STUDIES ON THE VALUE OF COCOA HUSK IN THE NUTRITION OF COCKERELS

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STUDIES ON THE VALUE OF COCOA HUSK IN THE NUTRITION OF COCKERELS

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ABSTRACT

Four studies were carried out to determine the nutritive value of cocoa husk in cockerel rations The parameters measured included performance and carcass characteristics, nutrient utilisation, histological studies, serum metabolites and economy of feed conversion.

In the first study, the four main by-products from the cocoa industry (cocoa shell, cake, dust and husk) were chemically evaluated and their metabolisable energy values determined. Cocoa cake was found to contain the highest amount of crude protein while the crude fibre was highest in cocoa husk. Cocoa husk which also contained the highest amount of ash had the lowest content of theobromine. However, cocoa shell had a higher metabolisable energy value than cocoa husk. The high mineral content and low level of theobromine in cocoa husk coupled with its availability confirmed its advantages as an animal feed over the other cocoa by-products.

In the second study, the wheat offal in the cockerel rations in both the starter and finisher phases was replaced with cocoa husk at 0, 25, 50, 75 and 100% levels in a twenty week study. In both phases, body weight gain decreased progressively with

increasing dietary level of cocoa husk. The depression in growth rate was attributed to the high fibre content of cocoa husk. The mean values of body weight gain in the starter phase were statistically significant ($P < 0.05$) from each other. At the end of the starter phase, however, best results of average daily gain and efficiency of feed utilisation were obtained on birds fed the diet in which 25% of wheat offal was replaced with cocoa husk. This represents about 7% of cocoa husk in the ration for the starter phase. For the finisher phase, best results of average daily gain, efficiency of feed utilisation and dressing out percentage among the cocoa husk diets were also obtained on birds fed the finisher diet in which 25% of wheat offal was replaced with cocoa husk. In addition, the lowest feed cost/kg liveweight of ₦4.89 was obtained on this diet which represented about 16% of cocoa husk in the finisher ration.

The third study focussed on the replacement of groundnut cake (GNC) in the cocoa husk based rations with palm kernel cake (PKC) at 0, 33, 66 and 100% levels in a sixteen week study. At the end of the starter phase, best results of average daily gain and efficiency of feed utilisation were observed on the birds fed cocoa husk diet in which 33% of the protein of the GNC was replaced with that of PKC. Average daily gain decreased with increasing levels of PKC in the diet. The protein intake in the starter phase also decreased with increasing level of fibre in the diet. The results of the performance of the cockerels in the finisher phase were not statistically different ($P > 0.05$) from one another. However, best results of efficiency of feed utilisation and lowest mortality in the finisher phase were obtained on the birds fed cocoa husk diet in which the GNC was completely replaced with PKC. Compared with the result obtained on the control diet, the highest dressing percentage was also obtained on the diet without GNC. The histological changes noticed in the brain, liver and kidney tissues in all the treatments indicated chronic theobromine poisoning. Finally in this study, 20% and 37% levels of PKC were recommended in the cocoa husk based rations for the starter and finisher phases respectively.

In the last study, cocoa husk was treated with the alkaline cocoa pod husk ash in order to improve it's digestibility. The treated cocoa husk (TCH) was mixed with the starter and finisher diets of cockerels in a study which lasted for sixteen weeks. The mean values of daily feed intake in the starter phase were statistically different ($P < 0.05$). The best results of body weight gain and protein utilisation were obtained on birds fed diets with 14% and 20% TCH in the starter and finisher phases respectively. The higher blood pH values obtained in the finisher phase could be due to the higher levels of treated cocoa husk (TCH) in the finisher diets. The highest dressing percentage was obtained on the diet containing 20% TCH while the best result of feed conversion was recorded on the diet containing 24% TCH. The results of this final study indicated that cockerels can tolerate higher levels of TCH in the ration as compared to the lower levels of untreated cocoa husk recommended in the previous studies. Therefore, the levels of 14% and 20% TCH can be incorporated respectively in the starter and finisher diets of cockerels for optimal performance. However, as economy of feed conversion is of paramount importance to the poultry farmer, 24% of TCH in the finisher diet will be ideal.

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Finally, I give thanks to my God for His merciful blessings and for giving me the good health.

DEDICATION

This thesis is dedicated to God Almighty for his merciful blessings, to my wife, children and all members of ABIOLA Family.

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C E R T I F I C A T I O N

I certify that this work was carried out by MR. Samuel Soladoye Abiola in the Department of Animal Science, University of Ibadan.

20/9/88

(S u p e r v i s o r)

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CHAPTER ONE

INTRODUCTION

1.1 The Livestock Feed Industry In Nigeria

Feedmilling started in Nigeria with the operation of small hammer mills by the regional Ministries of Agriculture and Natural Resources. These Ministries produced poultry feeds for their exotic breeds of chicken on the government farms. Gradually private individuals started poultry business on small scale while commercial feedmilling started in 1963. As of 1982, there had been a total of 232 feedmills in Nigeria out of which 93 percent could produce 5 tonnes of feed in an hour while about 4 percent have the capacity of 25 tonnes per hour. The Livestock Feeds Limited which was the first to set up two livestock feed manufacturing plants at Ikeja and Aba, respectively in 1963 is still the biggest feed manufacturing company. The other companies in order of size ranking after Livestock Feeds Limited are Top Feeds and Sanders, respectively.

Presently, the Livestock Feeds Limited is the only one that has a quality control unit for the purpose of analysis of raw materials and finished products and for the formulation of least-cost ration. Of all the various feeds produced in Nigeria, only poultry mash and pellets are presently sold in commercial quantities. This position is likely to remain unchanged over the next few years until commercial production of cattle, pigs, sheep and goats under intensive culture develops.

Out of the total demand for manufactured animal feeds in Nigeria, 95 percent comes from commercial poultry, 3 percent from piggery, 1.5 percent from cattle while about 0.5 percent of the total demand comes from horses, rabbits and mice (Livestock feeds, 1988). Demand for animal feeds will continue to rise phenomenally because of the increased interest in poultry and livestock rearing. This is certainly a tremendous challenge which requires considerable policy attention to the number, size, location and efficient management of feedmills in the country.

The feed industry in Nigeria is currently faced with acute shortage and high prices of feed ingredients and this is why the cost of poultry and livestock feeds has risen astronomically within the last few months.

The recent ban on the importation of maize, wheat and malted barley by the Federal Government and the inability to match the local production of these materials with the demand are some of the causes of the scarcity and high prices of feed ingredients. Researchers have identified the nutritive value of some agro-industrial by-products which could be incorporated into animal feeds. Plant-waste products like cassava peels, corn cobs, rice bran, rice husk, cocoa husk, etc have been used successfully in poultry and livestock feeds. The feed industry should now be involved in the processing and utilisation of these by-products in order to reduce feed cost. This step is highly necessary since the projected poultry production in Nigeria is expected to increase between 1988 - 1993 (Livestock Feeds, 1988).

1.2 Cocoa by-products in Animal Nutrition

Equitorial Guinea (Fernando Po) is important in the history of cocoa in West Africa for it was from this Island that the seeds were brought to Nigeria to establish the first successful plantings. The earliest definite records show that Chief Squiniss Ibanningo planted seeds obtained from Fernando Po at Opobo, Rivers State in 1874. Other organisations like the Christian Missionaries, Soldiers, farmers' association and the Cocoa Research Institute, also, helped in the early expansion of the cocoa tree. The result was that by 1960 Nigeria had become the worlds second largest cocoa producer.

The bed rock of the nations economy was agriculture as the nation took her pride of place in the committee of nations exporting agricultural products for foreign earnings. The main product of the East was palm produce while the West dominated the cocoa growth and trade. The earnings from cocoa and other agricultural produce increased with time and the country was able to have a steady growth in this direction up to 1971. Consequently, cocoa production rose from 51,010 tonnes in 1930 to 307,900 tonnes in 1971 (Adegbola and Abe, 1982).

However, with the arrival of the oil boom in 1972, cocoa, which was the single largest foreign exchange earner in the non-oil sector suffered a sharp set back. There was a general economic reactivation culminating in the execution of grandiose projects that provided other gainful employments. The era of the oil boom is gone and the Federal Government of Nigeria has now decided to encourage cocoa production and its exportation in order to improve the country's foreign exchange earnings. Efforts have now been shifted towards cocoa production especially in the cocoa producing areas of the country while companies and individuals now engage in cocoa business. Nigeria is expected to export about 180,000 tonnes of cocoa to places like Britain and U.S.A. in 1988.

As cocoa production increases, waste products from cocoa plantations and industries will increase tremendiously. Researchers have evaluated the nutrivite value of some of the cocoa by-products and found that most of them are useful in poultry and livestock feeds. The prohibitive cost of feed ingredients in Nigeria has necessitated the use of such by-products in animal feeds so as to reduce the cost of production. Presently, there is acute shortage of maize, wheat offal, DBG, Fish Meal, etc nation-wide.

Maize forms a major component of the Nigerian diet and about 60% in animal feeds. It enjoys widespread recognition just as wheat is of significance in the Middle East and rice in South East Asia. In Nigeria, the per capital consumption of maize exceeds 100 kg per year although the world average ranges between 21 - 25kg per annum (Sunday Sketch, 1988). With a galloping annual population growth rate, the demand for maize far outstrips the present local production.

Maize suffered a severe glut in the 1982/83 season due to over production. Suddenly it became a scarce commodity in Nigeria. A kilogram of maize which sold for 90 kobo in January 1986 sold for ₦2.20 by the end of the same year. As at January 1988, the same kilogram of maize sold for ₦3.50.

Before the ban on importation of grains, more than one million tonnes of maize were imported annually. The users of maize include Feed Millers (for animal feeds), Industrial processors (for sweetners and corn oil), Flour Millers, Brewery Industry and Humans. Because of its scarcity and prohibitive cost, animal nutritionist have substituted maize with agricultural by-products such as cassava peels, yam peels, cocoa-husk, etc. Adeyanju et al (1975) replaced corn with cocoa husk in maintenance rations for sheep and goats and observed increase crude fibre digestibility with increasing levels of cocoa husk substitution. Haines and Echeverria (1955) used cocoa pod as a substitute for corn in tropical dairy rations. The authors observed improved dry matter digestibility.

The cocoa by-products, hitherto considered as wastes, are now receiving greater attention in animal nutrition.

The ban placed on the importation of wheat in January 1987 has resulted in the scarcity of wheat offal, a feed ingredient popularly used to increase bulk. The 200,000 tonnes of wheat locally produced yearly in Nigeria is grossly inadequate to meet the Flour Mill Industry's raw material needs (The Guardian, 1988). Following the ban on the importation of wheat into the country, various organisations have intensified efforts to cultivate wheat on a large scale. The United Trading Company (UTC) planned to harvest 140 tonnes of wheat from its experimental farm (600 hectare) in Tenti, near Jos, Plateau State before the end of 1988. Kano State Government expects at least 80,000 tonnes of wheat to be produced in 1988. The Lake Chad Research Institute (LCRI) has decided to focus on the production of wheat, barley and millet in Borno and Gongola States. However, it is not certain when maize and wheat offal will be available in sufficient quantity for use in animal feeds. Therefore the usefulness of other agricultural by-products need to be determined so as to find a complete substitute, particularly to wheat offal.

The rearing of cockerel is becoming very popular in Nigeria because of its cheap cost, hardy nature, high survival rate and ability to tolerate fibrous feeds, it would be desirable therefore to incorporate cocoa husk in cockerel's ration in order to reduce cost of production.

1.3 General Objectives

Many research workers have used cocoa husk successfully in livestock and poultry feeds but the report of the use of other cocoa by-products in animal feeds is very scanty. It is therefore necessary to harness the potentialities of all the major cocoa by-products with a view to finding these that could be incorporated into livestock feeds at levels which will lower feed cost considerably. This study was therefore conducted in order to:

(i) Determine the chemical composition and energy values of cocoa by-products and their potentials as possible feed ingredients in cockerel rations.

(ii) Determine the level at which cocoa husk could replace wheat offal in cockerel rations.

(iii) Investigate alternative protein source in cockerels fed cocoa husk diets.

(uv) Determine the effect of treating cocoa husk with cocoa pod husk ash on the performance of cockerels.

CHAPTER TWO

LITERATURE REVIEW

2.1 Cocoa By-products in Nigeria

In other to produce hygienic and acceptable food products, there is the need to discard part of the raw-materials from which they are made. The discarding process begins with the treatment of the harvested crop. In the preparation of cereals like rice, waste materials like rice bran, rice polishing and rice middlings are left behind. The preparation of corn leaves behind straws and corn cobs. Some of the waste products are either left behind on the farms at the time of harvest or in the mill or food factory at the time of processing. The by-products fromcocoa include the cocoa husks which are usually left behind in the cocoa farms and plantations, cocoa shell, cocoa dust and cocoa cake/meal which are by-products from cocoa industries.

2,1.1 Cocoa Husk

Freshly harvested cocoa fruit consists of the husk, which contains about 40 beans. The beans are embedded in the mucilaginous material inside the husk or pod. After removing the beans, the husk which is left forms, on the average, about 75% of the raw cocoa fruits. About 4 million tons of the husks are produced annually in Nigeria as farm wastes. These are usually discarded and left to rot in cocoa farms and plantations.

Haines et al.(1955), and Adeyanju et al.(1975) have suggested the possible use of the cocoa husk as livestock feed. Like many feed ingredients that are high in crude fibre, the cocoa husk, which has crude fibre of about 26 - 42%, is better used as feed for ruminants (Adeyanju et al.1975a). However, if the cocoa husk can be processed to reduce its crude fibre content it will be possible to feed it with better results, in the diet of both ruminants and non-ruminants (Ogutuga, 1975).

Ogutuga (1975) investigated some of the Physical and Chemical characteristics of the cocoa husk in some greater detail. The author indicated that the husk of all the cocoa variaties had 3 well - defined regions namely Outer pericarp, middle pericarp and inner pericarp.

The outer pericarp which is mainly parenchymatous constitutes about 44 - 63% of the pod husks of the 3 varieties. The middle pericarp contains mainly lignified xylem cells made up of a large number of sclerenchymatous cells. The highest concentration of crude fibre can be found in this region. The inner pericarp consists of mainly parenchymatous cells with thin cell walls containing few starch grains. The author concluded that both the outer pericarp and the inner pericarp gave a better nutrient balance than the whole husk, since both regions contain less crude fibre and higher levels of crude protein, ash, EE, and NFE.

Much has been reported about the implications of fibrous feeds on the performance of ruminant and non-ruminant animals. Woodman and Evans (1974) reported that fibrous feed may decrease the digestibility of crude protein and ether extract. Nwokolo et al. (1984) also indicated that fibrous feeds may impede mineral absorption. Birds fed on high fibre diet would require more water than those fed on low-fibre diet (Van Hemel and Myer, 1969). On the effect on carcass characteristics, Deaton et al. (1979) noted significant increases in gizzard weight as a proportion of body weight and intestinal length when high-fibre sunflower meal product was used as a replacement for soyabean meal in a diet for caged hens.

On the other hand dietary fibre has been considered by some other authors to be benefitial in animal nutrition as it provides bulk which has a laxative effect (Eastwood, 1974). Crude fibre may also counteract the toxic effects of drugs, chemicals and feed additives (Gail and Lovey, 1986). Ruminants and non-ruminant animals are capable of digesting crude fibre in the digestive tract.

Suggestions have been made to treat cocoa husk with calcium carbonate, formaldehyde or glutaraldehyde. Ogutuga (1974) suggested that reducing the amount of crude fibre in the cocoa husk will improve its feeding value. The author suggested cocoa breeding and processing e.g. separating the husk into its three regions using only the outer and the inner percarps which are known to have better nutrient balance than the whole husk.

