NUTRITIVE VALUE OF SUN- DRIED YAM PEEL MEAL IN BROILER DIETS

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ZARIA, NIGERIA

DECEMBER, 2011

DECLARATION

I declare that the work in the thesis entitled **“Nutritive Value of Yam Peel Meal in Broiler Diets”** has been performed by me in the Department of Animal Science, under the Supervision of Prof. G.S. Bawa, and Dr T.S. Olugbemi. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this thesis report was previously presented for another degree or diploma at any University.

______________________ ______________________

Inaku, Elizabeth Nkari Date

CERTIFICATION

This thesis entitled "**NUTRITIVE VALUE OF YAM PEEL MEAL IN BROILER DIETS"** by INAKU ELIZABETH NKARI meets the regulations governing the award of the degree of Master of Science in Animal Science of Ahmadu Bello University, and is approved for its contribution to knowledge and literacy presentation.

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DEDICATION

I humbly dedicate this work to Jehovah God Almighty who has given me strength to complete this work. I also affectionately dedicate this work to my very dear mother, Mrs Magaret Simon Ogar for giving me education as the greatest legacy of my life, may God reward her abundantly. This work is also dedicated to;

My Sisters for their love and contribution towards the success of this work,

My one and only brother Dr Kenneth Inaku Ogar and

My very dear husband George Reuben Awuna for his contribution to this work.

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ABSTRACT

Two trials were conducted to evaluate the nutritive value of yam peel meal (YPM) in broiler diets. In the first trial (Experiments 1 and 2), which lasted for 56 days, two hundred and twenty five one week old broiler chicks with an average initial live weight of 80g were randomly allotted to five dietary treatments with three replicates of 15 birds each in a completely randomized design. The experimental diets consisted of five treatments with varied levels (0, 10, 20, 30, and 40%) of YPM represented as treatments 1, 2, 3, 4, and 5, respectively. In the second trial (Experiments 3 and 4), 225 day-old broiler birds with an average initial weight of 43g were used. Birds were randomly allotted to five dietary treatments, with three replicates of 15 birds each in a completely randomized design. The YPM based diets had equal amount of yam peels (20%) in the starter and finisher phases of the trials and were supplemented with varying levels of palm oil (0, 1, 2, 3, and 4%) for diets 1-5 respectively. In Experiment 1, birds on diet 3 with 20% YPM obtained higher values than all the other treatments including the control diet in terms of final weight, daily weight gain, and better feed conversion ratio, indicating the possibility of including YPM up to the level of 20% without deleterious effect on the general performance of broiler starter birds. In the second Experiment, significant differences ($P<0.05$) were noted in average daily gain and feed conversion ratio as the level of YPM increased in the diet. Feed intake increased significantly with increasing level of YPM. The carcass analysis showed no significant difference ($P>0.05$) for most of the parameters considered with the exception of live weight, carcass weight and gizzard; those fed 20% YPM (diet 3) had the best performance and carcass characteristics than those on other yam peel meal based diets. It was concluded that 20% YPM is adequate for broiler finisher birds. In the third Experiment, there were significant differences ($P<0.05$) in daily feed intake and feed cost per kilogram gain among the dietary treatment. From the observed data, diet 2 with 20% yam peel meal

and 1% palm oil promoted the best overall performance in broiler starter chicken. In Experiment 4, dietary treatments had no significant effects ($P>0.05$) on most of the carcass parameters of broilers measured except for dressed weight, head, wings, leg and small intestines. Daily feed intake, feed conversion ratio, average daily gain and cost per kilogram gain differed significantly ($P<0.05$) among treatments. The use of YPM and palm oil at graded levels improved the quality of the yam peel meal based diets and favours its digestibility. It was concluded that supplementation of 20% YPM based diet with 3 % palm oil will promote better performance at the least cost in broiler finisher diets.

CHAPTER ONE

1.0 INTRODUCTION

Growth in the livestock industry in Nigeria has recently fallen below expectation due to rising prices of feed and shortage of feed supplies (Owen *et al*., 2009). This problem has been attributed to high cost of conventional feed ingredients, which has made livestock feed a major cost of production (Tewe, 1975). Birds eat to satisfy their energy requirements and provision of energy and protein in the diet of poultry accounts for about 90% of the cost of the whole diet and over 60% of the overall cost of production (Scott, 1987; Oruwari *et al.*, 1995), and in poultry nutrition, energy is used for provision of body heat, maintenance, growth and production. Cereal grains such as maize has remained the major energy source in poultry diets. It is high in starch which can readily be digested by birds 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 are also very low (Smith, 1997). Similarly, the low level of local production of maize coupled with the ban on importation of temperate cereals grains, such as wheat and barley has resulted in a buildup of excess demand for maize, both as food for humans and raw materials for industries like feed mills, 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 poultry feed (Oladunjoye *et al*., 2004).

In view of these, the use of agro-industrial by-products that are not consumed by man, available in large quantities all year round and obtainable at the cheapest cost to substitute for the scarce grains especially maize in poultry diets is worthy of consideration (Adeyemo and Borrie, 2002). Yam peel (*Dioscorea rotundata*) is a by-product that has such potentials. Yam peels are by-products obtained when yam is peeled for cooking and other purposes.

Yam peels have relatively high amino acid content (Eka, 1986) and dietary fibre (Akinmutimi and Onen, 2008). At present, yam peels do not form regular sources of dietary nutrients to man. This indicates that there may be considerable cost advantage of using it to replace a substantial amount of the grain component of broilers diet. In spite of the enormous potential of yam peel as a source of energy in poultry diets, it has been relegated to the background because of its relatively low metabolizable energy and dustiness. To get round this problem, oils can be added to the diet. Palm oil is a rich source of essential fatty acids which facilitate supply and absorption of fat soluble vitamins, reduces dustiness and increases the energy profile of a diet (Tewe, 1997).

The objectives of this study were to:

1. Determine the proximate and anti nutrient composition of Yam Peels
2. Determine the nutritive value of Yam Peels in broiler diets
3. Evaluate the effect of including Palm Oil in Yam Peel Meal diets fed to broilers
4. Evaluate the economic potential of replacing maize grain with yam peel meal.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Origin and Distribution of Yam

Yams were dispersed by the Portuguese and Spanish during their voyages for slaves, in their missionary journeys, and by Arab traders. The genus Dioscorea has a wider diversity of origin with different species adapted to different ecosystems. *D. trifida* is indigenous to tropical America; *D. rotundata, D. cayenensis, D. bulbifera* and *D. dumetorum* are native to West Africa; *D. alata, D. esculenta* and *D. opposita* are indigenous to South Asia. *D. opposita* and *D. japonica* have their centre of origin in China (Coursey, 1983).

Yams are the only root crops in which the Asian and African species developed independently of each other. Exchange of species was due to the influence of Portuguese explorers. They learned of the value of *D. alata* from the Indian and Malayan seafarers who used it on their ships on long voyages because it stored well and had antiscorbutic properties. The Portuguese soon adopted it and introduced it into Elmina and Sao Tome in West Africa. Subsequently, through the Atlantic slave trade, the Portuguese carried the African species *D. rotundata* and *D. cayenensis* and the Asian species *D. alata* to the Caribbean where they became important staple foods (Coursey, 1983). *D. alata* seems to have arisen from the wild relatives, *D. hamiltoni* and *D. persimilis* in the north and central pans of the Southeast Asian peninsula, probably Burma or Assam. So also *D. esculenta* while *D. hispida, D. pentaphylla* and *D. bulbifera* originated from an Indo Malayan centre. *D. rotundata* is of African origin, where it is known as "water yam" indicating that it was brought across the water or sea. *D. rotundata* is the most important African yam, especially in the forest zone, and is probably a hybrid of the other African yam, *D. cayenensis,* which is a savannah species. In West Africa it is grown in the roots and tubers belt, which extends 15°N and 15°S of the equator (Owen *et al*., 2009; Huxley, 1992).

When reporting on the world producers of yam in million metric tons, Food and Agricultural Organization (FAO) cited some countries production status as: Nigeria 26.6; Ghana 3.9; Australia 3.2; Cote de Ivoire 3.0; Benin 2.3; Togo 0.6; and Colombia 0.3; a world total of 39.9 million metric tons, showing a wide distribution of yams in Nigeria, hence its potential as animal feed (FAO, 2005). Yam can be grown in nearly all tropical countries provided water is not a limiting factor. In Nigeria it is grown within the coastal region up to latitude 12^0N and corresponds to the rain forest, wood savanna and southern savanna belt. This is the region where the annual rain fall exceeds 800mm in amount and 4 months in duration (Walsh, 2003). In some parts of Nigeria, yam cultivation still depends largely on intensive labour, traditional hoe-cutlass techniques of production. Many aspects of production like clearing, planting, weeding, staking and harvesting require considerable inputs of labour. Roots and tuber crops, especially yam, generally require loose soil for better performance. This is because of the manner in which the roots form and penetrate into the soil (Hooper *et al*., 2005). Although yams can be grown on the flat soil, holes, ridges or mounds, it is traditionally planted on mounds in Nigeria. The sizes of the mounds vary from place to place depending on the size of the set and the hydromorphic nature of the soil.

2.2 Nutritive Value of Yam Peels

The nutritive value of any food stuff is determined by its chemical composition in terms of dry matter, energy, protein, fibre, vitamins and minerals. The same feed stuff may vary in their chemical composition. As seen from the summary table of the chemical composition of yam peels by various authors on Table 2.1.

Table 2.1: Proximate composition of yam peel meal

Constituent	Akinmutimi and Onen (2008)	Igwebuike *et al.* (2009)	Akinmutimi *et al.* (2006)
		Percentages	
Crude protein	12.7	13.20	11.33
Crude fat	1.05	3.00	1.20
Crude fibre	6.30	7.00	9.50
Ash	9.30	1.50	9.80
Dry matter	89.25	88.80	91.66
Gross Energy, Kcal/kg	2,980	3,404	2,988

The variation existing among the parameters could be due to certain factors such as the type of soil, on which the yam was grown, method of processing, depth of edible pulp removed with the yam peel when knife is used, and the accuracy and method of laboratory analysis (Coyne *et al*., 2006).

When compared with the conventional energy source such as the cereal grains, the protein level of yam peel is higher. Reports (Akinmutimi and Onen, 2008, Igwebuike *et al.*, 2009) indicate that the crude protein content of yam peels ranges between 11.33 and 13.20%, while that of maize ranges from 8.0 to 11.0. Yam peels are much richer in crude protein content than the edible portion (pulp). While the crude protein ranges from 11.33 to 13.20%, the edible portion ranges from 2.0-2.4% (Holfold, 1998 and Bridge *et al*., 2000). These authors gave an overall composition of the edible portion of fresh yam tuber as follows; energy 439 kJ/100g; water 72.4%; protein 2.4%; fat 0.2%; carbohydrate 24.1%; fiber 0.6%; calcium 22 mg/100g; iron 0.8 mg/100g; thiamine 0.09 mg/100g; riboflavin 0.03 mg/100g; niacin 0.5 mg/100g; ascorbic acid 10 mg/100g Yam tuber is said to contain some pharmacologically active substances including dioscorine saponin and sapogenin. Vitamin C has been found in unpeeled yam slices which promote good health (Holfold, 1998, Bridge *et al*., 2000).

