPM level of inclusion respectively. Every attempt to reduce these costs will therefore be welcomed if it does not drastically reduce profit margins.

Although informations (Longe and Tona, 1988) portrays palm kernel oil as inferior to palm oil in absorbility and energy value, it should be explored as an alternative to palm oil in cassava peel diets. It is cheaper than palm oil, it is not directly used as

cooking oil and therefore does not find its way into human diets as prominently as does palm oil. Longe and Adekoya (1988) experimenting with layers indicated that inclusion of 5% palm kernel oil in palm kernel (PKM) diets fed to layers gave a good performance which was comparable to 5% level of inclusion of palm oil in PKM diets. Further work to investigate the economic benefits of using palm kernel oil in pig diets may be necessary for a clear cut conclusion to be made on its use as substitute for palm oil in pig diets.

The results obtained from this study seem to suggest that the optimum level of cassava peel supplemented with optimum level of palm oil to give the best pig performance may not be the ideal for economic production. This implies that with adequate processing of the cassava peels and well supplemented with protein sources there may be no need to supplement cassava peel diets with palm oil even if the pigs performance is slightly inferior to those receiving palm oil supplementation. A viable alternative may be to use palm kernel oil in place of palm oil where it is available.

The inclusion of high dietary levels of fibre for pigs have been shown to reduce carcass and meat cut yields. The results obtained with feeding 0, 5, 10 and 15% CPM to finisher pigs showed similarities in pork yield (dressing percentage) although the control diet had the highest carcass yield as compared to the CPM base4 diets (Omole and Sonaiya, 1977). Obioha *et al.* (1985) feeding 0, 15, 30, 45 and 60% CPM in diets of finisher pigs also reported no significant effect of dietary treatments on the dressing percentage. The animals fed on the CPM based diets

however had higher dressing percentages compared to those fed the control diet. In the present trial, dietary treatment had no significant ($P>0.01$) effect on the dressing percentage.

The least dressing percentage (meat yield) obtained at the highest level of CPM inclusion may be attributed to the dietary fibre level. The inclusion of high dietary levels of fibre for pigs have been shown to reduce carcass and meat cut yields. Bohman *et al.* (1955) and Merkel *et al.* (1958) reported that the inclusion of fibrous feeds in the diets for pigs increased the percentages of viscera and hence reduced the dressing percentages of carcasses. In the present trial, the average offal yield was highest for pigs fed diet 4 which might be responsible for the low carcass dressing percentages of pig fed on that diet as compared to those fed on the other diets of less dietary fibre levels.

The slightly higher dressing percentages obtained in the CPM based diets for the present study can be attributed to the higher fat deposition as a result of the palm oil supplementation in the CPM based diets. Edwards and Hart (1971) have reported findings with poultry that showed a positive correlation between the dietary oil and the composition of the body fat of the chick which might be responsible for the increase in the dressing percentages with increase in the level of the dietary oil.

Dietary treatment had no significant effects ($P>0.05$) on weights of spleen, kidney, heart, lungs or liver. While spleen, heart and lungs weights had no definite variation with increased cassava peel and with palm oil levels, there was a positive correlation between the weights of liver and kidney and the level

of CPM supplemented with palm oil in the diets. The fat depots of the pig's body include the abdomen, around the intestine, heart, liver and the kidneys. This implies that the increase in the weight of the liver and kidney with the increase in the level of palm oil observed in the present study is because of fat deposition in these organs. The liver among other functions is actively involved in fat and fatty acid metabolism and storage. Jensen *et al.* (1976) have reported findings with poultry that increased dietary fibre often resulted in depressed liver lipid content. The increase in the liver weight with increase in the CPM level supplemented with palm oil despite the corresponding increase in the dietary fibre in the present study could be attributed to the palm oil supplementation.

In general, the weight of the soft organs obtained in the present study is in support of Omole and Onwudike (1983) and Iyayi and Ngodigha (1991) who also included palm oil in CPM based diets for rabbits.