2.1.2 Cocoa Shell

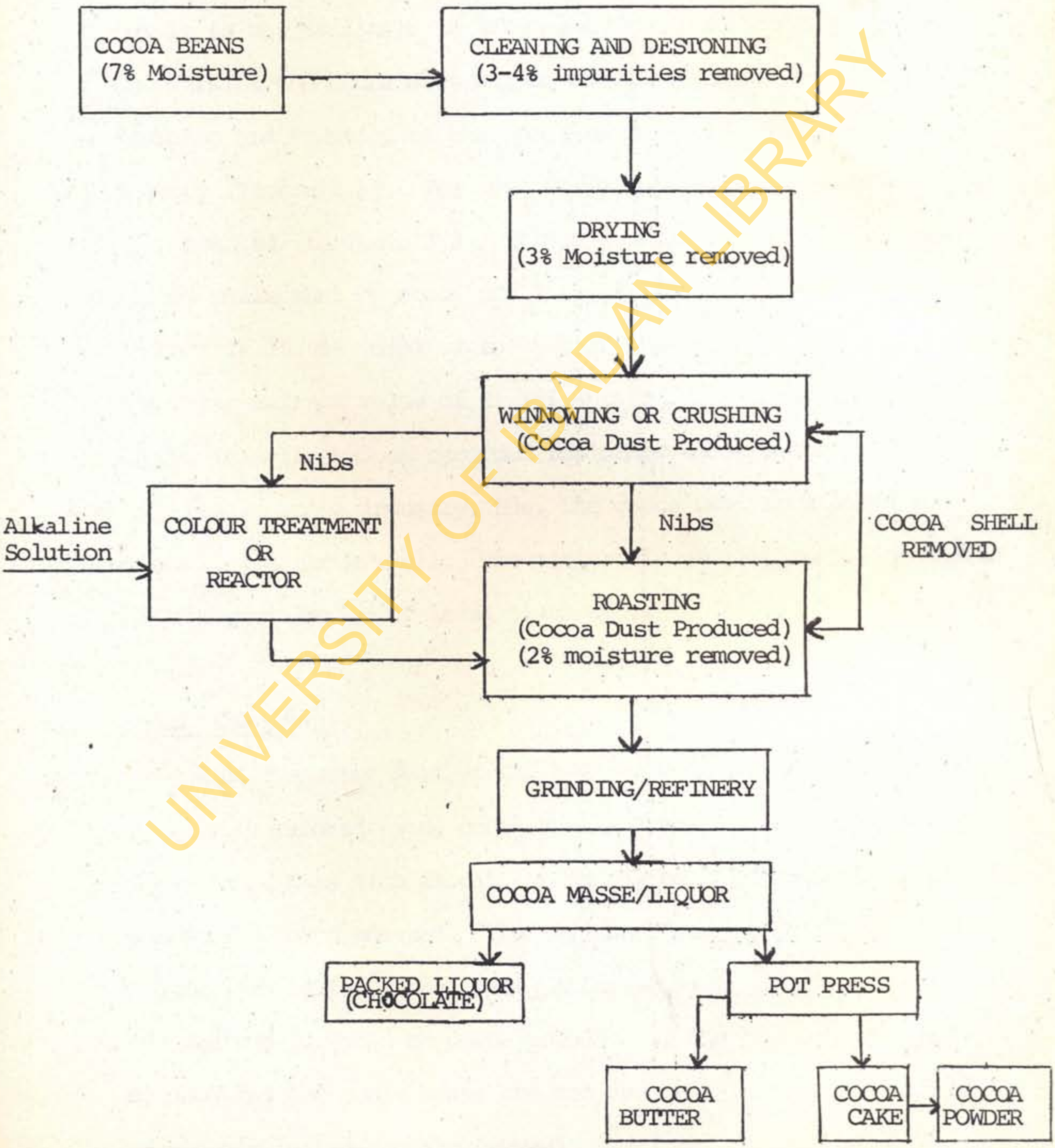
It is a dry, crisp, brown shell with pleasant smell. It is very rich in digestible protein and in ash and low in crude fibre. It contains a substantial amount of vitamin D_2. Cocoa shells constitute at least 10% of the weight of the bean. The first step in the processing of cocoa bean at the cocoa industry involves the cleaning and destoning of the beans in other to remove 3 - 4% of impurities. The clean beans with 7% moisture content are later transfered to the dryer where about 3% of the moisture will be removed. The shells are later separated from cocoa nib (edible portion) by roasting during which about 2%

moisture content of the bean is further removed. Several tons of the shells are produced daily as wastes from cocoa industries in Nigeria. The flow diagram of the production of cocoa shell in a modern cocoa industry is shown in fig 2.1. The fibre content of cocoa shell is very low when compared to that of cocoa husk.

Oyenuga (1955) reported a crude fibre content of 18.3% for cocoa shell while 30.25% was obtained for cocoa husk. The author also reported a crude protein content of 14.5% and Ether Extract of 3.1% for the cocoa shell. The higher fat content of cocoa shell is responsible for its higher energy content when compared to that of cocoa husk.

The limitation in the use of cocoa shell in animal feeds is because of its theobromine content. Roeltofsen (1958) observed that cocoa shell which was nearly free of purine bases may contain up to 2% of theobromine when dried after six days of fermentation. Hansen (1915) reported a lower value of 0.5 - 0.8% while Greenwood - Barton (1965) reported a value of 1.3%. The removal of the alkaloid theobromine will make it suitable as livestock feed since it is very rich in protein and ether extract.

Fig. 1.1: Flow Diagram of the Production of Cocoa Shell, Cocoa dust and Cocoa cake in a Modern Cocoa Industry in Nigeria.



2.1.3 Cocoa Dust

Cocoa dust is another waste product from cocoa industries but it is not available in large quantities for research work. The bulk of the cocoa dust can be obtained during the period of crushing and roasting of the cocoa beans in the cocoa processing factory (figure 2.1). The chemical composition of cocoa dust is presented in Table 3.2. It has a crude protein content of 15.39% while that of cocoa shell is 13.19%. Its crude fibre content is 19.08% compared to that of the shell which is 12.97%. The ether extract value of 21.14% obtained for cocoa dust is higher than the values recorded for other cocoa waste products.

At the cocoa industry, Ede, the cocoa dust is allowed to mix with the cocoa shell. The mixture is usually burnt into ashes for the preparation of local black soap,

2.1.4 Cocoa Cake/Meal

When the outer coat of the bean is removed and ground, it is usually refered to as cocoa shell/husk meal. The remaining kernel or nib is rich in oil, which may be extracted either by pressure or by a solvent. The residue after oil extraction by pressure is called cocoa cake. After extraction by a solvent the residue is known as cocoa powder. If the oil is extracted by crushing hhe whole bean, the residue in this case is described as undecorticated cocoa cake/meal.

Cocoa meal is composed of fragments of the bean collected from chocolate factory. Factor that may affect its composition is how much cocoa shell is incorporated in the meal.

The high content of theobromine and other alkaloids contained in the shell, have made cocoa-bean meals largely unsuitable as livestock feed (Ellenberger and Newlander, 1924; and Braude, 1943).

Adegbola and Omole (1973) have described an inexpensive technique for large scale preparation of theobromine free cocoa meal from discarded cocoa beans. The authors demonstrated that over 99% of the theobromine can be removed from cocoa meal by boiling the latter in water for 1¼ hours.

2.2. Utilisation of Cocoa By-products

Various waste products from cocoa have been studied by many research workers (Winkler, 1938; Oyelaja et al. 1970, and Adegbola and Omole, 1973). Adeyanju et al. (1975) evaluated the nutritional value of cocoa husk in poultry diets. The authors observed depressed body weight gains and feed/gain ratio in all rations containing cocoa husk. The main purpose for the use of waste products from cocoa in livestock feeds is to reduce cost of production without sacrificing efficiency of production.

2.2.1 Cocoa husk as feedingstuff

With the rapid growth of the world population and the resulting shortage and high price of grain and other foodstuffs, it has become necessary to seek alternative animal feeds based on agricultural wastes. The large availability of cocoa husk makes it a suitable object of study as a replacement for grain in livestock feed in order to meet the increasing demand for the latter for human consumption.

The amounts of protein and fibre in the pod are similar to those for grass hay and this suggests their possible use as a cattle feed (Greenwood - Barton, 1965).

There has been interest in the possibility of using pods of Theobroma Cacao for livestock feed ever since mules were first noticed consuming the fresh pods (Bateman and Fresnillo, 1967). Several feeding trials have been carried out with a view to finding out their usefulness in poultry and livestock feeds. Experiments have been carried out in Costa Rica in which artificially dried pods were converted into a meal and used as concentrate for dairy cows at 50% of the ration. Comparisons were made between pod meal on the one hand and cassava meal and corn on the other. Milk production when the pod meal was fed, was found to be just as high as when the cows were fed on corn (Haines and Echeverria, 1955). Many research workers have used cocoa pod husk in animal feeds with satisfactory results. Cocoa husk has been used satisfactorily as food for work horses (Winkler, 1938).

De Alba et al. (1954) compared a dairy ration containing 50% maize with one containing 50% cocoa pod. Differences in milk production favoured the latter ($P < 0.01$). A second trial also favoured cocoa-pod meal but differences were not significant. Haines and Echeverria (1955) substituted cocoa pods for corn in tropical dairy rations. The authors concluded that cocoa-pod meal was 96 - 97% as valuable as corn and cob meal for milk production. De Alba and Basadre (1952) substituted dried pods for half of the maize in swine ration containing 75% maize and found that weight gains of pigs receiving each ration were similar.

Adeyanju et al. (1975) replaced corn with husk at 0, 25, 50 and 100%, respectively to wethers and castrates and found a significant decrease in the digestibility of CP, DM, and total digestible nutrients in both the sheep and the goats with increases in the level of cocoa husk substitution. Crude fibre digestibility, however, increased with increasing levels of cocoa husk substitution

Adeyanju et al. (1975a) also evaluated the nutritional value of poultry diets containing 0, 10, 15 and 20% cocoa husk, respectively. The author reported that all rations containing cocoa husk depressed body weight gains and feed/gain ratio; but compared with the control diet, egg production almost doubled when diets containing up to 15% cocoa husk were fed. The authors also reported that the diet containing 10% cocoa husk proved acceptable to broiler chicks fed starter diets containing 0, 5, 10 and 15% levels of cocoa husk, respectively.

2.2.2 Cocoa Husk In Soft - Soap Manufacture

In parts of West Africa, some fruit wastes e.g. peels of plantains, banana and cocoa husk find use in traditional soap manufacture. Analysis has shown that the ashes of cocoa husk, plantains and banana peels possess strong caustic properties, Potash is the largest component and forms about 3 - 4% of dry cocoa husk and about 30 - 40% of the ash (Dittmar, 1958; and Ankrah, 1974).

2.2.3 Cocoa Husk as fertilizer

If the pods are considered as a possible fertilizer, their contents of Nitrogen and Phosphorus place them in the same category as manure from farm animals. Because of the relatively high potash content, it has been suggested that cocoa husk may be used to manufacture a potash fertilizer or a potash rich compost (Dittmar, 1958; and Greenwood -Barton 1964). About 40 years ago, the West African Cocoa Research Institute at Tarfo, Ghana recommended the application of 8 cigarette tins of the ash per cocoa tree. This could be applied by clearing leaves and bush round the tree, scartering the ash up to one arms length, and replacing the leaves.

Oladokun (1986) compared four different preparations of cocoa pod husk with commercial fertilizer (NPK) in raising crops of maize. The author concluded that burning the dried cocoa pod husks and using the ashes to fertilise maize plant was the best method of application.

2.2.4 Cocoa Husk as local alkali

Alkali treatment has been extensively used for increased digestible dry matter intake (Mowa and Ololade, 1970; and Klopfenstein, 1978). Local alkali like cocoa pod ash has been considered as substitute to sodium hydroxide which is expensive and corrosive. Adebowale (1985) treated maize straw with cocoa pod husk ash and found that apparent dry matter, cellulose and energy digestibilities were improved, water intake and dry matter intake also increased.

Cocoa husk has also been used as source of pectin and other polysaccharides and in furfural production.

2.2.5 Cocoa Shell as Feedingstuff

Cocoa shell has been used from time to time as a feeding stuff and its value is similar to that of a good roughage. It is also a good source of Vitamin D. Unfortunately, it has the disadvantage of containing substantial amount of theobromine and this limits its use as a livestock feed. The use of cocoa shells and cocoa cake in rations for livestock have generally resulted in toxicity to the animals (particularly pigs) due to the high theobromine content (Braude, 1943). The shells have been successfully used as cattle feed when mixed in moderate quantities in compounded rations. In this form the theobromine content is known to have a stimulating effect upon milk production.

When cocoa shells, were fed to dairy cows, the butter fat and Vitamin D content of the milk increased.

Fatalities have occured in horses when their daily intake was 0.027 gm/kg of body weight and upwards. Under the fertilizers and feeding stuff regulations of the U.K. the use of cocoa shell as a fodder or fertilizer must be declared.

Muller et al.(1955) determined the effect of feeding cocoa shell as antioxidant on the stability of milk fat. Cocoa shell was selected as the test material in this study because it contains antioxidative substances for milk fat. A Jersey cow whose milk was susceptible to the development of an oxidized flavour was used for the feeding tests. The usual basal grain ration fed to the University herd was supplemented with 2.5% of ground cocoa shell from wasted fermented beans. The antioxidative effect of cocoa shell was determined by the thiobarbituric acid (T.B.A.) test and taste tests on the milk. Result revealed that cocoa shell increased the resistance of the milk to oxidative deterioration.

2.2.6 Cocoa Shell in local soap manufacture

Analysis of cocoa shell as carried out by some of the cocoa Industries in Nigeria revealed that the shell also contains potash in sufficient amount for soap manufacture. Consequently the cocoa shell is burnt into ash particularly at Cocoa Products Limited, Ede, where the ash is sold to the local soap manufacturer, presently at the rate of ₦5.00 for a 25kg of ash.

2.2.7 Cocoa Shell as fertilizer

Like the cocoa husk, cocoa bean shell is relatively rich in potassium (about 3%) and its use as fertilizer has been described by Knapp and Churchill (1937); and Greenwood - Barton (1964). Cocoa shell is used as a fertilizer in the U.K. and the U.S.A. In the ground up condition it will lighten heavy soils and act as a humus - farming base.

Cocoa shell has also been used in alcohol and furfural production. Because of its high fat content, suggestions have been made for its use in pharmaceutical and vitaminised cosmetic preparations.

2.2.8 Utilisation of Cocoa Dust in the Manufacture of Local Black Soap

Presently, cocoa dust is not available in large quantities in any of the cocoa industries in Nigeria for use in poultry and livestock feeds. Although it is very high in crude protein and ether extract,it has not been studied in animal nutrition. Cocoa dust is usually burnt along with cocoa shell and the resulting alkaline ash is used for the manufacture of black soap in Nigeria.

2.2.9 Utilisation of Cocoa Cake/Meal in Livestock Feeds

The use of cocoa cake/meal is not very popular in animal feeds because of its high content of theobromine. Nevertheless, some researchers have incorporated cocoa meal in cattle and pig rations. Ellengerger and Newlanger (1924) in a study feeding cocoa meals to Dairy cows observed that cocoa-bean meals were unsuitable as livestock feed because of the high content of theobromine and other alkaloids in the shell.

Braude and Foot (1942) detheobromized cocoa cake/meal before it was fed to pigs. However, few attempts have been made to reduce the theobromine content of cocoa beans in order to lower the level of theobromine in the cocoa meal. Mac Donald (1946) and

Lowe (1947) devised methods which involved the use of solvent extraction for detheobromizing cocoa meal. Before such process of removal can be economically feasible, it must be simple and able to make use of equipment which are readily available at the local level. To achieve this objective, Adegbola and Omole (1973) prepared discarded cocoa bean meal in a non-toxic and nutritious form for incorporation into livestock feeds. There is the need to research more into the methods of detheobromising cocoa cake meal in order to render it safe as livestock feeds.

2.3 Toxic Principle in Cocoa Products

During the early stages of the 1939 - 45 war, cocoa waste products received a great deal of attention as possible animal feedstuffs. However, several outbreaks of poisoning were encoutered, particularly in pigs and poultry. Poisoning from cocoa products is now a rare event, but is occasionally reported in the literature (Gunning, 1950). The toxicity of these products has been reviewed by Black and Barron (1943) and by Blakemore and Shearer (1943). Despite the suggestion that the harmful effect of cocoa waste is due to the presence of tannin, there can be little doubt that the toxicity of these products depends entirely upon their content of the alkaloid, theobromine.

The name alkaloid means alkali-like and refers to basic nitrogenous substances which are widely distributed in many plants. They may be relatively simple compounds such as the purine derivatives, caffeine and theobromine, or may possess very complex structures, e.g. strychnine, brucine. They can be classified according to the type of ring structure they contain. The alkaloid theobromine which is a methylated derivative of Xanthine, is found in cocoa in amounts up to 3% by weight (Oyenuga, 1959).

The theobromine in cocoa bean (Dimethyl purine) is toxic to domestic animals. It occurs in varying amounts in the different cocoa products depending on previous treatments. Hansen (1915) indicated that the theobromine content of cocoa bean is 1 - 2% and that of the shell from 0.5 - 0.8%. The author stated that during roasting of the beans at 230^{o}c, sublimation of the theobromine sometimes occurs and this may lead to the transfer of the drug from the bean to the shell. Greenwood - Barton (1965) indicated that about 0.20 - 0.21% of theobromine is found in cocoa husk while 1.3% is in the cocoa shell. The theobromine in cocoa shell is extracted commercially, but it is understood that most of it is methylated to form caffeine because there is so much higher demand for caffeine. Theobromine is also used in fish disease treatment and in phamaceutical preparations.

2.3.1 Toxic Dose of Theobromine

Although the toxic dose of theobromine is fairly high cocoa waste products are nevertheless dangerous to animals, and particularly to horses, pigs and poultry (Garner, 1967). Blakemore and Shearer (1943) cited earlier work by Marchadier and Goryon which indicates that a daily intake of 5g of theobromine is the safe limit for horses. Braude and Foot (1942) considered that cocoa meal containing about 2.5% of theobromine is of no value as feedstuff for pigs since, at a concentration of 7.5% of the ration, it will cause unthriftness and definite harmful effects in weaner pigs. Temperton and Dudley (1943) fed pullets a ration containing 10 - 30% of undercorticated cocoa cake meal and found that deaths (presumably from theobromine poisioning) began on the 5th day of the experiment. Ordinary household cocoa powder contains sufficient theobromine to render it harmful to poultry. Clough (1942) reported deaths in dogs receiving a proprietary food which was found later to include about 2g per kg theobromine.

2.3.2 Symptoms and Lesions of Theobromine Poisoning

Since theobromine is completely absorbed from the alimentrary tract and only slowly excreted, small doses can have a cumulative effect. Death from poisoning may thus be delayed until a critical level is reached. As a rule, few symptoms are seen, death occuring suddenly from heart failure. Black and Baron (1943) described nervous excitability as a feature of theobromine poisoning in poultry. Theobromine has a direct stimulant action upon the heart and causes diuresis and has been used in medicine for this latter purpose. Unlike the related alkaloid, caffeine, theobromine appears to have a little direct action on the central nervous system.