The nutritional value of yam in comparison with other roots and tubers shows that the protein content and quality of roots and tubers are variable, being approximately 2.1% on a fresh weight basis (Okolo *et al*. 1995). The protein contribution of these foods to the diets in developing countries, on a worldwide average is only 2.7 percent, which is provided mainly by potato and sweet potato (Okolo *et al*. 1995). However, these starchy staples do provide a much greater proportion of the protein intake in Africa, ranging from 5.9% in East and Southern Africa to a maximum of 15.9% in the humid Africa, supplied mainly by yam and cassava. In root crops, the quality of the protein in terms of the balance of essential amino-acids present may be compared to that of standard animal proteins in beef, egg or milk. Most root crops contain some lysine, though less than in legumes, but the sulphur amino-acids are limiting. For example, yam is rich in phenylalanine and threonine but limiting in the sulphur amino-acids, cystine and methionine and in tryptophan. The essential amino acid profile of selected root crops including yam are presented in Table 2.2.

All the root and tuber crops exhibit very low lipid content. These are mainly structural lipids of the cell membrane which enhance cellular integrity, offer resistance to bruising and help to reduce enzymic browning (Holfold, 1998) and are of limited nutritional importance. Yams are high in vitamin C, dietary fiber, vitamin B_6, potassium, and manganese; while being low in saturated fat and sodium. Vitamin C, dietary fiber and vitamin B_6 may all promote good health (Holfold, 1998). Furthermore, a product that is high in potassium and low in sodium is likely to produce a good potassium-sodium balance in the human body, and so protect against osteoporosis and heart disease (Huxley, 1992). Yam is a good source of industrial starch, the quality of which varies with the species; although the quality of starch of some species is said to be comparable to cereal starch.

According to Eka (1986) dioscorine which is the major alkaloid in yam is medicinally a heart stimulant. Yam products generally have a lower glycemic index (Mignouna, 2003), which means that they will provide a more sustained form of energy, and give better protection against obesity and diabetes. West Indians use it as a way of recovering after sprinting (Walsh, 2003).

Table 2.2-Essential amino acids of plantain, cassava, sweet potato, cocoyam and yam

Amino-acids (mg N/g)	Plantain	Cassava	Sweet potato	Cocoyam	Yam
Lysine	193	259	214	241	256
Threonine	141	165	236	257	225
Tyrosine	89	100	146	226	210
Phenylalanine	134	156	241	316	300
Valine	167	209	283	382	291
Tryptophan	89	72	-	88	80
Isoleucine	116	175	230	219	234
Methionine	48	83	106	84	100
Cystine	65	90	69	163	72
Total sulphur	113	173	175	247	172
Total	1042	1309	-	1976	1768

Source: Holfold (1998).

The high vitamin C concentration in some roots and tubers such as yam, potato and cassava may help to render soluble the iron and make it more available than in cereals and other vegetable foods. In the United Kingdom the iron supply from potato ranks third of all individual food sources, accounting for up to 7 percent of the total household dietary iron intake (Mc Naughton and Reece, 2000).

Yam can supply a substantial portion of the manganese and phosphorus requirement of adults and to a lesser extent the copper and magnesium. Yam peels have been described as a low energy feeding stuff compared to cereal grains (Adeyemo and Borrie, 2002). The energy level of yam peels ranges from 2980 to 3404kcal metabolizable energy per kilogram dry matter, while that of maize and yam flour, the energy content range from 3234 to 4390 kcal ME per kilogram of dry matter (Aduku *et al,* 1991, Bridge *et al*. 2000).

Most reports evaluate the utilization of yam peels with respect to fibre content. The crude fibre content of yam peels ranges from 6.04-9.50 (Akinmutimi and Onen, 2008; Igwebuike *et al.,* 2009). Ekenyem *et al*. (2006) and Fetuga and Tewe (1985) had acknowledged that the yam peels have a high fibre nature, although the fibre content of yam peels is more digestible than those of other roots and tubers such as cassava. These authors reported that the high crude fibre content of the peels limits their level of inclusion in monogastric ration, and that yam peels is better given to ruminants that can better handle high fibre and low energy feed than the monogastrics. The findings of Akinmutimi *et al.,* 2006; Akinmutimi and Onen, 2008; Igwebuike *et al*., 2009 have however shown that yam peels can be used to an advantage in monogatric feeding despite the high fibre content, provided the diet is supplemented with sulphur amino acids.

2.3 Methods of Improving Yam Peel Utilization

Regardless of the potentials of yam peels as a cheap source of energy in livestock feeds, there are certain constraints to its usage in monogastric diets. These are its high fibre content, anti nutritional factors and the physical form of the yam peels. It becomes pertinent to improve the quality and physical form of the yam peels to enable its inclusion at higher levels in broiler diets. Various methods have been considered to enhance yam peel utilization by poultry birds.

2.3.1 Sun drying

As earlier reported by Anakebe (2006) and Akinmutimi and Onen (2008), the anti-nutritional factors present in yam peels are; Phytate, Tannin, Oxalate, Cyanide and Saponin; these anti-nutrients could be reduced to the barest minimum using sun drying. Sun drying has been described by most workers as the most practical and effective method of reducing the anti nutrient present in fresh yam peels. Sun drying is a traditional method in which foods dry naturally when placed in the sun (Akinmutimi and Onen, 2008).Yam peels collected fresh from kitchens after peeling, or from yam processing centres, and partially spoilt yams from yam barns are chipped to a particle size of 0.5mm-5mm thickness and then dehydrated by spreading under the sun for about 4-7 days to reduce the action of enzymes, anti-nutrients and micro organisms on it, thereby preventing spoilage. An advantage is the fact that the dried product weighs very little and the size is reduced considerably for easy storage. Sun drying can be done with window screens that are washed thoroughly, placed on blocks and sandwich the washed and sliced food between them. It is then flipped over and the other side is dried after a few hours in very hot sun (Ekenyem *et al.*, 2006).

Sun drying has also been an effective method of processing cassava peels for livestock consumption. Tweyongvere (2002) reported on the cyanogenic potential of the cassava peels and assess the effectiveness of sun drying, heap fermentation and wet fermentation (soaking) in reducing the cyanide potential of the peels. Treatment of the peels by sun-drying, heap fermentation or soaking reduced the cyanide potential to below 100 mg cyanide equivalent/kg of dry matter at 48, 72 and 96 h respectively. Sun-dying caused an early sharp fall in the cyanide potential, but heap fermentation or soaking gave the lowest residual cyanide after 120 h. Cassava peels could be safely used as livestock feed if they are treated to reduce the cyanogenic potential.

2.3.2 Oven drying

Oven drying has proved to be an effective method of removing the anti-nutrients in yam peels. Anti nutrients such as Phytate, Tannin, Oxalate, Cyanide and Saponin have been found in oven dried yam peels, but in negligible amounts that do not exert any harmful effect on the animal's performance provided it is properly processed (Igwebuike *et al*. 2009). Yam peels can be oven dried by placing it at 50^{o}C for about 1 hour until it becomes crispy (Ekenyem *et al.,* 2006). Oven drying has been found to be the simplest way to dry feed because there is almost no need for special equipment. It is also faster than sun drying or using a food dryer, but oven drying can be used only on a small scale. Okolo *et al*. (1995) and Hertzberg *et al*. (1982) reported that an ordinary kitchen oven can hold only 4 to 6 pounds of feed at one time. The oven is set on the lowest possible setting and preheated to 140 degrees ^{0}F (60 C).

2.3.3 Fermentation

Tewe and Kasali (1986) described fermentation as a chemical reaction carried out by many types of microorganisms to obtain energy. Fermentation of yam peels has been found to remove considerable amount of cyanide and hence improve its utilization. Adeyemo and Borie (2002) and Davis and Stone (2009) pointed out that fermentation of the peels seemed to remove all the cyanide content than other methods of processing mentioned. In fermentation, microorganisms break down complex organic compounds into simpler substances. Although chemical changes and microbial growth usually mean food spoilage, in some cases fermentation is desirable and microorganisms are actually added to foods. Alcohol, acids, and other compounds produced in fermentation act as preservatives, inhibiting further microbial growth. Fermentation has also been used to remove the cyanide content of cassava (Eka, 1986). When compared to the sun-drying and oven drying methods of processing, Tewe and Kasali (1986) reported that fermentation of the peels reduces an appreciable amount of the hydrogen cyanide (HCN) content than any of the two methods of processing.

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.

Studies on the The Effect of fermentation of sweet orange (*Citrus sinensis*) fruit peel on its maize replacement value in broiler diet have showed that fermentation of sweet orange (*Citrus sinensis*) peels depressed broiler performance. However, it did not result in disproportionate growth of most of the carcass cults nor did it jeopardize the health of the birds. The only mortality recorded was the loss of one chicken in the control group. With the exception of the kidney weight, substituting dietary maize with sweet orange peel meal did not produce any significant effect as visceral organ weights. The nutrient composition of sweet orange fruit peel seems to highlight its potential to serve as an alternative feed stuff to maize, it was reported that the fermentation technique employed in the present study was not adequate to transform it into a form that will enhance its usefulness and further studies are required to discover appropriate processing methods to harness its nutritional potential (Agu, 2006)

Ganiyu (2006) fermented cassava pulp with pure strains of *Saccharomyces cerevisae* and two bacteria namely; *Lactobacillus delbruckii* and *Lactobacillus coryneformis* for 3 days. The squeezed liquid from the fermented pulp was used to ferment cassava peels for 7 days. Analysis of the dried fermented peels revealed that there was a significant ($P < 0.05$) increase in the protein content of the cassava peels fermented with squeezed liquid from the inoculated cassava pulp (21.5%) when compared with the unfermented cassava peel (8.2%). Moreover, the treatment equally brought about a significant ($P < 0.05$) decrease in the cyanide (6.2 mg/kg) and phytate content (789.7 mg/100g) when compared with the unfermented cassava peels, which had 44.6 mg/kg cyanide and 1043.6 mg/100g phytate. It is believed that fermented cassava peels could be a good protein source in livestock feeds.

2.3.4 Pelleting

Pelleting of feed is practiced in animal feeding to improve the physical characteristics of the feed. Concentrated feeds made into pellets have the advantages of ease of handling, lack of dust and waste, and a standard composition of the pellets consists of a mechanical compression of ground feeds or mash into hand pellets. Pellets are said to be a small ball or piece of material that has been pressed tightly together, example for animal feed or medicine (Davis and Stone, 2009).

Benefits of pelleting feeds as cited by Bawa (1995) for poultry include the use of less storage space as the feed is reduced by compression, prevention of selective eating, increased feed consumption, increased palatability and value of the diet. Yam peel meal is powdery, dry, loose, and bulky. Pelleting is necessary to reduce bulk and improve the nutrient density of the feed. The dusty nature of yam peel meal may have a negative impact on the respiratory tract thereby lowering feed intake, this makes pelleting advantageous in monogastric diets (Ekenyem *et al*., 2006).

Pelleting has also been found to be very helpful in reducing the HCN in cassava peels fed to live stock feed as well as reducing the problem of dustiness, the heat generated by the steam treatment and high pressure during pelleting could release the cellulose from the lignin-cellulose bonds, which increases the digestibility of starch and fibre (Fetuga and Tewe, 1985). These researchers also pointed out that pelleting will also destroy some growth inhibitors of microbial origin (Moulds, fungi and other contaminants during sun drying storage) and probably destroy part of the glucosides as well. Pelleting of the peels may also result in increase in nutrient density, which in turn improves its nutritive value and digestibility of essential nutrients (Eka, 1986).

2.3.5 Palm Oil Supplementation

Ijaiya and Awonusi (2005) noted that the use of palm oil in broiler diets was beneficial in overall improvement of performance of birds as compared to the use of groundnut oil, mustard oil and sunflower oil. Palm oil has been found to be very helpful in influencing the use of yam and cassava peels used as animal feed and commercial garri fried with palm oil contain a smaller amount of cyanide compared to white garri that was processed without palm oil. Isika *et al*. (2006) reported that vegetable oils especially palm oil seem to be a better supplements in yam peel 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 yams 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 yam peels since delay in decomposition of the yam 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 yam peel based diet has also been ascribed to the presence of palm oil in such diets.