The wholesale cuts yield(Ham, Shoulder and Boston butt) followed the same trend with the carcass dressing percentage. In the same vein, the average yield of the intestine, stomach, liver, lungs, heart, kidney and spleen expressed as percentage of the liveweight also followed the same trend with the soft organ weights which could not be unrelated to the performance of the animals fed the dietary treatments. The increased gut dimensions (linear and mass) as the CPM levels increased in the present study is in agreement with Pond *et al.* (1981) who linked fibre with increases in weight and or length of the stomach and the various segments of

the gastro-intestinal tract. They stated that the enlarged stomachs and intestines in pigs were means of adapting to the high fibre content in their diets which increased the capacity of the gastro-intestinal tracts and facilitated microbial digestion in the lower segment of the gut.

The slightly improved head and trotters yield for pigs fed upto 38.20% CPM level as compared to the control diet might be due to the palm oil supplementation which improved the feed efficiency and hence better growth performance as compared to the control diet. The low yield of both the head and the trotters in pigs fed the highest (57.28%) level of CPM could be due to the level of the dietary fibre which might have had negative influence on the general performance of the animals.

The general increase in weights and yield of some of the edible offals with increase in the level of CPM supplemented with palm oil is of interest. Edible offals such as liver, heart, kidney, spleen and lungs are called variety meat (Forrest *et al.* 1975). The head, trotters and empty gut are popularly used for pepper soup. Results obtained from the present study have shown that the increase in yield of the edible offals with increase in the level of CPM supplemented with palm oil compared to the control diets resulted in increased volume of saleable parts and hence the profit margins.

Generally, excess trimmable fat in pork is not easily acceptable to pork consumers. Omole and Sonaiya (1977), Tewe and Oke (1983) and Obioha *et al.* 1985 have reported a decrease in backfat thickness with inclusion of CPM in grower-finisher pigs

diets. Their observation was in line with earlier workers who used fibrous feed stuff like rice bran (Bistoyong *et al.* 1968); Brewer's dried grain and corn cobs (Babatunde *et al.* 1975) and reported a decrease in backfat thickness as the levels of these materials increased in the diets of finishing pigs. The backfat thickness data which is a measure of the fatness of a pig obtained in the present trial revealed an increasing tendencies as the level of CPM and palm oil increased in the diet. In a chick study, Edwards, (1971) and Edwards and Hart, (1971), reported a positive correlation between the dietary oil and the composition of the body fat of the chick. They indicated that when the dietary oil is at a higher level, the composition of the body fat of the chick reflected that of the diet. They attributed their observation to the direct transfer of fat from the diet rather than it being produced through lipogenesis. In an attempt to make all the dietary treatments in the present study isocaloric, the level of the palm oil increase as the level of CPM increases in the diet. This corresponding increase in the level of palm oil (0 Vs 2.63 Vs 5.38 Vs 8.0%) may be responsible for the linear increase in the level of backfat thickness. The non-significant trend, observed in the present trial could be associated with the isocaloric nature of the diet. The area of the longissimus dorsi muscle (loin eye area) at the 10th rib of pig carcasses fed CPM diets in this trial showed insignificant depressions (9.50 Vs 8.83 Vs 7.58 Vs 7.33cm^2) which contrasts the trend observed by Omole and Sonaiya (1977). These workers reported an insignificant increase in the loin eye area (12.0 Vs 12.3 Vs 12.7 Vs 13.5cm^2) with increase in the level of CPM

in the diets. Generally, the findings in this trial affirmed the reports of Owen and Ridgman (1968) and Pond *et al.* (1981) who indicated that increased dietary fibre levels resulted in an insignificant decrease in the loin eye area.

Tewe and Oke (1983) obtained results of carcass lengths of pigs fed 0, 10, 20 or 30% CPM diets that showed tendencies towards longer measurement as the level of CPM in diets increased. Obioha *et al.* (1985) have also reported similar tendencies as the level of CPM in the diets fed to the finisher pigs rose from 0 to 60%. In the present study, the results obtained did not revealed any significant trend in carcass length which is in agreement with the findings of Omole and Sonaiya (1977), Tewe and Oke (1983) and Obioha *et al.* (1985). The linear increase in the dietary fibre with the corresponding level of CPM might be responsible for the general trend of the carcass length obtained in this present study and the previous workers.

It is difficult to explain the drop in carcass length measurements of pigs raised on diet with the highest level of dietary fibre (7.45%) as compared to the control diet

The conclusions drawn from the above results are that:

1. Supplementation of palm oil in CPM based diets resulted in effective utilization of nutrients for body building. CPM and palm oil at 38.20 and 5.38% levels in grower - finisher pig diets supported the best overall performance.
2. Levels of CPM as high as 38.20% can be included in grower-finisher pig diets without having a negative influence on the performance of the pigs provided the diets are well

supplemented with good protein sources and balanced for energy.