Several outbreaks of poisoning amongst pigs and poultry were reported to the Institute of Animal Pathology, University of Cambridge (Black and Barron, 1943). In each case it was found that the losses followed feeding meals containing cocoa products. The condition was characterised by sudden death within 48 hours after feeding the food. Owners stated that the birds which did not succumb appeared healthy because they consumed an increased amount of water. Symptoms of theobromine toxicity were also reported in layers. These were characterised by sudden death, precipitated by increase nervous excitability. It was also discovered that affected birds died in convulsions, often leaping into the air, finally laying on their backs with legs tightly drawn against their bodies. Comb showed marked bluish tinge and the cloaca was violently everted as though in an effort to expel faeces. At post mortem, organs were congested, liver being of a deep mahogany colour, while the kidneys were mottled.

Kidney showed histological changes. Sections of the kidney prepared and stained with haematoxylin and eosin showed: engargement of the capillary turfts, thickening of capillary walls and lobation of glomeruli.

Tolerance of individual birds varies. Results may therefore be affected by level of intake of the toxic principle e.g. low feed intake will make birds to succumb easily. If intake is high, accumulation will occur, then symptoms will develop.

CHAPTER THREE

CHEMICAL EVALUATION AND METABOLISABLE ENERGY DETERMINATION OF COCOA BY-PRODUCTS

3.1 INTRODUCTION

The prohibitive cost of feed ingredients has necessitated the use of agro-industrial by-products in animal feeds. Feed ingredients like wheat offal, dried brewers grain, rice bran, corn bran, palm kernel meal, etc hitherto considered as wastes, have been evaluated and found suitable for incorporation into poultry and livestock feeds.

Although the domestic fowl requires the same classes of nutrients as other farm animals (Oluyemi and Roberts, 1979), the pre-knowledge of the chemical composition of any waste product is essential in order to know the type of nutrients that are available in such waste-products. Some diseases have been reported to be associated with deficiencies of certain basic nutrients in man and animals, there is the need to ensure that diets are balanced in terms of chemical composition.

The reports of ME values of cocoa by-products are very scanty. There is the need, therefore, to determine the energy value of such by-products if they are to be used successfully in animal feeds.

The aim of these studies is to evaluate the chemical composition of cocoa by-products (e.g. cocoa shell, cake, dust, and husk) and to determine their ME values in order to determine which of the by-products could be incorporated into cockerels ration. The determination of ME was divided into 2 phases:-

Phase 1 - determination of ME of cocoa by-products using adult cockerels.

Phase II - determination of ME of cocoa by-products using adult cockerels at different ages.

3.2 MATERIALS AND METHODS

3.2.1 Collection of Samples

The cocoa shell used in this study was obtained from the Cocoa Industries Limited, Ikeja, Lagos, where about 1 - 2 tons of the shell is produced every week. The cocoa shell obtained was stored in Nylon bags and kept in the Feed Depot of the Teaching and Research Farm, University of Ibadan, Ibadan. Samples of the cocoa cake and cocoa dust were obtained from Cocoa Products Industry (Nigeria) Limited, Ede. The materials were stored separately in Nylon bags until required for chemical analyses.

The cocoa husks used in this study were those of F_3 Amazon variety obtained from the Cocoa Research Institute of Nigeria (CRIN), Onigambari, Ibadan. Fresh Samples of the husks were stored in jute bags and later transfered to the Department of Animal Science, University of Ibadan for further processing.

3.2.2 Processing of Samples

Samples of the cocoa shell were spread on corrugated iron sheet where they were allowed to dry in the sun for a whole day. Cocoa husks which contained a lot of moisture were spread on concrete slab and allowed to dry in the sun for 7 days. The dried husks were later chopped into small pieces, The sun-dried cocoa shell and husks, and the cocoa cake were milled separately into granular forms with the aid of Hammer Mill while the cocoa dust was further ground into powder form with the aid of kjeltec electric fine mill. All the four samples were later stored separately in polythene bags and kept at the Feed Depot of the University of Ibadan prior to chemical analysis.

3.2.3 Chemical Analyses

The four samples of cocoa by-products were analysed separately for their proximate constituents according to the AOAC (1975) procedures. Gross energy was determined with a ballistic bomb calorimeter, while theobromine content was determined according to the AOAC (1960) procedures.

3.2.4 Metabolic Studies - Phase I

Three diets were formulated for the metabolic studies. The chemical composition of Diet 1 (control diet) is presented in table 3.1. Diets 2 and 3 were test diets. Diet 2 was formulated by mixing 60% by weight of the control diet to 40% of cocoa shell while diet 3 was a mixture of 60% of control diet plus 40% of cocoa husk.

3.2.5 Experimental Procedure

50 day-old cockerels obtained from Alanco Agricultural Enterprises, Ibadan, were reared for 8 weeks on a starter diet containing 21% CP and 2.65 kcal/g ME. From 9 to 12 weeks of age the birds were fed finisher (control) diet containing 18% CP and 2.65 Kcal/g ME. At 12 weeks of age, 18 cockerels from the

Table 3.1: <u>INGREDIENT AND CHEMICAL COMPOSITION OF CONTROL DIET</u>

Ingredient	Proportion %
Maize	47.42
GNC	15.00
Wheat offals	31.33
Fish meal	2.00
Bone meal	2.00
Oyster shell	1.00
Premix	1.00
Salt	0.25
T o t a l (%)	100.00
Calculated Analysis	
Crude Protein (%)	18.12
" Fibre (%)	4.38
ME (kcal/g)	2.65
Determined	
Crude Protein (%)	15.38
" Fibre (%)	7.26
Ether Extract	3.80

group were randomly selected for metabolic studies. There were 3 treatments with six birds assigned to each treatment. All the experimental birds were placed in the metabolic cages in pairs of 3 replicates per treatment. The experiment lasted for 15 days with 10 days of preliminary adjustment and 5 days of fecal collection. Birds were weighed in pairs at the beginning and end of the experiment, feed and water were provided ad libitum while feed intake and fecal output were recorded daily. Faeces collected by total collection method were dried in a forced-drought oven at 70°C and later bulked for proximate analysis using the A.O.A.C. (1970) procedure, while gross energy was determined using Bomb calorimeter. ME was calculated using the formular of Han et al. (1976).

3.2.6 Metabolic Studies - Phase II

Four diets were formulated. Diet 1 was the same control diet (Table 3.1) used in Phase I while diets 2, 3 and 4 were formulated by mixing 80% of the control diet to 20% of cocoa shell, cocoa husk or dried brewers grain (DBG), respectively. The level of inclusion of test ingredients was reduced from 40% to 20% in order to control mortality from theobromine toxicity particularly with diet 2 which contained cocoa shell. The inclusion of the DBG as a test ingredient was to provide a standard for comparison since the ME of DBG is already known.

3.2.7 Experimental Procedure

Another set of 50 day old cockerels obtained from Alanco Agricultural Enterprises, Ibadan were reared for 7 weeks on a starter diet containing 21% CP and 2.65 kcal/g ME. At 8 weeks of age, 16 cockerels were randomly selected for metabolic studies. There were 4 treatments with 4 birds assigned to each treatment. The 16 cockerels were placed in the metabolic cages in pairs of 2 replicates per treatment. The experiment lasted for 80 days while faecal collections were carried out at 8th, 12th, 16th and 20th weeks of age. Weight of the experimental birds were recorded at the beginning and end of the experiment while feed and water were provided *ad libitum*. Faeces collected were treated the same way as in phase I. The formular of Han *et al.* (1976) was used for calculating ME of the test ingredients. The performance of the birds in terms of feed intake, weight gain and efficiency of feed utilisation were monitored throughout the experimental period.

3.3 RESULTS

3.3.1 Chemical Evaluation of Cocoa By-Products

The proximate composition of cocoa shell, cake, dust and husk is presented in Table 3.2. Cocoa husk which forms about 75% of the whole fruit has the highest moisture content of 7.33%. Their were variations in the values obtained for Crude Protein of cocoa waste products. Highest crude protein of 24.51% was recorded for cocoa cake while the values of 15.39%, 13.19% and 7.95% were obtained for cocoa dust, cocoa shell and cocoa husk respectively. The husk contains the highest amount of crude fibre with the value of 43.92%. Crude fibre content of 12.97% was recorded for cocoa shell while 19.08% was obtained for cocoa dust. The lowest crude fibre content of 10.90% was obtained for cocoa cake. The cocoa dust was highest in ether extract of 21.14% while the values of 14.60%, 12.29% and 1.10% were obtained on cocoa cake, cocoa shell and cocoa husk respectively. Cocoa husk has the highest ash content of 15.25%. The values of 7.30%, 7.15% and 6.80% were obtained as ash content of cocoa cake, shell and dust, respectively.

The results of the theobromine determination indicated that cocoa cake has the highest amount of theobromine with a value of 2.16%. The value of 1.85% was obtained on cocoa shell while

TABLE 3.2: CHEMICAL COMPOSITION OF COCOA BY-PRODUCTS

Components	Cocoa Shell	Cocoa Husk	Cocoa Dust	Cocoa Cake
Dry matter	95.00	92.67	94.34	96.47
Crude Protein	13.19	7.95	15.39	24.51
Crude Fibre	12.97	43.92	19.08	10.90
Ether Extract	12.29	1.10	21.14	14.60
A s h	7.15	15.25	6.80	7.30
N. F. E.	54.40	31.78	37.59	42.69
GE (kcal/g)	5.40	5.06	5.32	5.47
Theobromine	1.85	0.42	1.74	2.16

1.74% was the value recorded for cocoa dust. However, cocoa husk has the lowest content of theobromine with a value of 0.42%.

3.3.2 Metabolic Studies - Phase I

The results of the determination of ME Phase I are presented in table 3.3. The GE values of 6.09 kcal/g, 5.40 kcal/g and 5.06 kcal/g were obtained for the control diet, cocoa shell and cocoa husk respectively, while the ME values obtained were 4.86 kcal/g, 2.51 kcal/g and 2.06 kcal/g for control diets, cocoa shell and cocoa husk repectively.

3.3.3 Performance Characteristics - Phase II

The results of the perfomance of the birds on different test diets in the course of the determination of ME values are presented in table 3.4. The highest daily feed intake of 133.44 g/bird was recorded on the 20% cocoa husk while the lowest intake value of 72.53 g/bird was obtained on the 20% cocoa shell diet. The highest average daily body weight gain was obtained on the control diet while the lowest value of 10.43 g/bird was obtained on the cocoa husk diet. The best result of efficiency of feed utilization (5.62) was obtained on the control diet while the poorest ratio of 12.79 was recorded on

TABLE 3.3: ME VALUES OF COCOA SHELL AND COCOA HUSK USING ADULT COCKERELS AT 12 WEEKS OF AGE

Test Materials	GE (kcal/g)	ME (kcal/g)	MEn (kcal/g)
Control Diet	6.09	4.86	4.36
Cocoa Shell	5.40	2.51	2.42
Cocoa Husk	5.06	2.06	2.01

TABLE 3.4: PERFORMANCE CHARACTERISTICS OF COCKERELS ON REFERENCE AND TEST DIETS AT THE FINISHER PHASE (8 - 20 WEEKS).

Parameters	Experimental Diets					
	1	2	3	4	Mean	±S
Initial body weight (g/bird)	630.00	648.75	756.25	597.50	658.13	3.
Final body weight (g/bird)	2019.00	1494.33	1590.75	1861.00	1741.27	4.
Body wt. gain (8 - 20 wks)	1389.00	845.58	834.50	1263.50	1083.15	3.
Daily feed intake (g/bird)	97.59	72.53	133.44	93.17	99.18	2.
Daily body wt gain "	17.36	10.57	10.43	15.80	13.54	0.
Feed Conversion	5.62	6.86	12.79	5.90	7.79	0.
Mortality (%)	6.25	12.50	—	6.25	8.33	0.

TABLE 3.5: ME VALUES (KCAL/G) OF COCOA SHELL, COCOA HUSK AND DBG AT DIFFERENT AGES OF THE COCKERELS.

TEST MATERIALS		PERIOD			
		8th week	12th week	16th week	20th week
Control	ME	2.31±0.84	2.40±0.85	3.51±0.87	2.50±0.80
	MEn	2.05±0.43	2.10±0.48	2.34±0.81	2.18±0.65
Cocoa Shell	ME	2.16±0.64	2.10±0.48	2.16±0.51	2.05±0.46
	MEn	2.00±0.34	1.93±0.18	2.02±0.41	1.91±0.13
Cocoa Husk	ME	2.11±0.16	2.15±0.68	1.96±0.19	1.95±0.08
	MEn	2.00±0.43	1.07±0.08	1.64±0.19	1.63±0.31
DBG	ME	2.06±0.44	2.00±0.48	2.11±0.64	2.00±0.44
	MEn	1.93±0.11	1.81±0.10	2.01±0.08	1.89±0.02

the 20% cocoa husk diet. The highest mortality was recorded on the cocoa shell diet while no mortality was obtained on cocoa husk diet.

3.3.4 Metabolic Studies - Phase II

The results of the determination of ME values at different ages are presented in table 3.5.

There were variations in the ME values recorded for the 4 samples between the 8th and 12th week. Between the 12th and 16th week, the values obtained increased with increase in age of the birds. Between the 16th and 20th week, all the ME values obtained for the 4 samples showed inverse relationship. The values decreased with increasing age of the birds. Generally, ME values obtained for cocoa shell at different ages were higher than the values obtained for the cocoa husk and DBG.

3.4 DISCUSSION

3.4.1. Chemical Evaluation of Cocoa By-Products

The average moisture content of the sun dried cocoa pod husk of 7.33% obtained in this study is comparable with the value of 6.37% reported by Adeyanju et al. (1975). However, Oladokun (1986) in the study of cocoa pod husk as fertiliser for maize production obtained different values for different cocoa husk preparation. The author reported the values of 16.99% moisture content for the old cocoa pod husk, 11.97% for the rotten cocoa pod husk and 11.51% for the fresh cocoa pod husk. The high moisture content of the husk has necessitated its sun-drying for the period of about 7 days. The highest crude protein content of 24.51% obtained on cocoa cake is similar to the value of 24.90% reported by Oyenuga (1955). However, the crude protein of the cocoa dust is higher than that of the cocoa shell. The reason for this could be attributed to the denaturation of the protein of cocoa shell at the time of roasting the cocoa bean in the factory.

Cocoa husk recorded the lowest crude protein content. This could be due to the long period of sun drying during which some of the nutrients of the husk were de-natured. Adeyanju et al. (1975) reported a lower value of 4.60% as the crude protein content of cocoa husk while a value of 6.30% was reported by Ogutuga (1975) for the F_3 Amazon variety. Values of 6.25%, 7.18% and 6.80%, were reported as crude protein content (oven dry) for the husk by Ankrah (1974), Acquaye et al. (1964), and Bateman and Fresnillo (1967), respectively. Various authors recommended a quick drying process for the preservation of the nutrients in the husk. De Alba et al. (1954) indicated that sun drying reduced the Nitrogen free extract, lipid and protein contents of the husk.

The highest value of 43.92% crude fibre content obtained on cocoa husk is in agreement with the report of various authors concerning the fibrous nature of the husk. Oyenuga (1955) compared the crude fibre content of cocoa bean, husk, shell and cake and reported the highest value of 30.25% crude fibre for cocoa husk. The value of 27.30% crude fibre reported by Ankrah (1974) is comparable with the value of 26.34% obtained by Adeyanju et al. (1975) while a value of 29.90% crude fibre was reported by Ogutuga (1975) for F_3 Amazon variety of cocoa husk. Bateman and Fresnillo (1967) also reported a high value of 35.4% crude fibre for oven dry cocoa husk. Oyenuga (1955) reported a value of 9.0% crude fibre for cocoa cake as against the value of 25.90% obtained in this study. However, the fibre content of cocoa shell and dust are generally lower than that of cocoa husk. The limitation in the use of cocoa husk in animal feeds is due to it high fibre content. Ogutuga (1975) indicated that most of the crude fibre in the husk is located in the middle pericarp while the outer and inner pericarps are less fibrous. The author suggested processing of cocoa husk as a means of reducing its crude fibre content.

The high ether extract content of cocoa dust shows that it could be used in livestock feeds as energy source . Some researchers have used oils in animal feeds to promote growth. Sunde (1956) reported increase in the weight of chicks and improved feed efficiency when the energy level of chicks diet were raised by the addition of fat. Carew <u>et al</u>. (1963) indicated that inclusion of some oils could increase the availability of metabolizable energy of the feed leading to optimum growth rate. In the present study, both cocoa shell and cocoa cake have high level of ether extract while cocoa husk is very low in ether extract, probably due to its high fibre content. Oyenuga (1955) recorded values of 5.0%, 3.10% and 1.10% ether extract for defacted cocoa cake, cocoa shells and husk, respectively while Adeyanju <u>et al</u>. (1975) reported a value of 5.70% only for cocoa husk.

The result of the ash composition of cocoa by-products shows that cocoa husk contains a lot of minerals when compared with the other by-products. Oyenuga (1955) also indicated that cocoa husk contains higher ash content when compared with either cocoa shell or cocoa cake. The author recorded values of 13.43%, 6.70% and 6.10% as ash content of coca husk, cocoa shell and defatted cocoa cake, respectively. There are slight variations in the results of ash content of cocoa husk as reported by other authors. Ankrah (1974) obtained a value of

8.10% while Bateman and Fesnillo (1967) reported a value of 9.70% for the ash content of oven dry cocoa husk. Adeyanju et al.(1975) reported a value of 8.08%. Oladokun (1986) obtained different cocoa pod husk preparations. The author reported values of 14.37%, 10.34% and 37.33% as ash content of old, fresh and rotten cocoa husks, respectively. The ash of cocoa husk is believed to contain minerals like calcium, phosphus, sodium, potasium etc thus making cocoa husk to be palatable. The results of this study indicated that cocoa cake contained the highest amount of gross energy probably due to its low content of crude fibre. The lowest gross energy value obtained on cocoa husk could be due to its high fibre content. Various authors have confirmed that high fibre content of feeds could decrease available energy in such feed.