Oluyemi and Roberts (2002) recorded better live weight gains with birds fed yam peel-based diets supplemented with palm oil in their diet. This improved performance was attributed to increased energy intake of the animal due to supplementation with palm oil. The fact that palm oil can be used to boost the dietary energy for better performance was seen from an experiment which was conducted to determine the comparative advantage of palm oil and animal fat as sources of increasing dietary energy in pullets. The diets contained 2800Kcal/kg metabolizable energy. Five diets were supplemented with 2.5% and 5.0% palm oil or broiler offal fat at the expense of maize. Birds on diets with palm oil tended to retard attainment of sexual maturity, but egg production was significantly ($P<0.05$) increased at 5% broiler offal fat or palm oil, and the latter additionally resulted in higher egg mass. It was concluded that 5% broiler offal fat or palm oil comparably promoted higher egg production; the latter also supported heavier egg mass of the domestic fowl. Broiler offal fat holds great potential as energy source in pullets rearing (Isika *et al.*, 2006). Palm oil has been found to play an important role in influencing the use of cassava based diets for optimum performance of pigs (Bawa, 1995).

Okolo (1995) 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 metabolism 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. Palm oil is said to be rich in carotenoids (pigments found in plants and animals) which functions in egg yolk coloration in layers. This pigment is responsible for its deep red colour (Mudiope, 1998).

2.4 The Use of Cassava Peels and Potato Peels in Livestock Diets

Tewe and Pessu (1982) evaluated the performance and nutrient utilization of growing pigs fed cassava peel diets containing different cyanide level. The pigs were allocated to three treatment groups which were a maize-based control diet, cassava peel-based ration and a cassava peel plus dietary potassium cyanide (KCN) ration. The three diets contained 0, 96, and 400ppm cyanides levels, respectively. Feed intake and growth rate were non-significantly reduced on the cassava peel-based diet. The feed efficiency reduced on the cassava peel based diet. The feed efficiency and protein efficiency ratio on the cassava peel-based diets compared favorably with the control. They concluded that performance traits were negatively correlated with dietary cyanide level.

Bawa (1995) reported on the nutritive value of cassava peel meal for pigs. Cassava peel meal was included in the diets at 0, 7.5, 15.0, 22.50 and 30% levels. Results obtained showed that weaner pigs of the weight used can be fed up to 30% cassava peel meal in their diets. In another trial involving twenty crossbred (Large White and Landrace) pigs averaging 7.65kg fed five iso-nitrogenous diets with dried cassava peel meal included at 0, 14.22, 28.44, 42.65 and 56.87, it was reported that weaner pigs of the weight used can be fed up to 42.65 cassava peel meal in their diets.

Aduku *et al.* (1991) reported that cassava peel meal can be fed up to 15% level in maize-soya bean diets for broilers. They noted that the bulky nature of the cassava peel meal limits feed consumption to meet energy requirements of broilers at higher levels of cassava peel meal above 15% and that the cyanide content of the diets used for the study was low enough to be the major problem of cassava peel meal even at higher levels of inclusion.

2.5 Yam Peel Meal in Livestock Diets

Eka (1986) indicated that yam peels are valuable waste product which could be used to feed poultry, cattle, sheep and goats in areas of high yam production. Ene and Okoli (2000) observed that villages with a considerable number of small ruminants where yams are surplus have experienced increase in livestock production from the use of yam peels in rearing such animals especially where adequate browse is available. Kang and Wilson (1982) reported that yam peels could be used as energy source in sheep and goats diets as long as they are adequately supplemented with protein sources. Although not much work has been documented on the use of yam peels as source of ingredient for ruminant local farmers in Nigeria consider yam peels to be more of ruminant diets than those of the monogastrics due to its fibre content. But many researches on its use in monogastric diets have proven this to be false for example Akinmutimi and Onen (2008) reported that poultry can be fed 10% yam peel meal in their diet. Better carcass quality was recorded at 5% yam peel inclusion level. Ekenyem *et al.* (2000) evaluated the effect of partial replacement of yam peel meal (YPM) for maize meal (MM) on performance and carcass characteristics of finisher broiler chicks, inclusion of YPM up to15% improved the growth performance and carcass characteristics of birds at minimum cost of production showing that yam peels can be used as feed for both monogastric and ruminant animals alike.

2.5.1 Yam Peel Meal in Rabbit/Rat Diets

Akinmutimi and Onen (2008) and Anakebe (2006) conducted a trial to determine the performance of weaner rabbits fed graded levels of yam and sweet potato peel meal in place of maize based diet. The test ingredients replaced maize at 20, 30, 40 and 50%. It was observed that the feed conversion ratio values favored 40% inclusion of yam and sweet potato peel in place of maize diet. However judging from growth performance, carcass characteristics, organ weights, biochemical indices and economics of the diet, it was recommended that yam and sweet potato peel meal can be included at 40% in the diets of rabbits without adverse effect on their performance. Studies on the effect of replacing maize with ripe plantain peels and yam peels at 0, 25, 50, 75, and 100% in the diets for weaner rabbits showed that a combination of plantain and yam peels could be used to replace maize at 50% in the diet of weaner rabbits (Akinmutimi *et al.,* 2006).

Nwakpu and Onu (2005) investigated the efficacy of an enzyme-Roxazyme G on the utilization of yam peel meal by weaner rabbits. Results showed improvement in the average final weight, feed intake, water intake, body weight gain and feed efficiency as the level of Yam peel meal increased in the diets. Digestibility of crude protein, crude fibre, ether extract and nitrogen free extract were significantly ($P<0.05$) different among the dietary treatments. Better digestibilities were been obtained, among the diets with yam peel meal and Roxazyme-G.

2.5.2 Yam Peels in Poultry Diets

Akinmutimi and Onen (2008) reported that poultry can tolerate up to 10% yam peel meal in their diet. Better carcass quality was recorded at 5% yam peel inclusion level. Ekenyem *et al.* (2000) evaluated the effect of partial replacement of yam peel meal (YPM) for maize meal (MM) on performance and carcass characteristics of finisher broiler chicks. It was observed that inclusion of YPM up to15% improved the growth performance and carcass characteristics of birds at minimum cost of production.

Mohammed *et al.* (2009) conducted a study on the haematological indices and carcass characteristics of broiler chickens fed 0, 20, 25, and 30% YPM as a replacement for maize. Packed cell volume, haematological concentration, red blood cell count, white blood cell count, mean corpuscular volume, mean corpuscular haemoglobin and mean corpuscular haemoglobin concentration did not differ significantly among the treatments. It was concluded that up to 30% yam peel meal could be included in the diets of broiler finisher without adverse effect on the haematological and carcass parameters of the birds.

Ekenyem *et al.* (2006) concluded that replacement of yam peel meal for maize at higher levels in broiler diet yielded better performance and carcass characteristics and those birds placed on yam peel diets produce lean meat had faster rate of metabolism and growth.

2.6 Fibre Utilization by Poultry

It is known that broilers are monogastric animals with simple stomachs that cannot utilize highly fibrous feed; therefore monogastrics are limited in their utilization of fibre because their digestive juices do not contain the enzyme cellulase which is capable of breaking down fibre (Walsh, 2003). Cellulose, hemicelluloses and lignin which are constituents of crude fibre are therefore unavailable to monogastric animals, although considerable amount of cellulose may be utilized if the bacteria present in the intestines have cellulase to degrade cellulose in monogastric animals. Due to the bulk of fibrous feed, feed intake is affected in monogastric animals. The inclusion of fibrous feeds in diets for poultry has been found to affect their growth rate, feed efficiency and carcass quality (Opara, 1996 and Iyayi, 2001).

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 monogastrics. A review by the Agricultural research council (1967) concluded that every percent increase in the dietary fibre content of the diet is accomplished by an increase of approximately three percent in feed intake. At the same time, it was reported that additional dietary fibre reduced the growth rate of birds despite the increased intake which did not appear to compensate fully for the lower digestible energy content of the diet and an increase in consumption of low energy fibrous diets is an attempt by the animal to cancel out the energy deficit. Akinmutimi and Onen (2008) indicated that feeds high in crude fibre content limit the weight of feed eaten by birds and thereby placing physical limitation upon the intake of the digestive nutrients. Akinmutimi and Onen (2008) had earlier reported that yam peels are rich in dietary fibre which is easily digestible by birds.

2.7 Response of Broilers to Various Dietary Energy Levels

Dietary energy level appears to be the most important factor affecting feed intake. It is known that broilers attain a minimum energy intake from diets containing different energy levels; as such their energy requirements are not always precise (NRC, 1994). There are no consistent responses of broiler chicks to varying contents of metabolizable energy (ME) in their diets. The main reasons for this discrepancy are the nutrient composition and/or digestibility of diet, the physical form of diet, type and level of added fat, dietary ME level, strain, gender, age of bird, ambient temperature, and the interactive effects of dietary ME and amino acid density and certain additives **(**Dozier III *et al*., 2007 and Zhou *et al.,* 2009).

Dozier III *et al*. (2007) investigated the combined effects of feeding starter and grower diets having three different metabolizable energy (ME) contents and supplemented with Avian plus, Sicozyme and their combination on growth performance, nutrient digestibility, carcass traits and blood parameters of unsexed broiler chicks with their ME contents of 3100, 2900 and 2700 kcal/kg. It was observed that decreasing dietary ME level in both starter and grower periods from 3100 to 2700 kcal/kg positively affected efficiency of energy utilization and percentage of abdominal fat. However there was no significant effect on final live body weight, body weight gain, Crude protein intake, efficiency of protein utilization, economic efficiency of growth, efficiency of energy utilization, feed intake, carcass traits or blood parameters of broiler chicks as the level of energy increases it was evident also in feed conversion ratio, efficiency of protein utilization, metabolizable energy intake. Dietary supplementation with Avian Plus, Sicozyme and their combination had no significant effect on all criteria of response. It was concluded that the optimal dietary ME level for broiler chicks was suggested to be between 2900 and 3100 kcal/kg during both starter and grower periods.

It has been consistently shown that if an adequate quantity of essential nutrients is maintained in relationship to dietary energy, increasing levels of dietary energy for broilers results in a more rapid rate of gain and improvement in feed conversion efficiency. Controversy exists regarding the influence of dietary energy levels on carcass composition and quality, but in general, carcass fatness increases as dietary energy level increases (Zhou *et al.*, 2009).

Two trials were conducted to determine the response of 23- to 47-day-old broiler chickens to dietary lysine and energy levels when reared in a 26.7^0 C environment. There contained 3100, 3175, 3250, or 3325 kcal ME/kg of feed and were fed in combination with either 0.308 or 0.322% lysine/Mcal (kg) with a constant 18.7% dietary protein. Male and female body weights were not statistically different (P<0.05) among dietary energy levels when both sexes were fed 0.308% lysine/Mcal (kg). When the male chicks were fed 0.322%

lysine/Mcal (kg), body weights increased with increasing dietary energy level. Feed utilization also increased with increasing dietary energy level when broilers were fed either 0.308 or 0.322% lysine/Mcal (kg). These data suggest that the body weight response to dietary energy level when broilers were reared in a warm environment will occur only when adequate amino acid levels are used (McNaughton and Reece, 2000).

A trial was conducted to study the effect of Metabolizable Energy (ME) and Balanced Protein (BP) on the performance of 1-35-day-old male and female Hubbard x Hubbard broilers. Dietary treatments involved 3 levels of and 4 levels of Balanced Protein. Each diet was fed to 5 replicate pens of 17 chicks. From results obtained, dietary combinations of ME and BP to optimize body weight and feed conversion ratio are suggested on weekly basis.. There was no evidence that rate of lay or egg quality was limited by nutrients other than energy (Auckland and Fulton, 1973).