3. Palm oil could be used to a level of up to 5.38% in CPM diets fed to grower - finisher pigs without any adverse effect on their performance.
4. There is no significant cost benefit in using palm oil in CPM diets. The control diet gave a cheaper cost per kg body weight gain as compared to the CPM diets supplemented with palm oil.
5. Positive correlation between the palm oil level in the diets and the backfat thickness was observed. This implies that the use of palm oil especially at a higher level of inclusion may result in fat carcasses.

CHAPTER EIGHT

8.0.0 GENERAL SUMMARY AND CONCLUSION

The results obtained from the entire study have indicated that cassava peel constitutes the major waste product of cassava processing and that its inclusion in diets of pigs is beneficial.

Results from laboratory analyses revealed that the peels constituted about 17.48 and 11.8% on wet and dry matter basis respectively in cassava. The rind on the other hand constitutes about 18.60 and 8.05% on wet and drymatter basis respectively in cassava. The lower percentage yield of rind compared to that of the peels was attributed to the variable thickeness of the edible pulp left on the peels while peeling. Results of the chemical analysis show that cassava peel is 91.39% drymatter; 6.46% crude protein, 9.63% crude fibre, 1.13% ether extract, 7.16% ash and 75.80% Nitrogen-free extract. The Gross energy of cassava peel was 3978.65 Kcal/kg while the free hydrocyanic acid level was 140.90mg/kg. It appears from the chemical analysis also that cassava peel is high in crude fibre and ash but lower in crude protein, ether extract, Nitrogen-free extract and energy than maize. This suggests that cassava peel is of low nutritive value than maize.

In the weaner trial, (Experiment 1), the pigs were fed isonitrogenous rations containing 20% CP cassava peel meal replaced maize at levels of 0, 7.5, 15.0 22.50 and 30% in the diet. All the growth performance parameters measured were not statistically significant. There was cost benefit in using CPM in swine diets.

The results were in support of the use of CPM upto the highest level of inclusion (30%) in a practical weaner pig diet.

Further investigations with the weaner pigs (Experiment 2), have shown that the expensive maize fraction of the diets can be reduced and that as high as 42.65% CPM (which correspond to 75% of maize replaced by CPM) can be included in the diet without deleterious effect on their growth performance. The use of CPM beyond 75% replacement for maize in weaner pig diets may have an adverse effect on the final liveweight of the pigs which implies an increase in length of feeding time to reach the market weight. The result also revealed that poor performances of weaner pigs on CPM diets could be attributed to the combined effect of hydrogen cyanide, high crudefibre, low caloric value and dustiness (which might depress feed intake) usually associated with cassava peel feeding. Any attempt to correct any of these factors may enhanced utilization of cassava peel in swine diets. The cost per kilogramme gain in weight decreases as CPM level increased in the diet and this was in accord with the result of the first trial.

The nutrient digestibility and utilization study (Experiment 3) shows that the use of upto 50% maize replacement level of cassava peel may not have negative effect on the digestibilities and utilization of the nutrients. However, where maximum feedcost savings are desired and provided that the lowered performance is compensated by feed cost savings, higher levels of upto 75% maize replacement (which correspond to 42.28% CPM level) are feasible in practical pig diets. This suggests that less emphasis would be placed on maize as dietary energy source without adversely

affecting the ability of the pigs to effectively utilize the nutrients in their diets.

For the grower-finisher pig trial (Experiment 4) all the animals were fed isonitrogenous and isocaloric rations containing 16% CP and 3.13 Mcal, ME/kg respectively. The diets were formulated such that 0, 25, 50 and 75% of maize were replaced by cassava peels while 2.63, 5.38 and 8.0% palm oil levels were used to raised the CPM diets 2, 3 and 4 respectively to be of the same caloric value with that of the control. The results showed that supplementation of palm oil in CPM based diets resulted in effective utilization of nutrients for body building. CPM and palm oil at 38.20 and 5.38% levels (Diet 3) in grower-finisher pigs diets supported the best overall performance. There was no significant cost benefit in using palm oil in CPM diets. The control diet gave a cheaper cost per kg body weight gain compared to the CPM supplemented palm oil diets. the dressing percentage of all pigs fed 50% maize replaced diets with 5.38% palm oil was significantly better than those fed other dietary treatments. Other carcass parameters were not significantly affected by dietary treatment. The backfat thickness increased as the level of palm oil in the diet increased suggesting that the use of palm oil especially at a higher level of inclusion may result in poor carcass quality. With the present trend that pork consumers desired more of lean pork and are prepared to offer more money for such meats than for fatty meat, the use of palm oil especially at a higher level of inclusion may not be encouraged.