The results of the extraction of theobromine content of the four cocoa by-products showed that cocoa cake has the highest amount of theobromine. The value of 2.16% obtained in this study is lower than the value of 2.50% reported by Braude and Foot (1942). The theobromine content of cocoa shell is slightly lower than that of cocoa cake. The value of 1.85% obtained on cocoa shell compares favourably with the value of 1.30% reported by Greenwood-Barton (1965). However, Hansen (1915) reported the lowest value of 0.5 - 0.8%. The author attributed the theobromine content of cocoa shell to the transfer of the drug to the shell during the roasting of cocoa beans at 230°C. The theobromine content of cocoa dust is comparable with that of cocoa shell. A lower value of 1.74% was recorded in this study for the cocoa dust while the lowest value of 0.42% was obtained as the theobromine content of cocoa husk. Most researchers have reported very low theobromine content in cocoa husk. Greenwood - Barton (1965) reported a value of 0.20 - 0.21% for cocoa husk while Barnes (1984)obtained a value of 0.32%. Haines and Echeverria (1955) indicated that the alkaloid theobromine is found only in traces in cocoa husk. The toxicity of cocoa by-products was reviewed by Black and Barron (1943). The authors confirmed that the toxicity depends entirely upon their content of theobromine. The overall results of the chemical composition of the four cocoa by-products therefore indicated that all the products have nutritive value. Cocoa shell, dust and cake contain appreciable amount of crude protein, ether extract and low fibre. However, the high content of theobromine in these products is the only limitation that stands against their use as feed ingredients. On the other hand, cocoa husk is very rich in minerals with low level of theobromine, but its high fibre content is the major concern to most researchers.

3.4.2 Metabolic Studies - Phase I

The results of the metabolic studies (phase I) as presented in table 3.3 showed that the ME of cocoa shell is higher than that of cocoa husk. The higher ether extract content of cocoa shell must have been responsible for its higher ME value (2.51 kcal/g) in relation to that of cocoa husk (2.06 kcal/g). Carew et al. (1963) reported that inclusion of some oils, even in small amounts could increase the availability of ME of the food. The lower ME value of 2.06 kcal/g obtained for cocoa husk must have resulted from its high crude fibre content. This is in agreement with the findings of Oluyemi et al. (1976) who related the low ME values of the Acacia seed-meal to its high fibre content. He also attributed the low ME values obtained for coconut meal and cotton seed meal to the impairment of their digestibility by a high crude fibre content. Spreadbury and Davidson (1978) in studies with rabbit observed that the DE and ME content of the diets fell as the fibre concentration increased. Fraps (1946) had shown that available energy is inverseely proportional to the fibre content of the feedstuffs.

A lot of other factors apart from chemical composition are known to affect ME values of feedstuff. Sibbald et al. (1960) concluded that ME content of a feed ingredient may change with age of the birds to which the material is fed. Hence, in the phase II of this study, the ME values of cocoa shell and cocoa husk were determined at various ages of the cockerels.

3.4.3 Performance Characteristics - Phase II

The performance of the birds at different ages of the determination of ME are presented in Table 3.4. The highest value of feed intake was obtained on the control diet. This agrees with the concept that fowl eats primarily to meet energy requirement. The high fibre content of cocoa husk must have lowered its energy value thereby resulting in increased feed intake. Farell et al. (1972) observed that feed intake was inversely related to energy concentration. Wells (1963) determined the relationship between dietary energy level, food consumption and growth rate in broiler chicks. He concluded that dietary energy governed food intake of chicks. Savory et al. (1976) observed that increased dietary fibre caused increased feed intake, and that birds on high fibre diets weighed less than those on low fibre diets. This is in agreement with the results of lowest average daily weight gain of 10.43 g/bird recorded on test diet 3 containing cocoa husk while the highest value of 17.36 g/bird was obtained on the control diet. The best efficiency of feed utilization was obtained on the control diet while the poorest result was obtained on the 20% cocoa husk diet which was the most fibrous.

The first mortality was recorded on the cocoa shell diet. The carcass which was presented for post mortem examination was positive for Fowl Typhoid infection, a disease in poultry characterised by enlargement and congestion of the liver and spleen and oedema of the lungs. The infection spread to other birds in the cage at the tail end of the study thereby killing some birds on Diets 1 and 4. However, no mortality was recorded on the cocoa husk diet.

3.4.4 Metabolic Studies - Phase II

The variations in the results of the ME obtained between the 8th and 12th week were not very significant. At the 12th week, higher ME values were recorded on the control diet and the cocoa husk diet while lower values were obtained the cocoa shell and the DBG diets when compared with what was obtained by the 8th week. This result probably indicated that the birds were developing the ability to metabolise the energy of the diets. This is in agreement with the report of Zelenka (1968) who observed that the rise in the ability of birds to metabolise energy with increase in age could be due to the development of the birds ability to digest food.

Between the 12th and 16th week, higher ME values were obtained on all the test materials except on cocoa husk when compaired with the values obtained between the 8th and 12th week. These results which showed increase in ME values with increasing age of the birds are in agreement with what was reported by Sibbald et al. (1960) . Baldini (1961) observed that the increase in ME contents with older chicks could result from betterutilization of dietary fat. This is more so with cocoa shell and DBG which have higher oil content (12.29% and 6.0% respectively) than cocoa husk (1.10%). The lower oil content of cocoa husk must have caused the decrease in the ME value obtained during this period. Nordfeldt (1954) suggested animal factors such as age to be capable of affecting energy value of feedstuff rather than its chemical composition. In a related development, Sibbald (1975a, b) indicated that adult cockerels should be used in ME determination.

Between the 16th and 20th week, all ME Values obtained decreased with age. This negative effect of age on the ME values obtained between the 16th and 20th week suggested that ability to metabolise feed ingrediets declined at about four months of age. Thus ME determination of feed ingredients is better carried out on cockerels before the age of 4 months. The results of phases I and II of the metabolic studies on cocoa shell and cocoa husk showed that the former has higher ME than the latter. As pointed out earlier, this may be due to the higher oil content of cocoa shell while the lower energy value of cocoa husk may be due to its high fibre content. It has been established from this study that age can influence the availability of ME content of feed ingredients. Other factors such as the chemical composition and combination of feed ingredients, methods used to estimate ME, level of inclusion of test ingredient in the basal diet and level of feeding can also affect the availability and digestibility of ME of feed ingredients. Although the ME value of cocoa husk is very low, it has been used successfully in animal feeds by many researchers because it contains little amount of alkaloid theobromine when compared with that of cocoa shell. In addition, cocoa husk is more readily available than cocoa shell. The higher ash content of cocoa husk when compared with the other cocoa by-products indicates higher mineral content in cocoa husk which may result in better skeletal tissue development and maintenance in birds.

CHAPTER FOUR

EFFECTS OF REPLACING WHEAT OFFAL
WITH COCOA HUSK IN COCKEREL RATIONS

4.1 INTRODUCTION

In the previous studies the results of the theobromine determination of all the four by products indicated that cocoa husk used in the study had the lowest theobromine content of 0.42%. The alkaloid theobromine is known to be toxic to domestic animals. Garner (1967) indicated that cocoa waste products are dangerous to animals, and particularly to horses, pigs and poultry. In the light of the above situation, most research workers used cocoa husk in animal feeds because of its low content of theobromine, richness in minerals and availability in cocoa farm plantations.

In this study, cocoa husk was used as a replacement to wheat offal in cockerel diets. The effects of the diets on growth, carcass characteristics, blood metabolites and economics of production were evaluated. The embargo placed on the importation of wheat and malted barley by the Federal Government of Nigeria in January 1987 and January 1988 resulted in the scarcity of wheat offal and dried brewers grain nation-wide. There is the need, therefore to harness the potentialities of other agricultural by-products like cocoa husk that can serve as substitute for wheat offal or DBG in animal feeds.

4.2 MATERIALS AND METHODS

4.2.1 Experimental Diets

Five experimental diets were formulated separately for the starter and finisher phases. The wheat offal in the diets was replaced with cocoa husk at the rate of 0, 25, 50, 75 and 100% at two protein levels i.e. 21% CP for the starter phase and 16% CP for the finisher phase. All diets in the starter phase had equal levels of fish meal, bone meal, oyster shell, premix, and salt. The levels of these ingredients in the finisher phase were also fixed. The ingredient composition and chemical analyses of the experimental diets for the starter and finisher diets are shown in tables 4.1 and 4.2 respectively. Mineral composition of the starter and finisher diets are also presented in table 4.3.

4.2.2 Management of Birds

One hundred and thirty day old hacco cockerels obtained from Michel Farms, Agege, Lagos, were randomly and equally alloted to 5 experimental starter diets containing 21% crude protein. There were 2 replicates of 13 day old cockerels per

TABLE 4.1: INGREDIENT AND CHEMICAL COMPOSITION OF EXPERIMENTAL DIETS FOR THE STARTER PHASE

Ingredients (%)	COCOA HUSK	REPLACEMENT		LEVEL	
	0%	25%	50%	75%	100%
Maize	43.40	41.40	39.40	37.40	35.40
Ground Cake	20.00	22.00	24.00	26.00	28.00
Wheat Offal	27.35	20.51	13.67	6.84	-
Cocoa Husk	-	6.84	13.68	20.51	27.35
Fish Meal	5.00	5.00	5.00	5.00	5.00
Bone Meal	2.50	2.50	2.50	2.50	2.50
Oyster Shell	1.00	1.00	1.00	1.00	1.00
Minovit Super*	0.50	0.50	0.50	0.50	0.50
Salt	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00
Calculated Analysis					
Crude Protein (%)	21.24	21.32	21.40	21.48	21.56
M.E. Kcal/g	2.65	2.66	2.64	2.63	2.61
Crude Fibre (%)	4.24	6.72	9.21	11.69	14.17
Calorie/Protein Ratio	124.76	124.82	123.36	122.44	121.06
Cost per kg of feed (₦)	1.09	1.08	1.07	1.07	1.06
Determined					
Crude Protein (%)	17.18	16.09	15.17	15.03	14.67
Crude Fibre %	7.20	8.20	13.60	17.70	19.00
Ether Extract (%)	0.23	0.11	0.10	0.11	0.12

*Minovit super by Intervet International BV Boxmeer Holland
Composition/100g:
Vit. A 7,500,000 iu, Vit D_3 1,500,000 iu, Vit. B_1 100mg, Vt B_2 2750mg, Vit. B_{12} 5mg, D-Calcium Pentothenate 5000mg, Vit.E 2500mg, Vit.K1500mg, Niacine 12,500mg, choline chloride 60,000mg, Ethoxyguin 5000mg, manganese Oxide 16,130mg, Potassium iodide 353mg, Cobalt sulphate 286mg, Zinc oxide 12,500mg,
Copperoxide 1283mg, Ferrocarbonate 20,323mg.

TABLE 4.2: INGREDIENT AND CHEMICAL COMPOSITION OF EXPERIMENTAL DIETS FOR THE FINISHER PHASE

Ingredients (%)	COCOA HUSK REPLACEMENT LEVEL				
	0%	25%	50%	75%	100%
Maize	27.08	23.08	19.08	15.08	11.08
Groundnut Cake	4.06	8.06	12.06	16.06	20.06
Wheat offal	63.86	47.89	31.93	15.97	-
Cocoa Husk	-	15.97	31.93	47.89	63.86
Fish Meal	1.50	1.50	1.50	1.50	1.50
Bone Meal	2.00	2.00	2.00	2.00	2.00
Oyster Shell	1.00	1.00	1.00	1.00	1.00
Minovit Super*	0.25	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00
Calculated Analysis					
Crude Protein(%)	16.36	16.32	16.27	16.27	16.21
M.E (Kcal/g)	2.27	2.27	2.27	2.26	2.26
Crude Fibre (%)	6.19	11.96	17.73	23.51	29.29
Calorie/Protein Ratio	138.58	139.09	139.52	139.91	139.42
Cost/kg Feed (₦)	0.59	0.56	0.53	0.50	0.47
Determined					
Crude Protein(%)	16.16	16.16	14.67	13.25	13.15
Crude Fibre (%)	11.60	13.70	17.50	20.10	22.00
Ether Extract (%)	0.15	0.13	0.13	0.14	0.14

*See Table 4.1 for Composition.

TABLE 4.3: MINERAL COMPOSITION OF STARTER AND FINISHER DIETS

Composition	Starter Diets					Finisher Diets				
	0%	25%	50%	75%	100%	0%	25%	50%	75%	100%
Calcium (ppm)	166.80	303.20	191.20	201.60	403.20	202.00	192.80	226.00	193.60	193.20
Phosphorus "	60.13	59.33	56.80	52.40	44.67	104.00	90.67	53.67	52.00	42.20
Magnesium "	28.40	28.40	33.20	35.20	33.20	40.40	45.60	47.60	49.20	56.40
Potasium "	96.00	96.00	116.00	132.00	120.00	104.00	144.00	164.00	172.00	192.00
Sodium "	44.00	44.00	44.00	47.00	44.00	32.00	38.00	56.00	44.00	48.00
Manganese "	0.88	0.88	0.71	1.00	0.97	0.79	1.21	1.17	1.37	1.38
Iron "	2.40	7.00	5.60	12.60	17.80	1.20	4.00	11.00	16.20	29.20
Zinc "	1.64	1.56	1.06	1.40	1.12	1.18	1.32	1.56	0.68	1.38

replicate. The starter phase lasted for 8 weeks. At the end of the starter phase, the birds were fed 5 finisher diets. The finisher phase lasted for 12 weeks. In both phases, feed and water were supplied ad libitum. Weight gain and feed intake were recorded weekly. Mortality was recorded as it occured. Routine vaccinations and necessary medications were administered on the birds when due.

4.2.3 Digestibility study and serum collection

At the end of each phase, digestibility study was carried out for 8 days with 3 days of preliminary adjustment and 5 days of faecal collection. Two birds per replicate were placed in metabolic cages where feed and water were provided ad libitum. Feed intake and faecal output were recorded daily. Faeces collected by total collection method were dried in a forced-drought oven at 100^{o}C and later bulked for chemical analysis. At the end of the finisher phase, 2 birds per replicate were bled by neck decapitation. Blood was collected into universal bottles and the serum (separated from the blood clot after 24 hours) pooled differently per replicate and centrifuged at 480 x g. The serum samples were stored at 4^{o}C until required for analysis.

4.2.4 Chemical Analysis

Energy content of both feed and faeces were determined with a ballistic calorimeter. The feed and faecal samples were assayed for crude protein according to the Association of Official Analytical Chemist (AOAC) procedure (1975). Total serum protein was determined by the Biuret method as described by Weichelbaum (1946). Serum creatinine and uric acid were determined by the methods of Slot (1965) and Caraway (1955) respectively. Cholesterol levels were determined according to Roschlau et al. (1974) method while blood glucose estimation was carried out by the method of Cooper and Mc Daniel (1970).

4.2.5 Carcass Analysis

2 birds per replicate were slaughtered and plucked. Eviscerated carcasses (after removal of head, shanks and internal organs) were weighed for the calculation of dressing percentages. Weight and length of small intestine, caeca, colon and rectum were also measured before and after the removal of internal contents. Weight of total edible meat and bones were also recorded per replicate.

4.2.6 Economic Analysis

The prevailing market prices of the feed ingredients used and that of the live chicken at the time of the study were used to estimate the feed cost and gross revenue, respectively.

4.2.7 Statistical Analysis

Complete Randomised Design was used in analysing the parameters measured. The Duncan's Multiple Range Test (Steel and Torrie, 1960) at 5 percent level of probability was used to access significant difference. Standard errors were calculated to identify the range of the means. A VAX 1 $\not{S}$ DRA - 1 programmable computer model BDP $\frac{11}{70}$ was used for the analysis.

4.3 RESULTS

4.3.1 Performance Characteristics and Nutrient Utilisation

The results of the performance of the birds in the starter and finisher phases are presented in tables 4.4 and 4.5, respectively. Experimental diets had no significant effects ($P > 0.05$) on feed intake in the starter phase. The feed intake decreased with increase in the levels of cocoa husk in the ration. Although the highest value of 77.75g was obtained on Diet 3 as the average daily feed intake/bird, feed consumption decreased gradually with the result that the lowest value of 57.92 g/bird was recorded

TABLE 4.4: PERFORMANCE CHARACTERISTICS OF COCKERELS FED COCOA HUSK DIETS WITH WHEAT OFFAL REPLACEMENT (STARTER PHASE).

Parameters	EXPERIMENTAL DIETS 0%	25%	50%	75%	100%	Mean	±S E
Initial body weight (g/bird)	28.60	26.06	28.14	24.32	29.91	27.40	0.89
Final body weight (g/bird)	755.38^{a}	764.62^{a}	713.64^{ab}	572.22^{bc}	533.69^{c}	667.91	36.02
Body weight gain (g/bird)	726.79^{a}	738.56^{a}	685.50^{ab}	547.90^{bc}	503.79^{c}	640.51	35.19
Daily body weight gain (g/bird)	14.54^{a}	14.77^{a}	13.71^{ab}	10.96^{bc}	10.08^{c}	12.81	0.70
Daily Feed intake (g/bird)	73.93	71.74	77.75	59.75	57.92	68.22	5.32
Feed conversion	5.12	4.87	5.67	5.46	5.75	5.37	0.52
Daily Protein intake (g/bird)	12.70^{a}	11.54^{ab}	11.80^{ab}	8.98^{b}	8.50^{b}	10.70	0.79
Protein Efficiency ratio	1.15	1.28	1.17	1.22	1.22	1.21	0.11
Mortality (%)	-	-	1.57	4.72	2.36	2.88	0.79

TABLE 4.5: PERFORMANCE CHARACTERISTICS OF COCKERELS FED COCOA HUSK DIETS WITH WHEAT OFFAL REPLACEMENT (FINISHER PHASE).