In an experiment designed to test the ability of broiler chickens to equalize daily energy intake when proximate components of the diet were changed. A combination of alfalfa meal, oats, and wheat middling was used to increase the fiber of the corn soy diet by approximately 2 and 4%. The 36 combinations were fed as mash. In addition, 8 of the diets were fed as pellets. All diets were fed for 12 days from the time broilers reached approximately 1.2 kg. A comparison of results from mash and pellets showed that only sex and form affected gain per day, feed per day, and kilocalories of ME eaten per day. For the mash and pellets, protein, fat, fiber, and several interactions affected the ME per gram; however, the ME per gram was similar for pellets and mash. The results suggest that the diet composition and form have a significant effect on the energy intake of broiler chickens (Champaign, 2008).

Parker and Arscott (2000) reported on the effect of restricting the caloric intake of male Chickens. 3 groups of 8 adult White Leghorn males were fed 90 g of feed/bird/day containing 2553, 2068 and 1584 kcal of ME/kg for 13 weeks. Results obtained showed no difference in the hatchability of eggs fertilized by semen from the 3 groups of males. The data indicated that energy restriction resulting in body weight loss from 11 to 16% was associated with reduced semen volumes and that the males became completely infertile when their weight loss was 30%. The diets containing 2553 kcal of ME/kg and providing 230kcal/bird/day approached the minimum necessary for normal body-weight maintenance.

2.8 Nutrient Digestibility of Monogastric Animals

Mujahid *et al.* (2003) experimented on the nutrient digestibility of broiler feeds containing different levels of differently processed rice bran stored for varying periods. Each trial was carried out on 111 chicks to determine digestibility of 36 different feeds. Chicks of 5 wk age were fed feeds containing raw, roasted, and extruded rice bran treated with antioxidant, Bianox Dry (0, 125, 250 g/ton), stored for a period of 0, 4, 8, and 12 months and used at levels of 0, 10, 20, and 30% in feeds. Digestibility coefficients for fat and fiber of feeds were determined. It was observed that increasing the storage periods of rice bran significantly reduced the fat digestibility of feed, whereas no difference in fiber digestibility was observed. Processing of rice bran by extrusion cooking significantly increased digestibility of fat even used at higher levels in broiler feeds. Interaction of storage, processing, and levels was significant for fat digestibility. Treatments of rice bran by different levels of antioxidant had no effect on digestibility of fat and fiber when incorporated in broiler feed.

In another trial, Ravindran *et al.* (2000) conducted a research on male broilers fed on wheat-sorghum-soya bean meal based diets containing 3 concentrations of phytic acid, 2 concentrations of non-phytate (or available) phosphorus (2.3 and 4.5 g/kg) and 3 concentrations of microbial phytase from day 7 to 25 post-hatch to test the influenced of dietary phytic acid and non-phytate phosphorous levels on their apparent metabolizable energy, nutrient digestibility and nutrient retention. Results obtained showed that Ileal digestibilities of nitrogen and essential amino acids were negatively influenced by increasing dietary levels of phytic acid but these negative effects were overcome by the addition of phytase. Supplemental phytase increased apparent metabolizable energy (AME), ileal digestibilities of phosphorus, nitrogen and amino acids and the retention of dry matter, phosphorus and nitrogen in broilers.

Sonaiya and Omole (1983) 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.

Abdu *et al.* (2009) experimented on the effect of varying level of inclusion of Ziziphus leaf meal (ZLM) in concentrate diet on nutrient digestibility and nitrogen balance. Results of nutrient digestibility showed significant differences in dry matter, crude protein, crude fibre, ether extract, ash and nitrogen free extracts as the level of ZLM increased in the diet. The control diets with 0% ZLM inclusion recorded the highest digestibility in all the parameters mentioned above. Both nutrient digestibility and nitrogen balance showed a decreasing trend in digestibilities with increase in ZLM inclusion in the experimental diets.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Experimental Site

The study was conducted at the Livestock Teaching and Research Farm of the Department of Animal Science, Faculty of Agriculture - Ahmadu Bello University, Zaria**.**

3.2 Determination of the Proximate Composition of Yam Peels

The proximate composition was obtained by analyzing the yam peels according to the methods described by AOAC (1990). The various methods are shown below:

3.2.1 Crude Protein:

Crude protein determination was done using the formula:

% total N per sample is given as $\%N = \frac{V1-V0 \times M \times 14 \times 100 \times 100}{0.2 \times 1000 \times 10 \times l}$

Where; V0= Vol. of HCl required for blank.

V1= Vol. of the HCl required for 10ml sample solution

14= atomic weight of N_2

100= total volume of digest

100= % conversion

10= volume of distillate

0.2= amount of sample taken in gram

1000= to convert to litre. The crude protein (cp) was calculated as % cp = 6.25.

3.2.2 Crude Fibre:

The crude fibre was calculated as the loss in weight on ashing using the formula:

$\%\ \text{crude fibre} = \frac{C2-C3 \times 100}{Wx1}$ Where; Weight of original sample = W.

3.2.3 Determination of Ash:

The determination of ash was done using the formula;

$$\% \text{ ash} = \frac{\text{Weight of ash} \times 100}{\text{Weight of sample} \times 1} = \frac{W3\text{-}W1 \times 100}{W2\text{-}W1 \ X1}$$

Where W1= weight of the crucible

W2= weight of the sample

W3=weight of the sample and crucible

$$\% \text{ organic matter} = \frac{\text{loss of weight} \times 100}{\text{Weight of Sample} \times 1}$$

3.2.4 Determination of Lipid content:

The extractible lipid was calculated as: % lipid (W/W) = wt of lipid extracted x 100

3.2.5 Carbohydrate Determination:

The total protein, moisture content, ash content and lipid content subtracted from 100 gives the carbohydrate and this is referred to as estimation by difference.

3.3 Determination of Anti-nutritional Factors in Yam Peels

3.3.1 Phytic acid: The procedure described by Reddy *et al*. (1982) was used.

Percentage phytic acid was calculated using the formula:

% Phytic acid = X x 1.19 x 100 / 2. Where X = Titre value x 0.00195

3.3.2 Tannic acid (Tannin): The method of Mega (1982) was employed.

The percentage tannin was calculated using the formula:

% Tannin = Absorbance x Average gradient x Dilution factor/ 10,000.

3.3.3 Oxalate determination: Oxalate determination was carried out as described by Fasset (1966). It was calculated using the formula:

1ml of 0.05N KMnO = 0.0225 anhydrous oxalic acid.

% Oxalic acid = Titre value x 0.00225 / 2 = T.U x 0.1125.

3.3.4 Saponin: The spectrophotometric method of Brunner (1984) was used for Saponin analysis.

% saponin = Absorbance of sample x Gradient factor x Dilution factor / wt sample x 10,000.

3.3.5 Cyanide: The alkaline filtrate method of AOAC (1990) was employed. The formula is given as: 1ml 0.02 mol/dm^3 of $ArNo_4$ = 1.08mg HCN.

3.4.0 Experiments 1 and 2: Replacement Value of Yam Peels for Maize in Broiler Diets (1-9 weeks).

3.4.1 Source and Processing of Yam Peels

The yam peels used for the studies were collected fresh from a restaurant in Ahmadu Bello University Zaria. The yam peels measuring 0.5mm-5mm thick were sundried for 4-7 days to reduce enzymatic and microbial reactions which can lead to spoilage and nutrient leaching. The dried peels were then milled before incorporation into the diet.

3.4.2 Experimental Diets (Experiment 1 and 2)

The dietary treatments comprised of five starter and finisher diets consisting of graded levels of YPM (0, 10, 20, 30, and 40%). The starter and finisher diets formulated contained 23 and 20% crude protein respectively as shown in Tables 3.1 and 3.2

3.4.3 Design and Management of Experimental Birds

A total of two hundred and twenty five (225) broiler birds were used for the study. The birds were fed diets containing graded levels of yam peel from one week of age. They were weighed and randomly divided on the basis of initial weight to five treatment groups of 45 chicks per group in a completely randomized design consisting of three replicates of 15 birds each. Birds were reared in a deep litter poultry house with feed and water provided *ad libitum*. Left over feed and body weight of birds were monitored on a weekly basis for the starter and finisher phases of the experiment and routine vaccines were given as recommended. All feed not consumed were removed, weighed, and recorded at the end of each week to enable calculations of weekly intake of feed. The average daily feed intake, daily weight gain, feed conversion ratio, and feed cost per kg gain were calculated.

Table 3.1: Composition of Experimental Starter Diets- Experiment 1

	Graded Levels of Yam Peels, %				
Ingredient	**0.00**	**10.00**	**20.00**	**30.00**	**40.00**
Soya bean (FF)	7.00	7.00	7.00	7.00	7.00
Maize	49.31	39.93	30.55	21.15	11.76
Yam Peel Meal	0.00	10.00	20.00	30.00	40.00
Wheat offal	8.00	8.00	8.00	8.00	8.00
Groundnut cake	31.79	31.17	30.55	29.95	29.34
Bone meal	2.50	2.50	2.50	2.50	2.50
Limestone	0.50	0.50	0.50	0.50	0.50
Methionine	0.20	0.20	0.20	0.20	0.20
Lysine	0.15	0.15	0.15	0.15	0.15
Salt	0.30	0.30	0.30	0.30	0.30
Premix *	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100
Calculated Analysis					
Met.Energy (Kcal/kg)	2914	2893	2872	2850	2829
Crude Protein (%)	23.00	23.00	23.00	23.00	23.00
Ether extract (%)	6.56	6.24	5.92	5.60	5.30
Crude fibre (%)	2.43	3.23	4.97	5.64	6.31
Calcium (%)	1.20	1.19	1.18	1.18	1.17
Phosphorus (%)	0.89	0.85	0.82	0.76	0.73
Lysine (%)	0.91	0.88	0.84	0.81	0.77
Methionine+Cysteine	0.67	0.64	0.58	0.53	0.50
Cost/kg feed(₦/kg)	61.13	56.61	52.0	47.57	43.0

**Vitamin Premix: Composition of vitamin premix per kg is as follows: Vitamin A, 8000 iu; Vitamin D_3, 1600 iu; Vitamin E 5 iu, Vitamin K 0.200 mg; Vitamins B, Thiamine B_1 0.5mg; Riboflavin B_2 4mg; Pyridoxine B_6 0.015 mg; Niacin 0.015mg; B_{12} 0.01mg; Pantothenic acid 0.5mg; folic acid 0.5mg and Biotin 0.020 mg; Chlorine chloride 0.02 mg; Anti-oxidant 0.125g and Minerals (Mn, Zn, Fe, Cu, I, Si, Co) 0.156g. FF: full fat. MET: Metabolizable.*

Table 3.2: Composition of Experimental Finisher Diets- Experiment 2

	Graded Levels of Yam Peels, %				
Ingredient	**0.00**	**10.00**	**20.00**	**30.00**	**40.00**
Soya bean (FF)	7.00	7.00	7.00	7.00	7.00
Maize	57.65	48.27	38.88	29.48	20.09
Yam peel meal	0.00	10.00	20.00	30.00	40.00
Wheat offal	8.00	8.00	8.00	8.00	8.00
Groundnut cake	23.45	22.83	22.22	21.62	21.01
Bone meal	2.50	2.50	2.50	2.50	2.50
limestone	0.50	0.50	0.50	0.50	0.50
Methionine	0.20	0.20	0.20	0.20	0.20
Lysine	0.15	0.15	0.15	0.15	0.15
Salt	0.30	0.30	0.30	0.30	0.30
Premix*	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100
Calculated Analysis					
Met. Energy (Kcal/kg)	2989	2968	2947	2925	2824
Crude Protein (%)	20.00	20.00	20.00	20.00	20.00
Ether extract (%)	6.13	5.81	5.49	5.18	4.87
Crude fibre (%)	3.56	4.22	4.90	5.57	6.24
Calcium (%)	1.18	1.17	1.17	1.17	1.16
Phosphorus (%)	0.71	0.83	0.80	0.80	0.74
Lysine (%)	0.79	0.75	0.71	0.68	0.65
Methionine+Cysteine (%)	0.60	0.56	0.51	0.47	0.44
Cost/ kg feed(₦/kg)	61.01	56.49	51.97	47.55	42.94