Generally, it can be concluded that cassava peels have

tremendous potentials of alleviating the teething problems of shortage of energy (maize) components of swine diets. Its inclusion in pig diets can bring about reduction in feed cost, cost of producing edible meat and more importantly reduce the competition between man and pigs for maize with the result that there would be more feed for the increasing human population and greater potential for the growth of the pig industry.

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Appendix 1: 1968 World Production, Acreage and Yield of Selected Crops

Crop	World hectarage (Million hectares)	World Yield 100kg/ hectare	World Production (Million metric tons)
Wheat	227.5	14.6	332.5
Rice (paddy)	132.2	21.5	284.2
Maize	106.0	23.7	251.1
Millet and sorghum	111.2	7.7	85.1
Sweet potatoes	16.0	84.0	134.4
Cassava	9.8	87.0	85.6

Source: FAO Production Yearbook, 1969.

Appendix II: Chemical composition of cassava peel meal from various sources (%DM)

Source	DM%	G.E. (Kcal/kg)	D.E. (Kcal/kg)	CP%	CF%	EE%	NFE%	Ash%	NCH Level (mg/kg)
Oyenuga (1968)	78.50	-	-	5.29	20.97	1.18	66.63	5.39	-
Devendra (1977)	-	2960	-	4.80	21.10	1.20	68.60	4.2	-
Sonaiya and Omole (1983)	86.50	3950	2460	6.50	10.08	1.00	62.50	6.5	163 ± 15
Eshiett & Ademosun (1981)	88.80	4001.2	-	5.98	9.30	0.65	65.87	7.00	47.65
Omole & Onwudike (1983)	87.90	-	-	6.20	10.60	1.00	63.30	6.8	157.40
Adebowale (1985)	-	-	-	6.80	10.50	-	-	7.9	-
Adegbola & Asaolu (1986)	66.25	-	-	5.45	-	3.5	-	15.5	-
Tewe & Kasali (1986)	90.10	-	2423	5.00	9.50	0.80	62.60	7.2	130.2-148
Osei & Duodu (1988)	92.10	-	-	5.7	9.30	6.50	69.30	7.4	-
Aregheore & Oluokun (1989)	87.85	4590	-	5.90	10.24	1.18	66.63	5.93	-
Osei (1989)	92.00	-	-	5.7	10.00	1.00	76.20	7.10	50.0
Aduku et al (1991)	-	-	-	5.0	9.5	5.8	62.60	7.20	-
Sekoni (1991)	94.29	-	2324	5.7	19.26	0.71	66.03	8.30	-
Ogbonna and Adebowale	86.20	3210	-	5.1	16.7	1.20	67.5	9.50	-

Appendix III: Proximate composition of feed ingredient (%)

Ingredient	Drymatter (DM)	Ash	Crude Protein	Crude Fibre	Ether Extract	Nitrogen Free Extract
Maize	90.73	9.67	9.56	2.2	4.05	74.52
Cassava peel meal	91.39	7.16	6.46	9.62	1.13	75.63
Wheat offals	91.25	7.91	17.06	10.02	2.97	62.04
Cotton seed cake	93.60	5.16	29.94	23.50	5.76	35.64
Bloodmeal	92.78	4.17	80.13	1.10	2.50	9.00

Appendix IV: Prices of Feed Ingredients at the time or the Experiments
(April - October, 1993)

Ingredient	Cost per kg (₦)
Maize	3.60
Cassava peel	0.22
Soyabean (full fat)	12.00
Bloodmeal	3.50
Wheat offal	11.00
Cotton seed cake	3.75
Bone meal	1.64
Limestone	0.80
Salt	10.00
Vitamin premix	50.00
Palm oil	26.00