Parameters	EXPERIMENTAL DIETS						
	0%	25%	50%	75%	100%	Mean	±SE
Initial body weight (g/bird)	900.72	915.77	874.83	513.20	637.89	768.48	18.24
Final body weight (g/bird).	158.28	1532.31	1473.22	1057.35	1139.59	1356.95	145.19
Body weight gain (g/bird).	681.56	616.55	598.40	544.15	501.71	588.47	138.74
Daily body weight gain (g/bird).	13.63	12.33	11.97	10.86	10.04	11.77	2.77
Daily Feed intake (g/bird)	134.08	128.50	145.57	126.71	107.93	128.56	10,73
Feed conversion	9.86	10.43	12.19	11.64	14.27	11.68	2.95
Daily Protein intake (g/bird)	21.67[a]	20.77[a]	21.35[a]	16.97[ab]	14.19[b]	18.95	1.49
Protein Efficiency ratio	0.63	0.59	0.56	0.65	0.66	0.62	0.1
Mortality(%)	-	-	-	-	0.88	0.88	-

a, b: Superscripts with different letters in horizontal rows are significantly different ($P < 0.05$).

on Diet 5 where the whole of wheat offal was replaced with 100% cocoa husk. Experimental diets had significant effects ($P \angle 0.05$) on body weight gain. Results of weight gain clearly showed inverse relationship between body weight gain and the levels of cocoa husk in the ration. The highest value of 14.77g was recorded on Diet 2 as the average body weight gain/bird in the starter phase. However, the rate of weight gain decreased with increasing level of cocoa husk in the diets with the result that the lowest average daily body weight gain of 10.08 g/bird was obtained on the Diet 5 with the highest level of cocoa husk. Although there was no significant differance ($P > 0.05$) in the results of efficiency of feed utilization, diet 2 was superior to the other 4 diets. The lowest feed conversion ratio of 4.87 was obtained on diet 2 where 25% of the wheat offal was replaced with cocoa husk.

The results of the daily protein intake were significant ($P \angle 0.05$). Highest value of 12.70g per bird per day was obtained on the control diet, while the lowest value of 8.50 g/bird/day was obtained on Diet 5. Although the results of efficiency of protein utilization were not significantly different ($P > 0.05$), the best ratio of 1.15 was obtained on the control diet. The replacement of wheat offal with cocoa husk had no significant effect ($P > 0.05$) on the mortality of birds. Most of the birds that died in the early part of the starter phase on diets 3, 4 and 5 were attacked by cats.

The result of the performance of the cockerels in relation to feed intake in the finisher phase as presented in Table 4.5 showed a similar picture of what was observed in the starter phase. The wheat offal replacement with cocoa husk had no significant effect ($P > 0.05$) on feed intake. In addition no significant difference ($P > 0.05$) was observed in the values obtained on body weight gain and efficiency of feed utilisation. However, body weight gain decreased with increasing levels of cocoa husk in the diets. The highest value of 13.63 g/bird was recorded as the daily body weight gain on the control diet while the lowest value of 10.04 g/bird was obtained on diet 5 where the whole of wheat offal was replaced with cocoa husk.

There was a significant difference ($P < 0.05$) in the results of the daily protein intake in the finisher phase. Highest daily protein intake of 21.67 g/bird was obtained on the control diet while the lowest value of 14.19 g/bird was recorded on Diet 5.

However, there was no significant difference ($P > 0,05$) in the result of efficiency of protein utilization, although the best ratio of 0.56 was obtained on Diet 3 while a poor ratio of 0.66 was recorded on diet 5. The only mortality recorded in the finisher phase was on diet 5 where the whole of wheat offal in the diet was replaced with cocoa husk.

4.3.2 <u>Carcass Analysis and Gut Morphology</u>

The results of carcass characteristics are presented in Table 4.6. Dietary treatments had significant effects ($P < 0.05$) on the liveweight of the birds. The live weight decreased with increasing levels of cocoa husk in the diets. The weight of the dressed carcass expressed as percentage of liveweight did not show any significant difference ($P > 0.05$). However, significant difference ($P < 0.05$) was observed in the eviscerated carcass when the highest value of 70.52% was recorded on diet 2.

The mean values of the flesh/bone ratio were not statistically different ($P > 0.05$) but the results obtained on the diets containing cocoa husk showed a decrease in the flesh/bone ratio with increasing levels of cocoa husk in the diets. The best flesh/bone ratio of 2.73 was obtained on diet 2 while the poorest ratio of 1.97 was obtained on diet 5.

The study on gut mophology showed the significant effects (< 0.05) of experimental diets on the percentage of intestines

TABLE 4.6: CARCASS CHARACTERISTICS OF COCKERELS FED COCOA HUSK DIETS WITH WHEAT OFFAL REPLACEMENT (AT 5 MONTHS).

Parameter	0%	25%	50%	75%	100%	Mean	±SE
Liveweight (kg)	2.01^{a}	1.93^{a}	1.81^{a}	1.30^{b}	1.22^{b}	1.65	0.06
Dressed carcass (%)	94.01	94.35	92.52	91.63	94.29	93.36	1.29
Eviscerated carcass (%)	67.70^{ab}	70.52^{a}	66.56^{ab}	62.30^{a}	64.87^{ab}	66.39	1.48
Flesh/Bone Ratio	2.12	2.73	2.57	2.30	1.97	2.34	0.22
Liver (%)	1.93	1.92	1.44	2.01	2.09	1.88	0.19
Gizzard (%)	2.43	2.36	2.83	3.23	3.24	2.82	0.22
Length Small Intestine (%)	7.62^{b}	7.47^{b}	8.97^{ab}	10.69^{ab}	13.05^{a}	9.56	1.10
Weight small Intestine (%)	2.38^{b}	2.45^{b}	2.31^{a}	3.12^{a}	3,77^{a}	2.80	0.12
Length of caeca (%)	1.07^{b}	1.09^{b}	1.16^{b}	1.54^{a}	1.66^{a}	1.30	0.08
Weight of caeca (%)	0.38^{b}	0.38^{b}	0.43^{b}	0.64^{a}	0.64^{a}	0.49	0.03
Length Large Intestine) (%)	0.69^{a}	0.54^{b}	0.54^{b}	0.77^{a}	0.80^{a}	0.66	0.03
Weight Large Intestine (%)	0.28^{a}	0.20^{b}	0.22^{b}	0.32^{a}	0.30^{a}	0.26	0.01

a, b - Superscripts with different letters in horizontal rows are significantly different ($P < 0.05$).

TABLE 4.7: SERUM PROTEIN METABOLITES, CHOLESTEROL AND GLUCOSE LEVELS OF COCKERELS FED COCOA HUSK DIETS WITH WHEAT OFFAL REPLACEMENT (FINISHER PHASE).

Parameters	0%	25%	50%	75%	100%	Mean	±SE
Total Protein (g/ml)	8.61^{a}	7.93^{b}	13.54^{a}	10.04^{b}	8.93^{b}	9.81	0.71
Albumin (g/ml)	4.62^{abc}	4.03^{c}	5.54^{ab}	4.47^{bc}	5.68^{a}	4.87	0.28
Globulin (g/ml)	3.99^{b}	3.90^{b}	7.91^{a}	5.57^{b}	3.25^{b}	4.92	0.59
Blood Urea (mg/100ml)	11.75	11.46	11.46	11.17	11.43	11.45	0.16
Creatinine (mg/100ml)	3.42^{a}	2.42^{b}	1.41^{c}	1.57^{bc}	1.33^{c}	2.03	0.24
Cholesterol (mg/100ml)	97.71^{a}	64.16^{c}	47.14^{a}	69.28^{bc}	76.43^{b}	70.94	2.07
Glucose (mg/100ml)	250.55	210.99	268.68	264.28	221.15	243.13	32.37

a,b,c, superscripts with different letters in horizontal rows are significantly different ($P < 0.05$).

TABLE 4.8: ECONOMIC ANALYSIS OF COCKERELS FED COCOA HUSK DIETS WITH WHEAT OFFAL REPLACEMENT.

Parameters	0%	25%	50%	75%	100%	Mean	±SE
Liveweight (kg)	1.59	1.53	1.47	1.66	1.14	1.36	0.15
Total feed intake intake (kg)	10.40	10.01	11.17	9.33	8.35	9.85	0.82
Feed Cost (₦)	7.99^{a}	7.48^{ab}	8.02^{a}	6.37^{ab}	5.64^{b}	7.10	0.55
Feed cost/kg Liveweight (₦)	5.04^{ab}	4.89^{b}	5.45^{ab}	6.04^{a}	5.07^{ab}	5.29	0.26
Estimated Gross Revenue (₦)	118.30^{b}	129.01^{b}	114.41^{b}	58.33^{a}	77.72^{a}	99.65	4.31
Gross Revenue Less feed cost (₦)	110.31	122.01	106.39	51.97	72.09	92.55	4.26
Revenue/Feed cost (₦)	14.85^{b}	17.32^{b}	14.40^{b}	9.17^{a}	13.99^{b}	13.94	1.14

a, b, superscripts with different letters in horizontal rows are significantly different ($P < 0.05$).

and caeca. Although mean values obtained on the percentage of gizzard were not statistically significant ($P > 0.05$), gizzard weight increased with increasing levels of cocoa husk in the diets. The length and weight of intestines and caeca respectively showed significant increase with increase in levels of cocoa husk in the ration. The longest intestine and caeca was recorded on diet 5.

The lowest value of 7.47% was recorded on diet 2 for the length of small intestine while the highest value of 13.05% was recorded on diet 5 with the highest level of cocoa husk. Value of 1.07% was obtained on the control diet while the highest value of 1.66% was recorded on diet 5. The lowest value of 0.54% was obtained on diet 2 as the length of large intestine while the highest value of 0.80% was obtained also on diet 5 containing 100% cocoa husk. Weight of small intestine, caeca and large intestine also increased with increasing levels of cocoa husk in the diets.

4.3.3 Blood Metabolites

The results of serum protein metabolites, cholesterol and glucose levels are shown in Table 4.7. Significant difference ($P < 0.05$) was observed in the results of the total protein.

The highest value of 13.54 g/ml was obtained on Diet 3. The results of albumin and globulin were also statistically significant ($P < 0.05$). Highest value of 5.68 g/ml albumin was recorded for the diet 5 while the highest value of 7.91 g/ml for globulin was recorded on Diet 3. However, results obtained on blood urea were not statistically significant ($P > 0.05$). The mean values recorded for creatinine showed a significant different ($P < 0.05$). The results revealed decrease in creatinine as the level of cocoa husk increased in the diet. The highest value of 3.42 mg/100ml creatinine was obtained on the control diet while the lowest value of 1.33 mg/100ml was recorded on diet 5. Although the results of the cholesterol levels were significantly different ($P < 0.05$) there was no positive correlation between its level and that of cocoa husk in the diet. Mean values obtained on glucose levels were not statistically different ($P > 0.05$) from one another.

4.3.4 Economy of Production

The results of the economic performance are presented in Table 4.8. Significant difference ($P < 0.05$) was observed in the results of the feed cost. The lowest feed cost of ₦5.64 was recorded on diet 5 where the whole of wheat offal in the diet was replaced with cocoa husk. The feed cost/kg. Liveweight was also statistically different (P ∠ 0.05). The highest value of ₦6.04 was obtained on diet 4 while the lowest value of ₦4.89 was recorded on diet 2.

4.4 DISCUSSION

4.4.1 Performance Characteristics and Nutrient Utilization

Results of this study showed that up to 25% of the wheat offal in both the starter and finisher diets can be replaced with cocoa husk. This represents about 7% and 16% of cocoa husk in the starter and finisher diets, respectively. Diets containing levels of cocoa husk higher than those mentioned above depressed growth rate. Although the results of the feed intake in both phases (Tables 4.4 and 4.5) were not very significant the values recorded on diet 3 in both phases were higher than those recorded on other diets. These could be due to the low energy content of the diets. The result of the highest feed intake recorded on Diet 3 in both phases conforms with the report of Hill and Dansky (1954) who indicated that chicks tended to eat in order to satisfy their energy requirement.

Several authors have observed high papatability of cocoa husk because of its high mineral content, most especially potassium, calcium and sodium. Atuahene (1984) reported high feed intake by cattle and broiler chickens fed cocoa husk diets at higher levels. William (1971) ascribed the palatability of cocoa husk to the presence of volatile and non-volatile compounds in the husk. The highest feed intake value recorded particularly on Diet 3 in the finisher phase, therefore must have been due to the palatability of the diet due to its high content of calcium (Table 4.3). There was an inverse relationship between the growth rate and levels of cocoa husk in the ration in both phases. Best performance in terms of daily body weight gain (14.77 g/bird) was recorded on diet 2 in the starter phase where 25% of wheat offal was replaced with cocoa husk while lowest value of 10.08% g/bird was recorded on diet 5 where 100% cocoa husk replaced wheat offal in the ration. Crude fibre content of the ration increased with increasing levels of cocoa husk. The growth depression must have resulted from the increase in the crude fibre content of the diets. A similar result of growth depression was observed in the finisher phase where the body weight gain decreased with increasing fibre content of the diets. Consequently, the lowest value of 10.04 g/bird was recorded as daily body weight gain on diet 5 where cocoa husk replaced the whole of wheat offal in the ration. This observation of growth depression as a result of the fibrous nature of the diets is in aggreement with the report of several authors. Fraps (1941) reported that available energy is generally correlated with the crude fibre content of the ration and that increasing fibre content of a ration will decrease the amount of available energy and produce lower growth rate. Adeyanju et al. (1975) evaluated the nutritional value of poultry diets containing 0, 10, 15 and 20% cocoa husk respectively. The authors observed a depression in body weight gain and that of the feed/gain ratio in all rations containing cocoa husk. In another report, Adeyanju et al. (1977) observed significant ($P < 0.05$) decrease in body weight with increasing levels of cocoa husk in broiler ration. Savory and Gentle (1976 a, b) in a study with Japanese quail also concluded that birds on high fibre diets weighed less than those on low fibre diets.

Although the efficiency of feed utilisation were not statistically significant in both phase ($P > 0.05$) the results obtained indicated that feed efficiency decreased with increasing fibre content of the diets. In the starter phase, best efficiency of feed utilisation was obtained on diet 2 where feed/gain ratio of 4.87 was obtained while a ratio of 9.86 was the best result obtained on the control diet in the finisher phase.

Apparently, the crude fibre content of the experimental diets affected the efficiency of feed utilisation. Some authors have reported that fibre increases the bulkiness of a diet and when present in high concentrations limit the weight of food eaten by the bird and thereby imposes a physical limitations upon the intake of digestible nutrients. Sosulki and Cadden (1982) concluded that high fibrous diet depresses nutient utilisation. Adeyanju and Ilori (1979) in a study on pigs fed cocoa husk diets observed a decrease in efficiency of feed utilization with increasing husk content of the ration. The fibrous nature of the diets used in this study must have affected the daily intake of protein since there was an inverse relationship between the protein intake and the fibre content of the ration.

In both phases, lowest value of daily protein intake was obtained on diet 5. This observation conforms with the report of Woodman and Evans (1984) who indicated that fibrous feeds may decrease digestibility of crude protein. In the same manner, Halnan (1930) observed that crude fibre lowered the digestibility of organic matter and nitrogen free extract in poultry rations. Glover and Duchie (1958) also observed a decrease in crude protein digestibility as the crude fibre content of the rations fed to ruminants and non-ruminants increased.

The overall performance data at both the starter and finisher phases proved that 25% of wheat offal can be replaced with cocoa husk in both the starter and finisher diets for cockerels without serious effects on the performance of the birds. This represents 7% of cocoa husk in the ration in the starter phase and 16% in the ration in the finisher phase. The use of cocoa husk in poultry and livestock feeds is receiving serious attention. It has been used successfully by many research workers not only as a replacement of some other feed ingredients but also to reduce the cost of production. Adeyanju et al. (1975) recommended up to 20% of cocoa husk in poultry layers mash. Barnes et al. (1984) replaced 25% of maize with cocoa husk successfully in a study with growing finishing pigs. Tuah et al. (1984) fed up to 60% level of dry cocoa husk meal to sheep without adverse effect on growth rate, feed intake and efficiency of feed utilization.

4.4.2 Carcass Analysis and Gut Morphology

Analysis of the carcass (Table 4.6) showed the significant effects ($P < 0.05$) of the replacement of wheat offal in the ration with cocoa husk on carcass yield. In the appraisal of carcass composition, three variables need to be considered i.e. the bone, muscle and fat. It is the relative proportion of these 3 tissues in carcasses of similar weight that determines the carcass value. However, the growth patterns of body tissues can be changed by controlling the dietary energy, thus affecting the composition of muscle. In the present study, the weight of the eviscerated carcasses expressed as percentage of live-weight appeared to decrease with increasing levels of cocoa husk in the diets. The highest value of 70.52% was obtained on diet 2 where the wheat offal was replaced with 25% cocoa husk while the lowest value of 62.30% was recorded on diet 4 with 75% cocoa husk as a replacement of wheat offal. Adeyanju et al. (1975) in a study on cocoa husk in poultry diets reported that chickens fed diets containing 15% and 20% cocoa husk respectively dressed slightly lower than those fed either the control or a diet containing 10% cocoa husk. In another study on pigs fed cocoa husk, Adeyanju and Ilori (1979) further reported the decrease in dressing percentage as level of cocoa husk increased in the ration.