**Vitamin Premix: Composition of vitamin premix per kg is as follows: Vitamin A, 8000 iu; Vitamin D_3, 1600 iu; Vitamin E 5 iu, Vitamin K 0.200 mg; Vitamins B, Thiamine B_1 0.5mg; Riboflavin B_2 4mg; Pyridoxine B_6 0.015 mg; Niacin 0.015mg; B_{12} 0.01mg; Pantothenic acid 0.5mg; folic acid 0.5mg and Biotin 0.020 mg; Chlorine chloride 0.02 mg; Anti-oxidant 0.125g and Minerals (Mn, Zn, Fe, Cu, I, Si, Co) 0.156g. FF: full fat. MET: Metabolizable.*

3.4.4 Digestibility Trial

A digestibility trial was carried out at the end of the finisher phase (week 9) of the experiment. This was done by selecting 3 birds from each treatment. The birds were housed in individual cages. The birds were fed the experimental diets (Table 3.4) for five days adjustment period. Faecal samples were collected for 7 days and oven dried at 60^0C for 12 hours. The faecal samples were subjected to proximate analysis. Nutrient retention was determined for crude protein, ether extract, crude fibre, ash, and nitrogen free extract using the equation:

$$\text{Nutrient retention} = \frac{\text{Nutrient intake} - \text{Nutrient output}}{\text{Nutrient intake}} \text{ X } 100$$

3.4.5 Carcass Analysis:

Three birds were selected from each treatment based on the group mean weight for the carcass analysis. The selected birds were fasted overnight and thereafter bled by severing the jugular vein, followed by scalding in hot water and subsequently defeathered. The head, neck, shank and viscera were removed to get the dressed weight and percentage dressed weight calculated. The thigh, drumstick and back were removed from each carcass. All parts were weighed and expressed as percentages of the dressed weight; also organs like the heart, kidney, spleen and gizzard were weighed and expressed as percentages of the dressed weight.

3.4.6 Statistical Analysis

Data collected were subjected to Analysis of variance of SAS procedures (2002). Significant differences between treatment means were separated using Duncan’s multiple range test (Statistical Analysis System, 2002).

3.5 Experiments 3 and 4: Performance of Broilers (0-8 weeks) Fed Yam Peel Meal Supplemented with Varying Levels of Palm oil.

3.5.1 Source and Processing of Yam Peels

The yam peels used for the studies were collected fresh from a restaurant in a female hostel, within Ahmadu Bello University, Zaria. The yam peels measuring 0.5 - 5mm thick were sundried for 4-7 days to reduce enzymatic and microbial reactions which can lead to spoilage and nutrient leaching. The dried peels were then milled before incorporation into the diets.

3.5.2 Experimental Diets (Experiments 3 and 4)

The optimum level of yam peel meal (20%) from Experiment 1 was used in all the dietary treatments. The diets were: Treatment 1 (0% YPM and 0% palm oil), Treatment 2 (20% YPM and 1% palm oil), Treatment 3 (20% YPM and 2% palm oil), Treatment 4 (20% YPM and 3% palm oil) and Treatment 5 (20% YPM and 4% palm oil) as shown in Tables 3.3 and 3.4.

3.5.3 Design and Management of Experimental Birds

At the start of the experiment the birds were randomly divided into the various pens on the basis of their initial weight to ensure equal weight. A total of two hundred and twenty five (225) day-old broiler chicks were used for this study. The birds were housed on deep litter system and divided into 5 groups of 45 chicks per group in a completely randomized design with three replicates of 15 birds each. Feed and water were provided *ad libitum* and light provided throughout the second phase of the experiment. Palm oil was included to improve the energy value of yam peel meal and reduce dustiness.

Table 3.3: Composition of Broiler Starter Diets- Experiment 3

	Graded Levels of Palm Oil, %				
Ingredient	**0.00**	**1.00**	**2.00**	**3.00**	**4.00**
Maize	49.31	29.31	28.04	26.79	25.54
Soya bean(FF)	7.00	7.00	7.00	7.00	7.00
Yam peel meal	0.00	20.00	20.00	20.00	20.00
Wheat offal	8.00	8.00	8.00	8.00	8.00
Ground nut cake	31.79	30.80	31.06	31.31	31.56
Bone meal	2.50	2.50	2.50	2.50	2.50
Limestone	0.50	0.50	0.50	0.50	0.50
Palm oil	0.00	1.00	2.00	3.00	4.00
Methionine	0.20	0.20	0.20	0.20	0.20
Lysine	0.15	0.15	0.15	0.15	0.15
Salt	0.30	0.30	0.30	0.30	0.30
Premix*	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100
Calculated Analysis					
Met. Energy (kcal/kg)	2914	2917	2962	3007	3052
Crude protein (%)	23.00	23.00	23.00	23.00	23.00
Ether extract (%)	6.56	6.89	7.85	8.81	9.77
Calcium (%)	1.20	1.20	1.30	1.40	1.42
Phosphorus (%)	0.89	0.82	0.82	0.82	0.82
Lysine (%)	0.91	0.84	0.95	0.84	0.84
Methionine+ Cysteine (%)	0.70	0.60	0.60	0.60	0.60
Crude fibre (%)	3.63	4.95	4.92	4.90	4.90
Cost/kg (₦/kg)	61.13	53.36	54.61	55.70	57.12

**Vitamin Premix: Composition of vitamin premix per kg is as follows: Vitamin A, 8000 iu; Vitamin D_3, 1600 iu; Vitamin E 5 iu, Vitamin K 0.200 mg; Vitamins B, Thiamine B_1 0.5mg; Riboflavin B_2 4mg; Pyridoxine B_6 0.015 mg; Niacin 0.015mg; B_{12} 0.01mg; Pantothenic acid 0.5mg; folic acid 0.5mg and Biotin 0.020 mg; Chlorine chloride 0.02 mg; Anti-oxidant 0.125g and Minerals (Mn, Zn, Fe, Cu, I, Si, Co) 0.156g. FF = Full Fat .*

Table 3.4: Composition of Broiler Finisher Diets

	Graded Levels of Palm Oil, %				
Ingredient	**0.00**	**1.00**	**2.00**	**3.00**	**4.00**
Maize	57.65	37.38	36.38	35.12	33.88
Soya bean(FF)	7.00	7.00	7.00	7.00	7.00
Yam peel meal	0.00	20.00	20.00	20.00	20.00
Wheat offal	8.00	8.00	8.00	8.00	8.00
Ground nut cake	23.45	22.47	22.72	22.98	23.22
Bone meal	2.50	2.50	2.50	2.50	2.50
Limestone	0.50	0.50	0.50	0.50	0.50
Palm oil	0.00	1.00	2.00	3.00	4.00
Methionine	0.20	0.20	0.20	0.20	0.20
Lysine	0.15	0.15	0.15	0.15	0.15
Salt	0.30	0.30	0.30	0.30	0.30
Premix*	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100
Calculated Analysis					
Met. Energy (kcal/kg)	2989	2991	3037	3082	3128
Crude protein (%)	20.00	20.00	20.00	20.00	20.00
Ether extract (%)	6.13	6.50	7.42	8.11	8.11
Calcium (%)	1.20	1.23	1.29	1.35	1.41
Phosphorus (%)	0.71	0.80	0.79	0.79	0.79
Lysine (%)	0.79	0.72	0.72	0.72	0.72
Methionine+ Cysteine (%)	0.60	0.74	0.70	0.70	0.70
Cost/kg (₦/kg)	60.88	52.96	54.36	55.61	56.87

**Vitamin Premix: Composition of vitamin premix per kg is as follows: Vitamin A, 8000 iu; Vitamin D_3, 1600 iu; Vitamin E 5 iu, Vitamin K 0.200 mg; Vitamins B, Thiamine B_1 0.5mg; Riboflavin B_2 4mg; Pyridoxine B_6 0.015 mg; Niacin 0.015mg; B_{12} 0.01mg; Pantothenic acid 0.5mg; folic acid 0.5mg and Biotin 0.020 mg; Chlorine chloride 0.02 mg; Anti-oxidant 0.125g and Minerals (Mn, Zn, Fe, Cu, I, Si, Co) 0.156g. FF= Full Fat*

Vaccination schedule as recommended for Zaria was strictly followed. Left over feed and body weight of chicks were monitored on a weekly basis for the starter and finisher phases of the experiment. At the end of every week, performance data such as initial weight, final weight, weight gain, feed conversion ratio, average daily gain, feed efficiency, and feed cost per kg gain in weight were computed.

3.5.4 Digestibility Trial

A digestibility trial was carried out at the end of the finisher phase using the procedures described under item 3:5:4.

3.5.5 Carcass Analysis:

Carcass evaluation was carried out. Using the procedures described under item 3.5.5.

3.5.6 Statistical Analysis

Data generated in the study were subjected to Analysis of Variance of SAS procedures (2002). Significant differences between treatment means were separated using Duncan's Multiple Range Test (Statistical Analysis System, 2002).

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Proximate and Anti-nutrient Composition of Fresh and Sun Dried Yam Peels

The proximate composition of yam peel is presented in Table 4.1. Yam peels had a crude protein content of 11.06%. This value was within the range (11.33-12.70%cp) reported by other authors. (Akinmutimi *et al.* 2006: Akinmutimi and Onen (2008). The gross energy (3165kcal/g) is similar to that of Ekenyem *et al.* (2006) who recorded 3000kcal/kg; it also falls within the range of 2988kcal/kg and 3,404kcal/kg reported by Akinmutimi *et al.* (2006) and Igwebuike *et al.* (2009) respectively. The crude fibre value (6.04%) was similar to 6.3% reported by Akinmutimi and Onen (2008). The slight differences in crude fibre of the yam peels could probably be due to different sources and species of yam used to obtain the peels. Ether extract (1.69%), had values closer to those obtained by Akinmutimi and Onen (2008) who recorded 1.05, although with slight differences. The Ash (mineral) value of 5.93 was also closer to values reported by Ekenyem *et al.* (2006) given as 6.80%. The differences in the ash value could be due to the variation in the degree of accuracy of the laboratory analyses of the YPM. It could also be due to differences in variety.

Results of anti-nutrient composition of fresh and sun dried samples of yam peels are as follows; phyate (0.42; 0.16%), cyanide (0.86; 0.09%), tannin (0.22; 0.16), oxalate (0.68; 0.42) and saponin (0.94; 0.19). Values obtained for dried samples of tannin (0.16%), was the same with that obtained by Akinmutimi and Onen (2008). Others were saponin (0.19%), Phytate (0.16), cyanide (0.09) and oxalate (0.42) which was similar to those of Akinmutimi and Onen (2008) and Anabeke (2006) on dry matter basis. Results obtained showed a decrease in the sun dried yam peels compared to fresh samples, indicating that sun drying is a valuable method of reducing the anti-nutrients found in yam peels.

Table 4.1: Proximate Composition of Sun Dried Yam Peels

Feed Ingredient	% Composition
Dry matter (%)	93.02
Crude Protein (%)	11.06
Crude Fibre (%)	6.04
Ash (%)	5.93
Ether Extract (%)	1.69
Metabolizable Energy (Kcal/g)	3164
Nitrogen free extracts (%)	75.28

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4.2 Experiment 1: Replacement Value of Yam Peels for Maize in Broiler Starter Diets (1-5 weeks)

4.2.1 Results and Discussion

The performance of broiler starter fed varying levels of dried yam peels is presented in Table 4.2. There were significant differences (P<0.05) in the final live weight, daily feed intake, daily weight gain, and feed cost per kilogram gain across dietary treatment. Birds fed 30% YPM had the highest feed intake (70.09g), while those on treatment 3 (20% YPM) had the lowest (56.83g) with treatment 1, 2 and 5 having 62.27, 60.63 and 57.78g respectively. The increase in feed intake with increasing levels of YPM in the diets could be attributed to the lower metabolizable energy of YPM than maize which might have caused high feed intake by birds in their effort to optimize their energy intake. Alozie *et al.* (1987) had earlier reported that birds on YPM based diets tend to consume more feed than those on non YPM diets. The additional levels of fibre in the YPM based diets must have increased the feed intake of birds. Feed international (1985) concluded that every one percent increase in dietary fibre is accompanied by an increase of approximately three percent in feed intake. Scott (1987) and Aduku *et al*. (1991) reported that voluntary feed intake appears to be controlled by energy intake and birds eat primarily to satisfy their energy requirements.

Final weight showed significant differences (P<0.05) among birds in the various treatment groups. Birds in treatment 1 recorded the lowest final weight (564.23g) while the highest was obtained from birds in the treatment 3 (698.89g) although not significantly different (P<0.05) from those of treatments 2, 4, and 5 with 662.54, 688.65, and 638.18, respectively. No particular trend was observed. The results of this trial disagree with the report of Opara (1996), Iyayi (2001), and Ekenyem *et al*. (2006) who observed that additional levels of fibre in diets of animals depressed growth.

Table 4.2: Performance of Broiler Starter fed Yam Peel Meal in place of Maize Based Diets (1-5 weeks)

	Dietary Levels of Yam Peels					
Parameters	**0%**	**10%**	**20 %**	**30%**	**40%**	**SEM**
Initial weight, (g)	80.10	80.07	80.11	80.03	80.12	0.00
Final weight, (g)	564.23^{b}	662.54^{ab}	698.89^{a}	688.65^{a}	638.18^{ab}	14.05
Daily feed intake, (g)	62.27^{b}	60.63^{b}	56.83^{c}	70.09^{a}	57.78^{c}	14.45
Daily weight gain, (g)	16.19^{c}	24.90^{b}	40.20^{a}	37.20^{a}	19.06^{bc}	13.10
Feed conversion ratio	3.21	2.81	2.77	2.89	3.20	0.10
Cost/kg gain, (₦/kg)	202.28^{b}	159.08^{a}	144.01^{a}	137.34^{a}	137.90^{a}	5.78
Mortality, (%)	3.34	3.32	4.40	3.33	4.08	0.32

abcde= Means with different superscripts in the same row are significantly (P<0.05) different.

FCR= Feed conversion ratio, SEM = Standard Error of Means.

The similarity in this result and those of Igwebuike *et al.* (2009) could be as a result of low lignin and other complex compounds in yam peels thus making the fibre appreciably digestible (Ekenyem *et al*., 2006). This could probably be the reason why birds on the yam peel meal based diets had higher weight gain regardless of their low energy content than those on the control diet.

The daily weight gain of birds did not follow a particular trend. Birds in treatment 3 had the highest weight gain of 40.20g. This was not significantly different (P>0.05) from those on treatment 4 (37.20g), others were 16.19, 24.90, and 19.06 for treatments 1, 2, and 5 respectively. Although if the result of daily weight gain did not follow a particular trend it follows the same pattern with the final weight of birds obtained in this experiment as birds with the highest final weight recorded the highest daily weight gain and vice versa. However the lowest weight gain of birds was recorded in the control group, followed by those with the highest level of YPM inclusion (40%). This could be as a result of the metabolizable energy of YPM (3164kcal/kg) which is comparable to those of maize (3234kcal/kg) (Aduku *et al.,* 1991). This could account for the less variation in the weight gain of birds. The differences in the fibre levels of the various treatment groups could also be responsible for the different weight gain obtained in the treatments. The results of this trial disagrees with the work of Adeyemo and Borrie (2002) who had reported that inclusion of YPM at high levels resulted in depressed growth due to low nutrient value of fibre, decreased dry matter apparent digestibility and the resultant non availability of nutrients for growth in turn decreased weight gain of birds.

There were no significant differences (P>0.05) in the feed conversion ratio of birds. Birds on the treatment group 3 had the best (2.77) while those on treatments 1, 2, 4, and 5 had 3.21, 2.81, 2.89 and 3.20, respectively. The feed conversion ratio showed that birds on YPM based diets were more efficient than those on the control diets although the differences were not significant (P>0.05). This suggests better conversion of YPM diets to flesh compared to maize based diets. This is expected as birds in the YPM based diets recorded higher final weight than those on maize based diets and it is in conformity with the work of Ekenyem *et al.* (2000) who reported that heavier weights were achieved with increasing levels of YPM in the diets, Igwebuike *et al.* (2009) reported weights that were comparable with the control with increasing levels of YPM in broiler finisher diets.

The cost of feed per kilogram gain decreased from treatments 1-4 with increasing levels of YPM in the diets, except for treatment 5 which did not follow the same trend with values slightly higher than those of treatment 4. These were 202.28, 159.08, 144.01, 137.34 and ₦137.90 respectively for treatments 1-5. These results in a considerable reduction in the cost of broiler production and by extension make the product affordable to consumers. This is in agreement with the work of Akinmutimi and Onen (2008) and Ekenyem *et al.* (2006) who reported lower feed cost per kilogram gain with increasing levels of YPM in the diets. The results of mortality showed no significant differences (P>0.05) among birds in the various treatment groups. However, from the observed results birds in treatment 3 with 20% YPM recorded higher values than all the other treatments including the control diets in terms of final weight, daily weight gain, and feed conversion ratio, therefore it can be concluded that broiler diets can constitute 20% YPM without deleterious effect on their general performance.

4.3 Experiment 2

The performance of broilers fed the finisher diets is presented in Table 4.3. There were significant differences (P<0.05) across the dietary treatments in the average daily feed intake, weight gain, final weight, and feed conversion ratio. The average daily feed intake increased from treatments 1-5 with increasing levels of YPM in the diets. Birds in treatment 1 had the least feed intake (89.69g) which was significantly different (P<0.05) from those in treatments 2-5 with 95.68, 97.22, 97.61, and 101.56g, respectively. The higher feed intake with increased level of YPM is probably due to the lower metabolizable energy as birds eat to meet their energy requirements. Opara (1996), Iyayi (2001) and Ekenyem *et al.* (2006) had earlier documented that feed intake in broilers 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. Therefore the high level of feed intake observed in this trial could be attributed to the low energy level of yam peel meal compared to the maize based diet (control). The fibre content of the yam peels could also be a contributory factor as supported by the reports of Opara (1996), Iyayi (2001) and Ekenyem *et al.* (2006) who observed that the presence of fibre in YPM based diets for broilers increased voluntary feed intake.

The highest final live weight of 1910g was obtained from the control diets followed by diets 3, 2, 4, and 5 with 1860, 1835, 1775, and 1622g, respectively. This could be attributed to the increasing levels of YPM in the diet with a relatively lower metabolizable energy and higher fibre content than maize. The results of this trial agreed with those of Opara (1996), Iyayi

(2001) and Ekenyem *et al*. (2006) who observed that additional levels of fibre in diets of animals depresses growth.

Table 4.3: Performance of Broiler Finisher Fed varying Dietary Levels of Yam Peel Meal (5-9 weeks)

	Dietary Levels of Yam Peel Meal, %					
Parameters	**0.00**	**10.00**	**20.00**	**30.00**	**40.00**	**SEM**
Initial weight (g)	564.23^{b}	662.54^{ab}	698.89^{a}	688.65^{a}	638.18^{ab}	14.05
Final weight (g)	1910^{a}	1835^{ab}	1860^{ab}	1775^{b}	1622^{c}	17.25
Daily feed intake	89.69^{c}	95.68^{b}	97.22^{b}	97.61^{b}	101.56^{a}	0.387
Daily weight gain(g)	32.67^{a}	31.35^{ab}	31.80^{ab}	30.27^{b}	27.52^{c}	0.308
Feed conversion ratio	2.75^{a}	3.05^{b}	3.06^{b}	3.22^{b}	3.70^{c}	0.031
Cost/kg gain (₦/kg)	167.75^{b}	170.77^{b}	159.03^{a}	161.10^{a}	158.84^{a}	0.52
Mortality (%)	6.67	6.67	8.89	6.67	8.89	0.63

abcd= Means with different superscripts in the same row are significantly (P<0.05) different. SEM= Standard Error of Mean.

Significant differences (P<0.05) were observed among birds in terms of daily weight gain and final weight with birds on treatments 2 and 3 having similar weight gains and final weights as those on treatment 1 (control diet). Results of the average daily weight gain showed that birds on the control diets had the highest weight gain (P<0.05). Birds on treatment 5 had the least weight gain.

There was a trend towards depressed weight gain as the level of YPM in the diets increased from 0-40%. Birds fed the control diets gained an average of 32.67g per day. While those on treatment 2, 3, 4, and 5 had 31.35, 31.80, 30.27, and 27.52g per day, respectively. Mohamed *et al*. (2006) had earlier reported higher weight gain of birds with increasing levels of YPM in the diets.

Feed conversion ratio were significantly different (P<0.05) among birds in the various treatment groups, birds on the control diets (0% YPM) were most efficient with a trend towards poorer feed efficiency as the level of YPM increased from 0-40%. The control diets gave a feed efficiency ratio of 2.75, while others were; 3.05, 3.06, 3.22, and 3.70 for experiments 2-5, respectively. The best feed conversion ratio (2.75) were obtained on birds fed treatment 1 and significantly differed (P<0.05) from others. This is expected as feed conversion ratio is a function of feed intake and weight gain. Anakebe (2008) had earlier documented that higher inefficiency of feed utilization were obtained from diets with increased level of YPM.

There were significant differences (P<0.05) in the cost of feed per kilogram gain of birds. The highest cost of feed per kilogram gain was obtained from treatment 2 (₦170.77). Others were ₦167.75, ₦161.10 and ₦159.03, for treatments 1, 4, and 3, respectively. Birds on treatment 5 had the least cost per gain. This conforms to the findings of Akinmutimi and Onen (2008) who reported that lower cost of feed per kilogram gain was achieved with increasing levels of YPM in broiler diets. Ekenyem *et al.* (2006) also reported lower feed cost per kilogram gain with increased level of YPM in poultry diets. There were no significant differences (P>0.05) between birds in the various treatments means in terms of mortality.