Although the results of the flesh/bone ratio were not significantly different ($P > 0.05$) values obtained showed the superiority of diet 2 over all other diets including the control. The mean values decreased consistently with increasing levels of cocoa husk. The highest value of 2.73 was recorded on diet 2 where 25% of wheat offal was replaced with cocoa husk while the lowest value of 1.97 was obtained on Diet 5 where 100% of wheat offal was replaced with cocoa husk. There was no clear relationship between the liver weight and the levels of cocoa husk in the experimental diets. All the values obtained in this respect were not significantly different ($P > 0.05$).

However, the result of the gut morphology showed the significant effects of the various levels of cocoa husk in the ration ($P < 0.05$). The higher the level of cocoa husk in the ration the greater the amount of fibre in such ration. This is reflected in tables 4.1 and 4.2. Results of the gizzard weight expressed as percentage of liveweight indicated that the gizzard weight increased with increasing levels of fibre in the diet. Among the diets containing cocoa husk the highest value of 3.24 was recorded on Diet 5 as gizzard weight expressed as percentage of liveweight while the lowest value of 2.36 was recorded on diet 2. The increase in gizzard weight with increased levels of fibre in the diet conforms with the report of Deaton _et al_. (1979) who indicated that birds on fibrous diets exhibit greater mechanical grinding thus stimulating the muscular walls of gizzard which results in the increase in weight of the gizzard. The intestines and caeca presented the same picture like that of the gizzard. The length and weight of the small intestine, caeca and large intestine increased consistently with increasing levels of cocoa husk in the ration. The highest value in each case was recorded on diet 5 containing the highest level of crude fibre while lowest value in most cases was recorded on diet 2 containing the lowest level of crude fibre. A similar report of increase in intestinal length with increasing dietary fibre was made by Savory and Gentle (1976). It is possible that the muscular walls of the organs mentioned above were stimulated to cope with the fibrous diets. The caeca in particular are the sites of fibre digestion in poultry (Crampton and Harris, 1968). About 20 - 30% of crude fibre can be digested by poultry in the caeca. Daston et al. (1979) observed significant increase in gizzard weights and intestinal lengths when high fibre sunflower meal was fed to broilers.

4.4.3 Blood Metabolites

Although the results of most of the blood metabolites showed the significant effects ($P \angle 0.05$) of wheat offal replacement with cocoa husk, there was inconsitency in some of the results obtained. Usually the nutrient found in the blood is a balance between what is ingested and what is utilised. The result gives an indication of what reserves are available to the animal in condition of low nutrient intake. There was a partial relationship between the daily protein intake in the finisher phase and the mean valaues obtained on the serum protein. Results of protein intake and serum protein levels particularly on Diets 2 and 3 were almost positively correlated. Result obtained on total protein agrees to some extent with the report of Keyser et al. (1968) who observed a close relationship between dietary and serum protein concentrations. Doornenbal et al. (1986) suggested that adequate levels of plasma proteins should be maintained in animal body since these proteins usually bind to vital metabolites, metal ions, hormones and lipids. Decrease in the levels of plasma protein are often associated with impaired protein synthesis or diseases of the digestive systems or the liver.

There was no clear relationship between the albumin and globulin levels and the dietary protein while the uric acid levels were relatively constant between the dietary treatments. The results of the blood urea ranges between 11.17 mg/100m - 11.75 mg/100ml. Zyan'kou et al. (1978) reported that blood urea level, especially in monogastrics, is influenced by the quantity, quality and proximity of the preceding meal. It increases mostly after eating. The constant values of blood urea on all the treatments could be due to the balance in amino acid composition of the diets, Kunta and Harper (1961) indicated that an imbalance of amino acids in the diets could cause elevated blood urea concentrations. Increase deamination or kidney malfunctioning are other possible factors that may raise blood urea levels. The creatinine levels tended to decrease with increasing levels of cocoa husk in the diet. Compaired with the control diet, the highest level of 2.42 mg/100ml was recorded as the creatinine level on diet 2 while the lowest level of 1.33 mg/100ml was obtained on diet 5. The lower levels of creatinine obtained generally on diets 3 , 4 and 5 did not relate to a better protein utilization rather there was a complete muscular wastage particularly on Diet 5 which contained 100% cocoa husk as a replacement to wheat offal. Doornenbal et al. (1986) considered creatine level as predictor of lean tissue mass in the body.

Serum cholesterol concentrations did not show any particular trend in relation to dietary treatment. Generally lower values were recorded on all diets. Cholesterol level is usually an index of fat utilization in animals. Higher level of cholesterol may be indicative of higher tendency to fat deposition. In this study, most of the carcasses did not show any appreciable amount of fat on them. Hutagalung et al. (1969) reported the importance of diet in influencing serum cholesterol levels. Saturated fat in the diet determines the serum cholesterol concentration. Lombardi et al. (1962) also confirmed that diet is the most important factor regulating cholesterol level. The value of 97.71 mg/100ml was recorded as the highest cholesterol level on the control diet while the lowest value of 47.14 mg/100ml was obtained on Diet 3 where 50% cocoa husk replaced 50% of the wheat offal. There was no relationship between the levels of glucose and those of cocoa husk in the ration. Highest level of 268.68 mg/100ml was obtained on diet 3 while the lowest level of 210.99 mg/100ml was recorded on diet 2.

4.4.4 Economy of Production

Results of economics of production showed that feed cost was reduced with the replacement of wheat offal with cocoa husk in cockerels diets. Tables 4.1 and 4.2 showed the reduction in cost/kg of feed as the level of cocoa husk increased in the starter and finisher diets.

A critical look at the 4 diets containing cocoa husk showed the economic advantage of diet 2 over the others in terms of the feed cost/kg liveweight. The sum of ₦4.89 was recorded as the lowest feed cost/kg liveweight on the Diet 2 where 25% of the wheat offal was replaced with cocoa husk while the sum of ₦6.04 was the highest cost recorded on Diet 4 where cocoa husk replaced 75% of the wheat offal in the ration. The increase in the level of GNC in the ration as the level of cocoa husk increased in an attempt to balance for protein must have been responsible for the progressive increase in feed cost/kg liveweight since GNC is more expensive. About 70% of cocoa husk in the ration in the starter phase and 16% in the finisher phase are the recommended levels for cockerels in this study for economic reasons. Adeyanju et al. (1977) in a 6 week study on performance of broiler chicks on diets containing graded levels of cocoa husk observed that in terms of feed cost/kg body weight, feeding cocoa husk at isocaloric and isonitrogenous levels beyond 5% was not economical. The levels recommended for cockerels in this study are higher because of the hardy nature of cockerels since they can tolerate more fibrous feeds than the broiler chicks. It will be recalled that best result on cocoa husk diets in terms of body weight gain, nutrient utilization and flesh/bone ratio were achieved on Diet 2 in both phases corresponding to the levels recommended above, a further savings in feed cost/kg body weight at the recommended levels justifies the incorporation of cocoa husk in cockerels diets.

Adeyanju and Ilori (1979) in a related study on the growth, economics and carcass characteristics of growing/finishing pigs fed cocoa husk diets reported decreases in feed cost and cost/kg gain in live weight as the proportion of cocoa husk increased in the diet. The authors recommended up to 30% cocoa husk in the pigs diets. The use of cocoa hus as a replacement of wheat offal in poultry feeds is justifiable now that the Federal Government of Nigeria has banned the importation of wheat and malted barley which has resulted in the scarcity of wheat offal and Dried Brewers Grain .

CHAPTER FIVE

EFFECTS OF GROUNDNUT CAKE REPLACEMENT WITH PALM KERNEL CAKE IN COCOA HUSK BASED RATIONS

5.1 INTRODUCTION

In the previous study, it was established that cocoa husk could be economically incorporated in the starter and finisher diets of cockerels at 7% and 16% levels respectively. These 2 levels were used as control for both the starter and finisher diets in the present study, while the groundnut cake (GNC) in the ration was replaced with palm kernel cake (PKC) at 0, 33, 66 and 100% levels. Although the use of PKC in livestock feed is limited because of its grittiness, dryness and unpalatability (Collingwood, 1958) it is cheaper than the GNC and more readily available in the country because of the increase in the existence of oil mills and soap manufacturing industries. In addition PKC is high in calcium, phospharus, magnesium, manganese and iron (Njike, 1979). Blood meal, a protein source of animal origin was incorporated in the experimental diets because of the low level of protein in the PKC. Generally, vegetable proteins have been found to be less digestible than animal proteins (Joseph et al. 1963). The inclusion of the blood meal was to balance for the protein in the rations.

It will be recalled that the level of the GNC in the diets in the previous study increased as the level of cocoa husk increased leading to a further increase in feed cost/kg liveweight. In the present study therefore, the objectives of the replacement of GNC in the ration with PKC include (a) reducing feed cost/kg liveweight and (b) determining if cockerels would tolerate high fibre diets in both the starter and finisher phases. Performance and carcass characteristics, histological and pathological studies and economics of production were some of the parameters evaluated on the various diets.

5.2 MATERIALS AND METHODS

5.2.1 Experimental Rations

Four experimental rations were formulated separately for the starter and finisher phases. The GNC in the rations was replaced with PKC (protein for protein) at the levels of 0, 33, 66 and 100% (Diets 1, 2, 3 and 4 respectively). Corn Bran, a by-product from milling industry was used in this study as a complete substitute for wheat offal. The corn bran has a crude protein content of 12 - 14.36%, crude fibre 14 - 20%, ether extract 11.80% and Ash 93.40%. The diets in both phases were made to be isonitrogenous and isocaloric. The protein levels for the starter and finisher diets were 21% and 16% respectively. The maize and the corn bran in both diets were gradually reduced while the level of cocoa husk remained constant at 7% and 16% in the starter and finisher diets respectively. Blood meal was incorporated at various levels in order to balance for the protein while other feed ingredients remained fixed. The percentage ingredient composition and the chemical analysis of the diets are presented in tables 5.1 and 5.2 for the starter and finisher diets, respectively.

5.2.2 Management of Birds

One hundred and sixty day-old cockerels obtained from Alanco Agricultural Enterprises in Ibadan were started on the starter diet containing 21% protein. All the treatments were in replicate of 20 birds each. The birds were vaccinated against New Castle Disease on the second day with NDV (I/O) while Lasota was administered in water by the 3rd week. Anti-stress (Agrotonic) was administered in water for the first 5 days. The starter phase lasted for 8 weeks at the end of which all the birds were mixed together and redistributed to prevent the carry-over effects of the experimental diets. There were 16 birds/replicate for the finisher phase which lasted for another 8 weeks. The protein conte

TABLE 5.1: COMPOSITION OF COCOA HUSK BASED RATION WITH GNC REPLACEMENT WITH PKC (STARTER).

Ingredient	REPLACEMENT LEVELS			
	0%	33%	66%	100%
Maize	38.40	27.03	14.14	5.91
GNC	25.00	16.76	8.49	-
P.K.C.	-	20.61	41.28	62.50
Corn Bran	20.35	17.55	16.24	9.74
Cocoa Husk	7.00	7.00	7.00	7.00
Fish Meal	5.00	5.00	5.00	5.00
Blood Meal	-	1.80	3.60	5.60
Bone Meal	2.50	2.50	2.50	2.50
Oyster Shell	1.00	1.00	1.00	1.00
Minovit Super*	0.50	0.50	0.50	0.50
Salt.	0.25	0.25	0.25	0.25
Total =	100.00	100.00	100.00	100.00
Calculated Analysis				
Crude Protein (%)	21.34	21.31	21.30	21.30
ME (Kcal/g)	2.65	2.49	2.31	2.19
Crude Fibre (%)	8.03	9.47	11.10	12.13
Caloric/Protein Ratio	124.18	116.85	108.45	102.82
Cost/kg feed (₦)	1.35	1.13	0.91	0.72
Determined				
Crude Protein (%)	23.11	18.56	18.21	21.36
Crude Fibre (%)	11.10	17.60	24.30	29.00
Ether Extract (%)	1.90	2.70	5.40	7.40

* See Table 4.1 for Composition.

TABLE 5.2: COMPOSITION OF COCOA HUSK BASED RATION WITH GNC REPLACEMENT WITH PKC (FINISHER)

Ingredient	0%	33%	66%	100%
Maize	16.34	14.76	13.18	10.39
GNC	14.80	9.91	5.02	-
PKC	-	12.22	24.44	37.00
Corn Bran	47.86	40.86	33.86	27.86
Cocoa Husk	16.00	16.00	16.00	16.00
Fish Meal	1.50	1.50	1.50	1.50
Blood Meal	-	1.25	2.50	3.75
Bone	2.00	2.00	2.00	2.00
Oyster Shell	1.00	1.00	1.00	1.00
Minovit super*	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25
Total =	100.00	100.00	100.00	100.00
Calculated Analysis				
CP (%)	16.29	16.30	16.30	16.30
ME (Kcal/g)	2.27	2.26	2.23	2.21
CF (%)	14.81	15.04	15.23	15.61
Caloric/Protein Ratio	139.35	138.65	136.81	135.58
Cost/kg feed (₦)	0.78	0.69	0.61	0.51
Determined				
CP (%)	16.46	15.71	14.71	13.30
CF (%)	8.20	11.80	12.40	22.20
EE (%)	2.00	3.70	4.50	6.00

*See Table 4.1 for Composition.

of the finisher diet was 16%. Feed and water were provided ad libitum throughout the period of study. Weight gain, feed intake and mortality were recorded on weekly basis.

5.2.3 Balance Studies and Serum Collection

A five day total faecal collection was made at the end of each phase. 2 birds from each replicate were placed in the metabolic cages where feed and water were offered ad libitum. Daily feed intake and faecal output were recorded for the period. The faeces collected by total collection method were dried in a forced-drought oven at 100°C and later bulked for chemical analysis.

At the end of the 16th week of trial, 2 birds were randomly selected per replicate after starving overnight and bled by the neck decapitation. The serum was collected in universal bottles and later used for analysis.

5.2.4 Chemical Analysis

The energy in the feed and faecal samples were determined with a ballistic bomb calorimeter. The feed and faecel samples were assayed for crude protein according to the AOAC procedures (1975). Total serum protein was determined by the buiret method as described by Weichelbaum (1946). Serum creatinine and Uric acid by the methods of Slot (1965) and Caraway (1975) respectively, Cholesterol levels were determined according to Roschlau *et al* (1974) while Blood glucose estimation was carried out by the method of Cooper and McDaniel (1970).

5.2.5 Carcass Analysis

Birds for carcass analyses were slaughtered early in the morning after been starved overnight. Feathers were plucked the head and feet removed. All carcasses were later eviscerated. Weight of eviscerated carcasses was used for the calculation of dressing percentages. The internal contents of gizzards, small intestine, caeca, colon plus rectum (large intestine) were removed. The organs were later cleaned with water. The weight of liver, gizzard, small and large intestines and caeca were recorded. The length of small and large intestines and caeca were also recorded. The weight of total edible meat and bones were used for the calculation of flesh/bone ratio.

5.2.6 Histological and Pathological studies

Portions of the liver, brain and kidneys were taken for toxicological studies. The tissues were fixed for 8 hours in formalin fixative to prevent damage which may result from osmotic shock. The tissue samples were later cut into blocks and prepared for dehydration and clearing. The samples were embedded in molten wax and later cut on the michrotome. The prepared tissues were mounted on slides, stained in haematoxylin and eosin for microscopic examination.

5.2.7 Cost Analysis

The current prices of feed ingredients and the prevailing prices of birds at the time of the study were used to estimate the feed cost and gross revenue.

5.2.8 Statistical Analysis

The data obtained in both phases were subjected to analysis of variance using complete Randomised Design. The Duncan's Multiple Range Test (Steel and Torrie, 1960) at 5 percent level of probability was used to access significant difference. Standard errors were calculated to identify the range of the means. A VAX 1 $ DRA - 1 programmable computer model BDP $\frac{11}{70}$ was used for the analysis.

5.3 RESULTS

5.3.1 Performance Characteristics

The results of the performance of the cockerels in the starter phase are presented in Table 5.3. The mean values of daily feed intake were significantly different ($P < 0.05$) from each other. The highest daily feed intake of 64.14g/bird was recorded on the control diet where the PKC was not incorporated while the lowest value of 38.97g/bird was obtained on diet 4 where the whole of GNC in the ration was replaced with PKC. Compared with the result obtained on the control diet, a progressive decrease in feed intake was observed particularly on Diets 3 & 4 as the level of PKC increased in the the ration. Although the mean values of body weight gain were not statistically significant ($P > 0.05$), a similar picture of inverse relationship was also observed between the levels of PKC in the diets and the growth rate. The highest value of 9.96g/bird was recorded on Diet 2 as the daily body weight gain while the lowest value of 6.26 was obtained on Diet 4. A consistent decrease in weight gain was observed with increasing levels of PKC in diets. The best conversion ratio (although not significant) of 5.13 was also obtained on Diet 2. The results of daily protein intake were very significant ($P < 0.05$). The mean value of 14.82g/bird/day was the

TABLE 5.3: PERFORMANCE AND NUTRIENT UTILISATION OF COCKERELS FED COCOA HUSK BASED RATIONS WITH GNC REPLACEMENT WITH PKC (STARTER PHASE).