Table 4.4 shows the effect of feeding varying levels of yam peel meal on carcass characteristics of broiler finisher chicken. There was no significant difference (P>0.05) for most of the parameters considered with the exception of live weight, carcass weight and gizzard. Birds fed the control diet recorded the highest live weight (2370g) though this was not significantly different (P<0.05) from all the other treatments. Akinmutimi and Onen (2008) observed the same trend when YPM was fed to Broiler finisher birds. The carcass weight of birds in treatment 1 (1503g) did not differ significantly (P>0.05) from treatments 2, 3, and 4. Birds on treatment 5 had the least carcass weight. This is in agreement with the work of Mohammed *et al.* (2009) who fed graded levels of YPM to broiler chicks. This could probably be due to the increasing levels of YPM in the diets. The gizzard of birds on treatment 5 had the largest percentage of 4.57% and the least was obtained from treatment 1 (3.78%). Others were 4.27, 4.10 and 4.10 for treatments 2, 3, and 4 respectively, most probably due to the higher level of fibre in the diet. Gizzard size is known to be influenced by the degree of feed coarseness resulting from increased muscular activity of the gizzard during grinding (Fanimo *et al.*, 1996). The other parameters considered showed no significant differences (P>0.05) among birds in the various treatment groups. It was concluded that up to 20% inclusion of yam peel meal in broiler diets had no adverse effect on their performance and carcass characteristics.

Table 4.4: Effect of Feeding Varying Levels of Yam Peel Meal on Carcass Characteristics of Broiler Finisher Chickens

	Dietary Levels of Yam Peel, %					
Parameters	**0.00**	**10.00**	**20.00**	**30.00**	**40.00**	**SEM**
Live weight (g)	2370.7^{a}	2310.0^{a}	2366.0^{a}	2300.0^{a}	1880.0^{b}	49.6
Carcass weight (g)	1503.0^{a}	1350.0^{ab}	1420.3^{ab}	1276.7^{ab}	1116.3^{b}	45.6
Dressing (%)	63.40	58.44	60.03	55.51	59.38	1.56
Liver (%)	2.80	4.0	4.0	4.18	2.80	0.20
Heart (%)	0.78	1.05	1.11	0.78	1.20	0.12
Gizzard (%)	3.78^{b}	4.27^{ab}	4.10^{ab}	4.10^{ab}	4.57^{a}	0.09
Kidney (%)	0.93	0.96	1.15	2.96	3.98	0.61
Spleen (%)	0.42	0.60	0.61	0.70	1.60	0.12
Breast (%)	28.40	24.94	23.62	28.56	22.85	1.18

Head (%)	4.32	4.25	4.41	4.38	3.52	0.25
Back (%)	21.09	20.60	21.00	21.87	17.65	0.69
Wings (%)	14.62	14.62	13.49	14.20	11.98	0.64
Thigh (%)	34.82	35.88	33.10	34.16	29.29	1.51
Leg (%)	6.85	8.66	7.68	7.04	6.06	0.35
Neck (%)	8.43	7.98	7.86	8.51	7.33	0.42
Small intestine (%)	4.77	5.85	4.92	6.27	5.27	0.30
Small intestine length (cm)	234.0	272.33	257.67	270.0	265.7	0.88
Abdominal fat (%)	2.29	2.57	2.23	2.82	2.43	1.84

Means with different superscripts in the same row are significant (P<0.05) different. SEM= Standard Error of Means.

4.3.1 Nutrient Digestibility of Broilers fed Graded Levels of YPM (1-9 Weeks)

Nutrient digestibility for crude protein, ether extract, crude fibre, ash and nitrogen free extracts is presented on Table 4.5. The highest (85.01%) dry matter digestibility was obtained from birds in treatment 1 and was not significantly different from those of treatment 2, 3, 4, and 5 with (84.81%), 83.18, 80.84, and 81.80%, respectively.

There were significant differences (P<0.05) among the treatment groups in terms of crude protein digestibility. Birds in treatment 5 had 79.31% crude protein digestibility and was the lowest compared to those on treatment 2, 3, 4 and 5 with 82.57, 85.90, and 82.67%, respectively. The crude protein content of the maize based diet was more digestible than the YPM-based diets. This could be due to high fibre content of the YPM which might have limited intake and digestibility of the yam peel meal based diets compared with the control diet. Loosi *et al*. (1994) fed rice husk diets to pigs and reported a linear decline in the amount of nitrogen consumed with increased level of fibre. Frank *et al.* (1983) reported that differences in daily nitrogen intake by growing birds was basically due to differences in the fibre content of the diet.

Crude fibre digestibility showed significant differences ($P<0.05$) among birds among the various treatment groups. The highest digestibility was obtained from birds in treatment 1 (76.04), followed by 39.05, 40.51, 34.16, and 29.95 for treatments 2, 3, 4, and 5, respectively. The decrease in crude fibre digestibility as the level of YPM increased in the diet could be attributed to the high fibre content of YPM based diets relative to maize this agreed with the reports of Malmlof and Hakanssan (1984) and Morgan and Wehittemore (1988). It could be inferred from the result of this study that the inclusion of YPM peels in broiler diets especially at higher levels may result in higher loss of nitrogen through the faeces.

Table 4.5: Nutrient Digestibility (%) of Broilers Fed Graded Level of Sun dried YPM

	Dietary Levels of Yam Peels, %					
Parameters	**0.00**	**10.00**	**20.00**	**30.00**	**40.00**	**SEM**
Apparent dry matter digestibility	85.01^{a}	84.81^{a}	83.18^{b}	80.84^{c}	81.80^{c}	0.15
Apparent crude protein	92.19^{a}	82.57^{c}	85.90^{b}	82.67^{c}	79.31^{d}	0.17

digestibility						
Apparent crude fibre digestibility	76.04[a]	39.05[c]	40.51[b]	34.16[d]	29.95[e]	0.18
Apparent Ether extract digestibility	78.17[c]	92.68[a]	92.74[a]	91.31[a]	89.44[b]	0.21
Apparent Ash digestibility	47.76[a]	48.51[a]	48.68[a]	44.61[b]	42.74[c]	0.21
Apparent NFE	72.38[b]	78.38[a]	79.27[a]	72.38[b]	70.77[b]	0.24

abcde= Means with different superscripts in the same row are significantly ($P<0.05$) different.

NFE= Nitrogen Free Extract.

Malmlof and Hakanssan (1984) concluded that dietary fibre suppressed ammonia liberation in the colon, through the activity of the micro flora thereby reducing urinary nitrogen excretion and urinary nitrogen output, expressed as a proportion of nitrogen intake, decreased significantly (P<0.05) with increase in the level of fibre.

The percentage digestiblities of ether extract, ash, and nitrogen free extract were significantly different (P<0.05) across the dietary treatments and did not follow a particular trend. However birds on the control diet had apparent digestibility than those of the yam peel meal based diets in ether extract, nitrogen free extract, and ash. Therefore the general conclusions drawn are that: the control diet recorded higher digestibility than the yam peel meal based diets and is attributable to the high fibre nature, dusty nature of the feed, and its relatively low metabolizable energy in comparison with the maize based diet.

4.4 Experiment 3:

The performance of broilers fed the starter diets is presented in Table 4.6. There were significant differences (P<0.05) in daily feed intake and feed cost per kilogram gain among the dietary treatments. Birds on treatment 5 recorded the highest daily feed intake (34.68g). This was not significantly (P<0.05) different from birds fed treatments 2, 3, and 4 with 33.50, 34.52, and 34.04g, respectively. Birds on treatment 1 had the least feed intake value (31.37g). This could be attributed to the inclusion of palm oil in the diet which has been found to be beneficial in broiler diets. Isika *et al.* (2006) had earlier documented that 5% palm oil promoted higher egg production, increased feed consumption, acceptability of the feed and supports heavier egg mass of the domestic fowl. There were no significant differences (P>0.05) in terms of the final weight of birds across dietary treatment birds in treatment 2 had the highest final weight (519.60g) while those on treatment 5 (488.42g) had the least (488.42g).

Table 4.6: Mean Performance of Broiler Starter fed Yam Peel Meal and Palm Oil Supplement (1-4 weeks)

	Dietary Levels of Palm oil, %					
Parameters	**0.00**	**1.00**	**2.00**	**3.00**	**4.00**	**SEM**
Initial weight (g)	42.53	42.56	42.60	42.58	42.61	0.00
Final weight (g)	489.69	519.60	511.77	492.60	488.42	6.66
Daily feed intake (g)	31.37^{b}	33.50^{ab}	34.52^{a}	34.04^{a}	34.68^{a}	0.31
Daily weight gain (g)	15.97	16.79	16.76	16.08	15.92	0.24
Feed conversion ratio	1.97	2.00	2.06	2.13	2.18	0.03
Feed cost /kg gain(₦)	120.35^{ab}	106.51^{a}	112.56^{ab}	118.63^{ab}	124.47^{b}	1.86
Mortality (%)	0.00	0.00	0.00	0.00	0.00	0.00

abcd= Means with different superscripts in the same row are significantly (P<0.05) different.

The result of this trial could be as a result of the digestible nature of the fibre present in yam peels (Scott, 1987). Akinmutimi *et al*. (2006) obtained similar results when Yam peels and ripe plantain peels were fed to weaner rabbits. Igwebuike *et al*. (2009) recorded no significant differences in the final weight of birds fed yam peel meal in place of maize based diet. There were no significant differences in terms of the daily weight gain of birds.

The feed conversion ratio showed no significant differences (P>0.05) across the dietary treatments. Birds on treatment 1 had the best (1.97) others were 2.00, 2.06, 2.13, and 2.18 for treatments 2, 3, 4, and 5 respectively. Similar results was also obtained in the daily weight gain with the birds in treatment 2 having higher weights than others and the lowest from treatment 5. Igwebuike *et al*. (2009) also reported that no significant differences (P>0.05) was observed in the feed conversion ratio and the daily weight gain of birds fed graded levels of yam peel meal. These suggest that yam peel meal could be a better supplement for maize as an alternative energy source due to the similarity in the weight of birds obtained.

Significant differences (P<0.05) exist among birds in terms of feed cost per kilogram gain. Birds on Treatment 5 recorded the highest cost (₦124.47), which was followed by the control diet (₦120.35), while others were 106.51, 112.56 and ₦118.63 for treatments 2, 3, and 4, respectively. This implies that the cost per kilogram gain increased with increasing levels of palm oil from treatments 2-5 and could be attributed to the high cost of palm oil, although the low cost of YPM in the diets compensated for this and hence kept the cost of feed at minimum when compared with the control. This conforms to the result of Ekenyem *et al.* (2006) who reported that lower feed cost per kilogram gain was achieved with the inclusion of YPM in the diet.

It was therefore concluded that it appeared that diet 2 with 20% yam peel meal and 1% palm oil promoted the best overall performance in broiler starter chicken.

4.6 Experiment 4

The performance of broiler finisher birds fed experimental diets is presented in Table 4.7. There were significant differences (P<0.05) in daily feed intake, feed conversion ratio and feed cost per kilogram gain across the dietary treatments.

The amount of feed intake (91.48g) consumed by birds in the control diets differed significantly (P<0.05) compared to birds in YPM based diets. Birds in treatment groups 2-5 had 92.15, 92.20, 92.08, and 92.46g, respectively. The fact that birds in the treatment group 1 recorded the lowest feed intake could likely be attributed to the high metabolizable energy of the maize based diet as birds eat to meet their energy requirements (Tewe, 1975). The greater consumption of YPM-based diets compared to the maize based diet (control) was in agreement with the report of Bawa (1995) and Taylor *et al.* (1987) and could likely be attributed to palm oil supplementation. These authors indicated that addition of palm oil in cassava peel meal based diets reduced dustiness and improved its palatability. Alozie *et al.* (1987) had earlier noted that birds on YPM diets consumed more feed than those on maize based diets.

Daily weight gain of birds did not differ significantly (P>0.05) among the various treatment group. However, birds on the treatment 4 grew faster than those fed diet 1, 2, 3, and 5 with 39.73, 38.15, 37.37 and 37.20, respectively. This suggests that increasing the level of palm oil up to 3% in a 20% YPM diet would promote a better performance. Akinmutimi *et al*. (2006), Mohammed *et al*. (2009) and Igwebuike *et al*. (2009) had also reported higher weight gain in birds fed YPM.