PARAMETERS	0%	33%	66%	100%	Mean	±SE
Initial body weight (g/bird)	64.00	60.00	64.00	60.00	62.00	1.71
Final body weight (g/bird)	636.83	657.03	581.88	435.77	577.87	58.52
Body weightgain (g/bird)	572.83	597.03	517.88	375.77	515.87	57.55
Daily body weight gain (g/bird)	9.55	9.96	8.64	6.26	8.60	0.96
Daily Feed intake (g/bird)	64.14^{a}	51.66^{ab}	51.68^{ab}	38.97^{b}	51.61	4.07
Feed conversion	6.70	5.31	5.99	6.35	6.09	0.86
Daily Protein intake (g/bird)	14.82^{a}	9.59^{b}	9.41^{b}	8.33^{b}	10.54	0.93
Protein Efficiency ratio	0.65	1.05	0.92	0.76	0.84	0.13
Nitrogen Retention (%)	66.14	62.99	60.42	61.02	62.64	1.82
Mortality (%)	8.13	3.13	5.00	3.75	5.00	1.20

a, b - Supers cripts with different letters in horizontal rows are significantly different ($P < 0.05$).

TABLE 5.4: PERFORMANCE OF COCKERELS FED COCOA HUSK BASED RATIONS WITH GNC REPLACEMENT WITH PKC (FINISHER PHASE).

PARAMETERS	0%	33%	66%	100%	Mean	±SE
Initial body weight (g/bird)	563.13	498.75	485,63	576.25	530.94	28.77
Final body weight (g/bird)	1146.25	1085.07	1019.19	1159.81	1102.58	141.19
Body weight gain (g/bird)	583.13	586.32	533.57	583.56	571.64	157.83
Daily body weight gain (g/bird)	11.66	11.73	10.67	11.67	11.43	3.16
Daily Feed intake (g/bird)	152.15	100.48	121.20	88.83	115.66	0.60
Feed conversion	15.93	8.69	11.42	7.79	10.95	3.88
Daily Protein intake (g/bird)	25.04	15.79	17.83	11.81	17.62	0.09
Protein Efficiency ratio	0.47	0.75	0.60	0.99	0.70	0.15
Nitrogen Retention (%)	64.32	68.21	60.05	58.41	62.75	9.02
Mortality (%)	14.06	5.47	8.59	1.56	7.42	3.60

Mean values not followed by superscripts in horizontal rows are not significally different ($P > 0.05$) from each other.

highest protein intake obtained on the control diet while the lowest value of 8.33 g/bird/day was obtained on Diet 4. Daily protein intake decreased consistently with increasing level of PKC in the diets. However, efficiency of protein utilization was not very significant ($P > 0.05$) but the best ratio of 0.65 was obtained on the control diet.

Mortality was recorded in all the treatments with the highest value of 8.13% obtained on the control diet while the lowest value of 3.13% was recorded on Diet 2. The birds were attacked by cats in the second week of the study thus resulting in sudden losses in the starter phase.

The results of the performance of the birds in the finisher phase are indicated in Table 5.4. Experimental diets had no significant effects ($P > 0.05$) on feed intake but the highest value of 152.15 g/bird was obtained as the average daily feed intake on the control diet while the lowest value of 88.83 g/bird was recorded on Diet 4 where PKC replaced the whole of GNC in the ration. The results of average daily body weight gain was also not significantly different ($P > 0.05$) from one another. However, weight gain with the highest value of 11.73 g/bird was obtained in Diet 2 while the lowest value of 10.67 g/bird was obtained on Diet 3. The best result of efficiency of feed utilisation was obtained on Diet 4 where the ratio of 7.79 was recorded while the poorest ratio of 15.93 was obtained on Diet 1. There was a positive correlation between daily feed intake and daily protein intake. The highest value of 25.04 g/bird was recorded on Diet 1 as the daily protein intake while lowest value of 11.81 g/bird was obtained on Diet 4. The efficiency of protein utilisation showed a similar pattern with the best ratio of 0.47 recorded on Diet 1 while the poorest ratio of 0.99 was obtained on Diet 4. The results of protein intake and protein efficiency ratio were however not significantly different ($P > 0.05$) from one another.

Mortality was recorded in all the treatments in the early part of the finisher phase when the birds were mixed up and re-distributed into replicates. The value of 14.06% was the highest mortality recorded on Diet 1 while the lowest value of 1.56% was obtained on Diet 4.

5.3.2 Carcass Characteristics and Gut Morphology

The results of the analysis of the carcass as presented in Table 5.5 showed the significant effects ($P \angle 0.05$) of the experimental diets on carcass yield. The average liveweight of the bird decreased with increase in the PKC content of the ration.

TABLE 5.5: CARCASS CHARACTERISTICS OF COCKERELS FED COCOA HUSK BASED RATION WITH GNC REPLACEMENT WITH PKC

PARAMETERS	0%	33%	66%	100%	Mean	±SE
Average live weight (kg)	1.49^{a}	0.87^{b}	1.09^{ab}	0.83^{b}	1.07	0.12
Dressed Carcass (%)	88.89^{ab}	90.58^{ab}	82.65^{b}	94.54^{a}	89.16	2.08
Eviscerated Carcass (%)	59.63	56.40	54.82	58.16	57.25	3.60
Fat (%)	0.54	0.20	0.26	0.18	0.29	0.11
Flesh/bone ratio	2.19	1.46	1.94	1.84	1.85	0.27
Liver (%)	1.82	2.59	2.52	2.87	2.45	0.49
Gizzard (%)	2.76	3.35	3.03	3.21	3.08	0.42
Length small intestine (%)	9.97^{b}	15.47^{a}	12.07^{b}	15.89^{a}	13.35	0.55
Weight small intestine (%)	3.51	5.74	3.57	5.56	4.59	0.51
Length of caeca (%)	1.81	1.93	1.47	2.15	1.68	0.27
Weight of caeca (%)	0.50^{b}	0.75^{ab}	0.67^{b}	1.00^{a}	0.73	0.06
length of large intestine (%)	0.53^{b}	1.10^{a}	0.97^{ab}	1.09^{a}	0.92	0.12
Weight of large intestine (%)	0.24^{b}	0.37^{a}	0.34^{ab}	0.39^{a}	0.33	0.02

a, b - Superscripts with different letters in horizontal rows are significantly different ($P < 0.05$).

TABLE 5.6: SERUM PROTEIN METABOLITES, CHOLESTEROL AND GLUCOSE LEVELS OF COCKERELS FED COCOA HUSK BASED RATIONS WITH GNC REPLACEMENT WITH PKC

PARAMETERS	0%	33%	66%	100%	Mean	±SE
Total Protein (gm/ml)	8.69[a]	6.26[b]	6.90[b]	7.22[ab]	7.27	0.37
Albumin (gm/ml)	4.58[b]	4.74[b]	3.59[b]	6.27[a]	4.79	0.28
Globulin (gm/ml)	4.11[a]	1.53[b]	3.30[a]	0.95[b]	2.47	0.16
Uric Acid (mg/100ml)	5.63	6.00	4.36	4.09	5.02	0.67
Creatinine (mg/100ml)	2.25[a]	1.92[ab]	1.66[b]	2.08[ab]	1.98	0.10
Cholesterol (mg/100ml).	77.38[b]	68.10[b]	68.57[b]	47.14[a]	69.30	3.92
Glucose (mg/100ml)	84.51[ab]	90.18[a]	69.17[ab]	54.29[b]	74.54	6.55

a, b - Mean values with different superscripts in horizontal rows are significantly different ($P < 0.05$).

TABLE 5.7: ECONOMICS OF PRODUCTION OF COCKERELS FED COCOA-HUSK BASED RATIONS WITH GNC REPLACEMENT WITH PKC

PARAMETERS	0%	33%	66%	100%	Mean	±SE
Liveweight (kg/bird)	1.15	1.09	1.02	1.16	1.10	0.14
Total feed intake (kg/bird)	11.46	8.12	9.22	6.78	8.90	0.24
Feed Cost (₦)	11.13^{a}	6.96^{b}	6.55^{b}	3.95^{a}	7.15	0.29
Feed cost/kg Liveweight (₦)	10.17^{a}	6.46^{ab}	6.43^{ab}	3.41^{b}	6.62	1.37
Estimated Gross Revenue (₦)	55.322^{c}	100.69^{ab}	76.13^{bc}	125.93^{a}	89.52	8.72
Gross Revenue Less feed cost (₦)	44.19^{c}	93.73^{ab}	69.58^{bc}	121.98^{a}	82.37	8.47
Revenue/Feed Cost (₦)	3.92^{a}	13.48^{b}	10.62^{b}	30.95^{a}	14.74	1.07

a, b, c - Superscripts with different letters in horizontal rows are significantly different ($P < 0.05$).

The highest value of 1.49kg was recorded as the average live weight of the bird on the control diet while the lowest value of 0.83kg was obtained on Diet 4. A corresponding decrease in the weight of the eviscerated carcass was also observed between diets 2 and 3 as the level of PKC increased in the ration. However the highest value of 59.63% was recorded on the control diet as the weight of the eviscerated carcass expressed as percentage of liveweight. Comparing the results obtained on the control diet with diets containing PKC, the best result of 58.16% for enviscerated carcass was obtained on Diet 4 where the whole of GNC in the ration was replaced with PKC while the lowest value of 54.82% was recorded on Diet 3 where 66% of the protein of GNC was substituted with that of PKC. All the results obtained on eviscerated carcasses were not statistically different ($P > 0.05$) from each other.

Results of the abdominal fat on all the carcass were also not very significant ($P > 0.05$). The mean values of the fat content expressed as percentage of liveweight did not show any correlation with the level of PKC in the diet. Highest value of 0.54% was recorded as the average fat content of the carcass on the control diet, while the lowest value of 0.18% was obtained on Diet 4.

The GNC replacement with PKC did not show any significant effect ($P > 0.05$) on the result of flesh to bone ratio. But comparing the results obtained on all the 4 diets, the best result of 2.19 was obtained on the control diet as the flesh/bone ratio while a ratio of 1.46 was obtained on Diet 2 as the lowest value. Diet 3 with 66% replacement of PKC gave the best ratio of 1.94 when compared with the other diets containing PKC. The highest value of 2.87% liver weight as the percentage of liveweight was recorded on Diet 4 while the lowest value of 1.82% was obtained on the control diet.

The results obtained on gut morphology showed the significant effects ($P < 0.05$) of the experimental diets on the length and weight of gizzard, intestines and caeca. Generally, the highest mean value was obtained on PKC diets while lowest mean value was recorded on the control diet. The results of % gizzard were not statistically significant ($P > 0.05$) but the highest value of 3.35% was recorded on Diet 2 while the lowest value of 2.76% was obtained on the control diet. There were significant effects ($P < 0.05$) of the experimental diets in the results of intestinal length. The highest value of 15.89% was obtained on Diet 4 while the lowest value of 9.97% was recorded on the control diet. The results obtained on the weight of caeca and large intestine were also statistically different (P/_ 0.05) from one another. The highest mean value for the length and weight of caeca and weight of large intestine was obtained generally on Diet 4 while the lowest value was recorded on the control diet in all cases.

5.3.3 Histopathological Characteristics

Microscopic examination of all the organs (Brain, liver and Kidney) showed some pathological lesions.

The lesions observed on the brain tissue were those of severe and diffuse vascular congestion, hyaline degeneration of meningeal vessels, mild mononuclear perivascular cuffing and the folding of ependymal cellular layer (plate 5.1). The diagnosis for the above condition is that of non suppurative meningo - encephalitis.

The liver also showed some typical pathological lesions which include moderate but diffuse periportal mononuclear cellular infilteration, fibrosis with bile duct proliferation, heterophilic infilteration, proliferation of kuppfer cells and megalocytosis (plate 5.2). The morphological diagnosis is that of Hepatitis, chronic and necrotizing.

The pathologic lesions observed on the kidney tissue were those of multifocal areas of tubular degeneration, necrosis and heterophilic infilteration, presence of hyaline and cellular casts in the tubules some of which appeared calcified, diffuse vascular congestion and fibrosis of interstitial tissue (plate 5.3). The morphological diagnosis is Nephritis, Acute, necrotising.

5.3.4 Blood Metabolites

Table 5.7 shows the results of serum protein metabolites, cholesterol and glucose levels. Experimental diets had significant effects ($P < 0.05$) on the total protein. Compared with the result obtained on the control diet, the level of total protein increased with increasing the level of PKC in the ration. The lowest value of 6.26 gm/ml was obtained on Diet 2 while the highest value of 7.22 g/ml was obtained on Diet 4. The results obtained for total protein showed a negative correlation between the crude protein content in the diet and the serum protein. As the level of PKC increased in the diet, crude protein content decreased (Table 5.2) while the serum protein level increased. The results of the albumin and globulin levels were also significantly diffent ($P < 0.05$) from one another, but the values obtained were not consistent. However, results obtained on the

Plate 5.1

Photomicrograph of cockerel's brain tissue at sixteen weeks.

A - Lymphocytic cellular infilteration into the meninges.

H and E stain x 400.

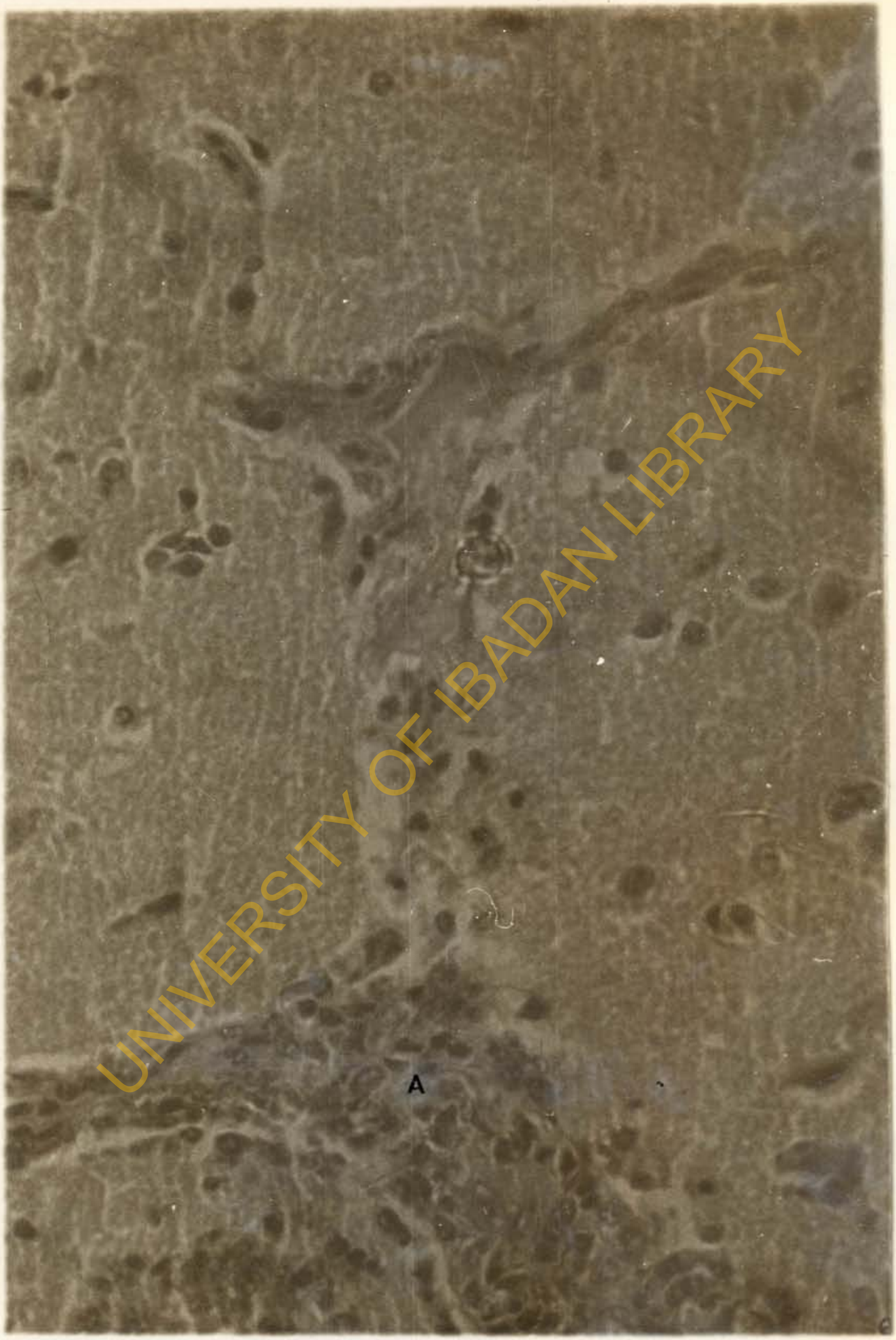

A

Plate 5.2

Photomicrograph of cockerel's liver tissue at sixteen weeks.

A - Moderate Mononuclear cellular infilteration into the liver parenchyma.

↓ - Small area of necrosis.

H - Congestion of the central vein

H and E stain x 400.