Table 4.7: Mean Performance of Broiler Finisher (5-8 Weeks) fed 20% Yam Peel Meal and Palm Oil Supplement

	Dietary Levels of Palm oil, %					
Parameters	**0.00**	**1.00**	**2.00**	**3.00**	**4.00**	**SEM**
Initial weight (g)	489.69	519.60	511.77	492.60	488.42	6.66
Final weight (g)	1702	1659	1680	1720	1630	14.34
Daily feed intake(g)	91.48^{b}	92.15^{a}	92.20^{a}	92.08^{a}	92.46^{a}	0.07
Daily weight gain(g)	39.73	37.37	38.15	40.26	37.20	0.53
Feed conversion ratio	2.30^{ab}	2.48^{b}	2.42^{b}	2.29^{a}	2.49^{b}	0.03
Cost/kg gain (₦/kg)	140.29^{ab}	131.10^{ab}	131.78^{ab}	127.19^{a}	141.57^{b}	1.82
Mortality	0.00	0.00	0.00	0.00	0.00	0.00

abcde = Means with different superscripts in the same row are significantly (P<0.05) different. SEM= Standard Error of Means. Av=Average

The final weight of bird fed dietary treatments were not statistically (P>0.05) significant. However birds in treatment group 4 recorded the highest (1720g) final weight compared to those on other yam peel based diets. This is in agreement with the work of Bawa (1995) that indicated better growth rates in pigs fed cassava peel meal supplemented with palm oil. Oluyemi and Roberts (2002) similarly reported that palm oil can be used to boost the dietary energy of birds for better performance.

Feed conversion ratio was significantly different (P<0.05) across the dietary treatment groups. Diet 4 was the most efficiently utilized, followed by diets 1, 3, 2 and 5 with (2.29 vs 2.30 vs 2.42 vs 2.48 and 2.49). Bawa (1995) also reported better feed conversion ratio of pigs fed cassava peel meal supplemented with palm oil. Similarly, Akimutimi and Onen (2008) indicated higher feed conversion ratio of bird fed YPM based diet and this could likely be attributed to the Palm oil supplementation which increased the energy profile and efficiency of utilization of the yam peel meal based diets.

The cost to produce a unit gain per kilogram increased with increased level of palm oil. The least cost per kg gain of ₦127.19 was obtained from birds fed diet 4. Bird on the control diet proved to be most expensive than the others except for treatment 5 that had 4% palm oil although not statistically different (P<0.05) from the control, with no particular trend observed. This result corroborated Ekenyem *et al.* (2006) who observed lower feed cost per gain with inclusion of YPM in the diet. Mohammed *et al.* (2006) observed the same trend when broiler chickens were fed diets containing graded levels of yam peels.

The summaries of data on the carcass evaluation of birds fed yam peel meal supplemented with palm oil are presented on Table 4.8. Dietary treatments had no significant effect (P>0.05) on most of the parameters measured.

Table 4.8: Effect of Yam Peel Meal and Palm Oil Levels on Carcass Characteristics of Broiler Finisher Chicken.

	Dietary Levels of Palm oil, %					
Parameters	**0.00**	**1.00**	**2.00**	**3.00**	**4.00**	**SEM**
Live weight (g)	2130.30	2120.0	1866.7	2150.0	1766.7	52.1
Carcass weight(g)	1316.7	1396.7	1193.3	1433.3	1233.3	45.3
Dressing (%)	61.81	65.88	63.93	66.67	69.81	0.78
Liver (%)	1.11	2.65	2.48	1.39	2.99	0.39
Heart (%)	0.36	0.45	0.38	0.45	0.37	0.02
Gizzard (%)	4.51	5.01	4.99	6.38	4.87	0.31
Kidney (%)	0.44	0.45	0.47	0.42	0.41	0.03
Spleen (%)	0.07	0.08	0.12	0.09	0.12	0.01
Breast (%)	25.963	26.30	26.30	27.57	27.86	0.73
Head (%)	2.99^{a}	5.91^{b}	6.10^{b}	6.85^{b}	5.66^{b}	0.18
Back (%)	24.59	21.67	22.96	22.81	22.16	0.69
Wings (%)	13.07^{b}	15.76^{ab}	14.82^{ab}	15.38^{ab}	16.66^{a}	0.64

Thigh (%)	33.68	34.12	30.60	31.73	31.73	1.51
Leg (%)	9.23^{ab}	9.65^{ab}	7.79^{b}	10.44^{a}	7.84^{b}	0.35
Neck (%)	10.84	9.85	9.19	11.21	9.72	0.42
Small intestine lngth (cm)	262.33^{a}	259.00^{a}	217.67^{b}	249.33^{ab}	255.67^{a}	0.88
Abdominal fat (%)	4.27	3.69	3.80	4.81	4.97	1.84

SEM=Standard Error of Mean; Lngth= Length

Birds fed diet 4 recorded the highest live weight and carcass weight (2150 and 1433.3g). Head, wings, leg and small intestines expressed as percent of carcass weight showed significant differences (P<0.05). These values were similar to those reported by earlier workers (Ekenyem *et al*., 2006, Akinmutimi and Onen, 2008 and Mohammed *et al.,* 2006).

Mohammed *et al.* (2006) had earlier reported a positive correlation between the dietary oil and the composition of the body fat of the chick. In the present study, the percent abdominal fat increased as the level of palm oil increased in the diet. Average liver, heart and spleen weights expressed as percentage of carcass weight were not significant (P>0.05) among dietary treatment. It was concluded that supplementation of 20% yam peel meal based diet with 3% palm oil will promote better performances at the least cost in broiler chicken.

4.7 Nutrient Digestibility of Broilers fed YPM and Palm Oil Supplement (0-8 Weeks)

Table 4.9 shows the result of nutrient digestibility of broilers fed yam peel meal diets substituted with varying levels of palm oil. There were significant differences (P<0.05) in the crude protein, crude fibre, ether extract, ash and nitrogen free extract. The crude protein digestibility of treatment 2 given as 97.45% recorded the highest value than those of the control and other YPM based diet. These were 96.51, 95.49, 97.36, and 95.24% for treatments 1, 3, 4, and 5, respectively. Similar results were also obtained in the crude fibre digestibility of the feed, except for the digestibility of birds in treatment 5 which recorded the lowest and this could be attributed to palm oil inclusion in the diets and is in agreement with the work of Bawa (1995), who stated that the inclusion of palm oil in cassava peel meal for pigs increased the dietary energy of the pigs and pigs on such diets performed better than those on the control diets.

Table 4.9: Nutrient Digestibility (%) of Broilers Fed (20%) Yam Peel Meal Supplemented with varying Levels of Palm Oil.

	Dietary Levels of Yam Peels, %					
Parameters	**0.00**	**20.00**	**20.00**	**20.00**	**20.00**	**SEM**
Dry matter	96.73	97.00	93.36	97.67	96.53	0.36
Crude protein	96.51^{ab}	97.45^{a}	95.49^{ab}	97.36^{a}	95.24^{b}	0.26
Crude fibre	59.67^{b}	60.40^{b}	59.66^{b}	64.48^{a}	48.19^{c}	0.25
Ether extract	59.46^{c}	60.26^{c}	67.20^{b}	70.36^{a}	78.49^{a}	0.23
Ash	46.41^{b}	48.63^{a}	42.14^{c}	48.86^{a}	42.88^{c}	0.25
NFE	82.04^{a}	80.38^{ab}	81.63^{b}	78.42^{b}	82.21^{a}	0.41

abc= Means with different superscripts in the same row are significantly (P<0.05) different.

NFE= Nitrogen Free Extract

Results of ether extract digestibility increased from treatments 1-5 with increasing levels of palm oil in the diets, this is understandable since palm oil has a high metabolizable energy than maize and was included in the diet at graded levels (0, 1, 2, 3, and 4%) for diets 1-5 respectively, and is in agreement with the work of Loosli (1994), who obtained similar results when palm oil was included in the diets for growing pigs.

The overall results showed that the inclusion of palm oil at graded levels improved the quality of the yam peel meal based diets and also favours its digestibility, making it comparable with the control diet, thereby proving that palm oil could be included up to the level of 4% in YPM based diets for broilers without adverse effects on their general performance.

CHAPTER FIVE

5.0 General Summary and Conclusion

The results obtained from the entire study showed that yam peels constitute the major waste product of yam processing and have tremendous potential of alleviating the problem of shortage of energy (maize) components of broiler diets. Its inclusion in broiler diets can bring about reduction in feed cost, and consequently the competition between man and animals for maize.

Results from chemical analyses revealed that yam peel is 93.02% dry matter, 11.06% crude protein, 6.04% crude fibre, 5.93% ash, 1.69% ether extract, and 75.28% nitrogen free extract. The Gross energy of yam peel is given as 3164 kcal/kg. The analyses suggest that yam peel is relatively high in crude fibre, ash and crude protein but lower in nitrogen free extract, ether extract and energy than maize. These likely suggest that yam peel is a potential feed stuff with high nutritive value for poultry.

In experiment 1 (starter phase), the birds were fed isonitrogenous rations containing 20% crude protein. Yam peel meal replaced maize at 0, 10, 20, 30, and 40% in the diet. Result obtained showed significant differences in the final weight, and daily feed intake. The results were in support of the use of YPM up to the level of 20% without deleterious effect on the general performance of broiler.

Further investigations with the broiler finisher birds (Experiment 2) have shown that as high as 20% can be included in poultry diet without adverse effect on the growth performance.

Result of Nutrient Digestibility of birds fed graded levels of yam peel meal showed that birds on the control diet had higher nutrient digestibility than those fed yam peel meal based diets and is attributable to the high fibre nature, dusty nature of the feed, and its relatively low metabolizable energy compared to the maize based diet.

In experiment 3, all the birds (225) were fed diets containing equal amount of YPM (20%) supplemented with graded levels of palm oil 0-4% for treatments 1-5 respectively. The result showed that supplementation of palm oil in YPM based diets resulted in effective utilization of nutrients for body building. YPM and palm oil at 1 and 20% (diet 2) in broiler starter diets supported the best overall performance. There was significant cost benefit in using palm oil in YPM diets, because lower feed cost per kilogram gain was achieved with the inclusion of YPM in diet 2, which recorded the best among all other treatments including the control. The best live weight and carcass weight was obtained from birds in treatment 3 fed 20% YPM and 2% palm oil. Other parameters except the gizzard were not significantly affected by dietary treatment suggesting that the use of palm oil especially at higher level of inclusion may result in poor carcass quality as such may not be encouraged a higher levels.

In Experiment 4 all the birds were fed isonitrogenous rations containing 20% crude protein. The diets were formulated such that all the treatment contained equal amount of YPM (20%) supplemented with 0-4% level of palm oil for treatments 1-5 respectively. The result showed significant differences in daily feed intake, feed conversion ratio and cost per kilogram gain across the dietary treatment.

The results of nutrient digestibility of broilers fed YPM and palm oil supplement showed that the inclusion of palm oil at graded levels improved the quality of the yam peel meal based diets which favoured its digestibility, making it comparable with the control diet, thereby proving that palm oil could be included up to level of 4% in YPM based diets for broilers without adverse effects on their general performance. Judging from the result obtained 3% palm oil gave the overall best performance and therefore is recommended for optimum performance of broiler finisher birds fed YPM diets at 20% inclusion level.

Generally, it can be concluded that yam peels have tremendous potentials of alleviating the problems of shortage of energy source (maize). Its inclusion in broiler diets can bring about reduction in feed cost, cost of producing edible meat and more importantly reduce the competition between man and bird for maize with the result that there would be more food for the increasing human population and greater potential for the growth of the poultry industry.

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