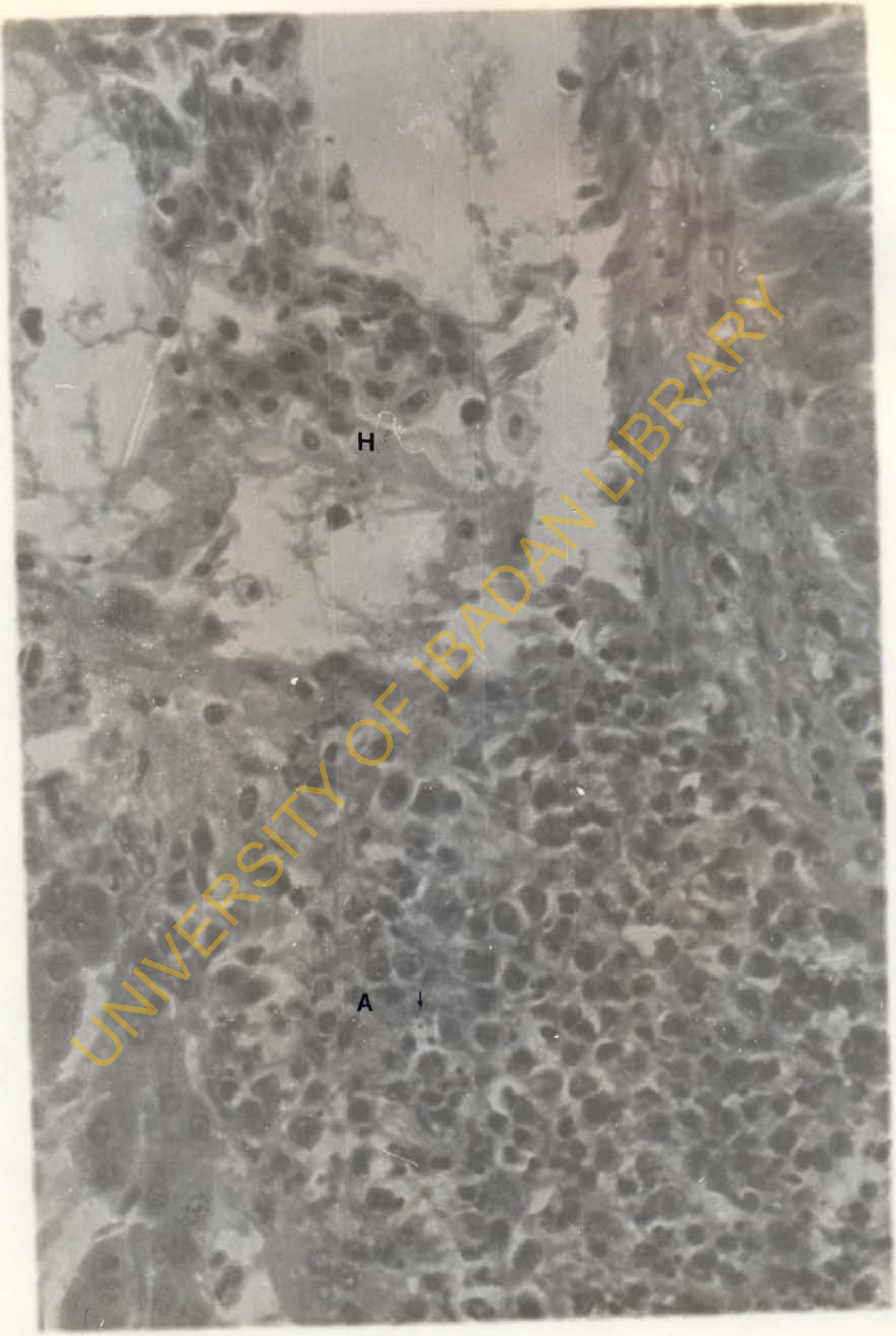

H
A

Plate 5.3

Photomicrograph of cockerel's kidney tissue at sixteen weeks.

A - Mild heterophilic cellular infilteration into the glomerulus.

G - Glomerulus degeneration.

H and E stain x 400.


A
G

uric acid level showed a decrease in the mean values as the level of PKC increased in the ration . The highest value of 6mg/100ml was obtained on Diet 4.

The results on creatinine, cholesterol and glucose levels were very significant $(P \angle 0.05)$. Highest mean value for either creatinine or cholesterol was obtained on the control diet while lowest value in both cases was obtained on the PKC diets. Glucose concentration decreased with increase in PKC levels in the ration. Highest value of 90.18 mg/100ml was obtained on Diet 2 while the lowest value of 54.29 mg/100ml was obtined on Diet 4.

5.3.5 <u>Economics of Production</u>

The GNC replacement with PKC had significant effects $(P \angle 0.05)$ on the economic performance of the cockerels. The results of the feed cost/kg in the starter phase as presented in Table 5.1 showed a consistent decrease in feed cost as the level of GNC decreased in the ration . A sum of ₦1.35/kg of feed was the highest amount recorded on the control diet with 100% GNC. The feed cost decreased progressively with increasing level of PKC to the extent that ₦.72/kg of feed was obtained as the smallest amount or Diet 4 where the whole of GNC in the ration was replaced with PKC. A similar situation occured in the finisher phase. The feed cost/kg decreased consistently with increase in the level of PKC in the diet as shown in Table 5.2. The sum of ₦0.78 was obtained on the control diet while ₦0.51 was recorded on Diet 4. Results of the feed cost (Table 5.2) were very significant (P ∠ 0.05). The cost decreased with increase in the level of PKC in the ration. The highest sum of ₦11.13 was obtained on the control diet as against the smallest sum of ₦3.95 recorded on Diet 4.

Experimental diets also had significiant effects (P ∠ 0.05) on the feed cost/kg liveweight. The highest sum of ₦10.17 was obtained on the control diet while the lowest sum of ₦3.41 was recorded on Diet 4 as the feed cost/kg liveweight. The most economical diet in this study therefore is Diet 4 where the whole of the GNC in the ration was replaced with PKC.

5,4 DISCUSSION

5.4.1 Performance Characteristics

The results of the performance of the cockerels in the starter phase in respect of body weight gain, efficiency of feed utilisation and mortality rate indicated that 33% of protein of GNC in the cocoa husk diets could be replaced with PKC without adverse effects on the performance of the birds. This represents about 21% of PKC in the starter ration. Nwokolo *et al.* (1977a) indicated that up to 30% of PKC could be incorporated in broiler starter ration without affecting the growth rate. The value of 9.96 g/bird recorded as the highest daily body weight gain on Diet 2 with the lowest value of 6.30 g/bird obtained on Diet 4 is indicative of the inverse relationship between the level of PKC in the diets and the body weight gain. As the level of the PKC in the diet increased, the fibre content of the diet increased resulting in the depression of growth.

This result of reduced body weight gain with increasing dietary fibre is in agreement with Savory and Gentle (1976 a,b) who reported that birds on high fibrous feeds weighed less than those on low fibre diets.

The depressed growth rate particularly on Diets 3 and 4 due to the high fibre content of these diets supports the findings of Fraps (1946) that increase in crude fibre content of diets will decrease amount of available energy resulting in lower growth rate. The implication of fibrous feed on the availability of nutrients has been emphasised in the previous study. The crude protein content, particularly of Diets 2 and 3 in the starter phase of the present study decreased with increasing the level of crude fibre in the diets (Table 5.1), suggesting a reduction in the amount of protein that could be available to the birds on PKC diets. This is probably why more protein was consumed on the control diet.

The result of the protein utilisation in the starter phase also showed the implication of high fibre diets. Best result of efficiency of protein utilisation was obtained on the control diet where no PKC was included while poor results were recorded on Diets 2, 3 and 4 containing PKC . This is in conformity with the report of Woodman and Evans (1984) who observed that fibrous feeds may decrease the digestibility of crude protein and ether extract. Fetuga et al. (1973) in a study with rats also indicated that the digestibility of nutrients in PKM was impaired by its high fibre content. Inspite of the poor reaults of protein utilisation obtained on the PKC diets (i.e. Diets 2, 3, and 4) owing to their fibrous nature, Diet 2 with the best result of body weight gain, feed conversion and lowest record of mortality could be considered as the ideal for the starter phase.

The result of the performance of the cockerels in the finisher phase in terms of feed intake shows the superiority of the control diet over the 3 other diets containing PKC. The lower values of daily feed intake recorded on diets 2, 3, and 4 could be attributed to the unpalatability of the 3 diets when compared with the control diets. This observation confirms with the report of Collingwood (1958) who attributed the limitation in the use of PKC in livestock feed to its grittiness and unpalatability. Although the results of the body weight gain in the finisher phase were not statistically significant ($P > 0.05$) the depression in growth rate observed on diets 3 and 4 could be attributed to the high fibre content of these diets as compared to that of Diet 2. A similar situation occured in the previous study on wheat offal replacement with cocoa husk. This observation is in agreement with Adeyanju et al. (1975) who attributed growth depression of cockerels fed cocoa husk diets to the increase in crude fibre content of the diets.

The best result of efficiency of feed utilisation recorded on Diet 4 containing the highest level of crude fibre is contrary to the report of Sosulk and Cadden (1982) who indicated that fibrous diet depresses nutrient utilisation. Mean values of protein intake and protein efficiency ratio were not statistically significant ($P > 0.05$) but best result in both cases were obtained on the control diet. The poor results of protein intake and protein efficiency ratio obtained generally on the diets containing PKC could be attributed to the high fibre content of the 3 diets. As the fibre content of the diets increased, the level of crude protein decreased (Table 5.2). Consequently, more protein was available to the birds on the control diet when compared to the amount available to the birds on the diets containing PKC.

This result must have caused the lower intake of protein on diets 2, 3 and 4, The fibrous nature of the three Diets must have affected the digestibility and utilisation of the protein in the diets. This observation is in conformity with the report of Glower and Duchie (1958) who observed a significant depressing effect of crude fibre on digestibility of protein in ruminants and non-ruminants. The poor result of protein utilisation reported on Diets 2, 3, and 4 was due to the high fibre content of the 3 diets. This is in support of the finding of Woodman and Evans (1947) who indicated that fibrous feeds may decrease the digestibility of crude protein and ether extract.

The mortality recorded in the finisher phase was mostly due to the aggressive behaviour of the cockerels when they were mixed up at the end of the starter phase for re-distribution. Aggressive behaviour involves some form of attack or threat which usually occurs when birds which are strangers to each other are placed together in an unfamiliar place causing one or more pairs to interact agonistically. Such strange birds usually attempt to establish their dominance relationships promptly. In this study, birds within the same replicate were observed to be pecking each other resulting in the death of some of the cokerels. This finding is in agreement with the report of Ratner (1965) when isolated male chicks were assembled at 10 weeks of age. The author observed that all the male chicks showed nearly immediate and intense agonistic behaviour with pecks being delivered to the backs, wings and heads of the others. It was estimated that 200 - 250 pecks were exchanged within two hours of assembling 14 isolated male chicks. Scott (1966 and 1971) indicated that in most of the laboratory studies on aggression, males (especially of mice, rats, cats, and Rhesus, Monkeys) are far more likely to behave aggressively towards each other than are the females probably because of the higher levels of androgen secreted in the males. Guhl (1958) also observed that from 6 - 10 weeks of age, peck orders form in small flocks of chicks. This observation conforms with the incidence of pecking which occured in this study between the 8th and 9th week. However, apart from the deaths which occured in the finisher phase as a result of pecking, some other birds died in the later part of the study due to coccidiosis (intestinal and caeca) infection, a disease condition in poultry mainly caused by the Eimeria species.

Compared with the control diet, Diet 4 can be considered as the best among the diets containing PKC for the finisher phase because of its best result of feed conversion and lower record of mortality.

Therefore, the conclusion from the results of this study is that in the starter phase, cockerels will tolerate a ration containing 20% PKC and 17% crude fibre while in the finisher phase, cockerels will perform creditably on a ration containing 37% PKC and 22% crude fibre. It is important to realise from the result of this study that the cockerels performed very well in the finisher phase on a lower crude protein content of 13% as against the 16% crude protein in the previous study.

5.4.2 Carcass Characteristics

The efficiency of animals in coverting feed to meat varies among species. Efficiencies range from that of the beef animal at 10 - 15%, to those of the pig 25 - 30%, chicken 40 - 45% and fish 65 - 70%. Forrest et al. (1975) observed that efficiency of meat animals in converting feed to meat is generally related to level of feed intake. But it appears, from the result of this study that it is the composition of the feed that determines the conversion of such feed into meat rather than the level of intake.

The results of the carcass analysis as presented in Table 5.5 showed the superiority of the control diet in terms of carcass yeild over the other 3 diets containing PKC. The best results in terms of weight of eviscerated carcass and flesh/bone ratio were recorded on the control diet with 100% GNC. The poor results obtained on the Diets 2, 3, and 4 could be attributed to the high fibre content of the 3 diets resulting in the decrease in the energy content of the rations. Birds on such high fibre diets usually spend more time feeding than those on low-fibre diet (Van Hemle and Myer, 1969). Consequently little energy is used for growth. Ready et al. (1962) has indicated that much energy may be expended on feeding activity. Adeyanju et al. (1975) observed that carcasses of birds on high-fibre diets dressed slightly lower than those fed low-fibre diets. But among the diets containing PKC, the best result of flesh/bone ratio was obtained on Diet 3 while the lowest result was obtained on Diet 2.

The % carcass fat was higher on the control diet where feed energy was used for growth than on diets 2, 3, and 4 containing PKC where much of the feed energy was used in the digestion of the fibre. Kiem and Kines (1979) feeding graded levels of cellulose, hemicellulose and lignin to mice found that as the level of fibre increased, feed consumption, weight gain, apparent digestibilities of protein and fat, percent of fat in faeces and carcass decreased.

Results of the gut morphology were similar to what was observed in the previous study in chapter 4. The length and weights of the gizzard, small intestine, caeca and large intestine increased with increasing fibre content of the diets. The fibre content of the diet however increased with increase in the level of the PKC in the ration. Generally, lower values in respect of length and weigth of the gut were recorded on the control diet while higher values were obtained in most cases on Diet 4 containing the highest amount of fibre. Moses (1974) indicated that amongst gallinaceous birds the digestive system is larger in relation to body weight in species which eat more fibrous diets. Lewin (1963) observed that the guts of California quail are longer in winter when the diet is more fibrous and less digestible than in summer. Some other researchers have reported similar results in agreement with the present study. Deaton et al. (1977) have observed the reduced weight of the gizzard of broilers reared in cages when compared with that of broilers reared on the deep litter despite the same feeding regime. This finding suggested that birds on the litter consumed some amount of the litter thus making the diet to be more fibrous. Deaton et al. (1979)

using a high - fibre sunflower meal product observed increases in gizzard weight and intestinal length of laying hens. However, Fenna and Boag (1974) did not observe any difference either in feed intake or gut size amongst the quail fed on a low-fibre diet and those fed on a high-fibre diet. This is contrary to the report of Savory and Gentle (1976) who indicated that Japanese quail fed on high-fibre diet weighed less, laid less eggs and had larger gut dimension when compared with those fed low-fibre diet.

While comparing the results of the carcass analysis of the control diet with those of Diets 2,3 and 4 containing PKC, it will be economical to recommend Diet 4 where 100% of the protein of GNC was replaced with PKC. It will be recalled that carcass on diet 4 recorded the highest dressing out percentage with moderate fat content when compared with Diets 2 and 3.

5.4.3 Histological and Pathological Studies

The results of the pathological lesions observed on the brain, liver and kidneys may suggest the cummulative effect of the alkaloid theobromine present in the cocoa husk. Some reseachers have reported mortalities in poultry following feeding meals containing cocoa products. Temperton and Dudley (1943) reported deaths in pullets fed a ration containing 10 - 30% of under conticated cocoa cake meal. Clough (1942) also reported deaths in dogs receiving meal which was later found to contain about 2 gram/kg theobromine. Black and Baron (1943) described nervous excitability as a feature of theobromine poisoning in poultry. Although the birds used in this study did not show any sign of nervous excitability in life, the summation of pathological lesions observed on brain tissue is indicative of nervous involvement. The reports of the histological changes of the kidneys of birds that had died of theobromine poisoning by some researchers are rather similar to the pathological lesions observed on the kidneys examined in this study. Although the post mortem examination of birds that died during the period of study did not reveal theobromine poisoning, the lesions of the organs examined will suggest that the cocoa husk incorporated in the experimental diets had some traces of theobromine sufficient enough to cause chronic theobromine poisoning.

5.4.4 Blood Metabolites

The laboratory analysis of the starter and finisher diets (Table 5.1 and 5.2) indicated a decrease in the dietary protein as the crude fibre content of the diets increased. However, there was no positive correlation between the dietary protein and serum protein. Rather, the serum protein values obtained on Diets 2, 3 and 4 increased with decrease in the dietary protein respectively. This is contrary to the report of Keyser et al. (1968) who observed a positive correlation between serum protein and dietary protein. Although the results of albumin and globulin levels were statistically significant ($P < 0.05$) there were inconsistencies in the mean values recorded on all the treatments. The highest value of 6.27 gm/100ml albumin concentration recorded on Diet 4 could be attributed to improper utilisation of protein by the cockerels on this diet. The protein which would have been utilised for growth was probably passed into the blood stream.

The uric acid levels decreased with increase in PKC in the diet. Highest value of 6.00 mg/100ml was obtained on Diet 2 while the lowest value of 4.09 mg/100ml was recorded on Diet 4.

Kunta and Harper (1961) attributed elevated blood urea to be due to an imbalance of amino acids. Wilson et al.(1972) also concluded that plasma urea values were inversely related to body weight gain. The finding of these authors is at variance wih the result of this study in that the best result of body weight gain (Table 5.7) and highest value of blood urea were both recorded on Diet 2. Doornenbal et al.(1983) indicated that age had pronounced effect on serum urea in a way that the level increases with increase in age. This fact will not be applicable to the results obtained in this study since the urea concentrations were not determined at different ages of the birds.

The value of 2.25 mg/100ml recorded as the highest concentration of creatinine on the control diet is indicative of protein catabolism. The best flesh/bon ratio observed on the control diet would suggest efficient utilisation of dietry protein. Doornenbal et al.(1986) confirmed that creatinine concentrations could serve as good predictor of lean tissue mass in the body. The lower levels of creatinine observed on PKC diets could be indicative of very little protein catabolism.

The result of the cholesteral levels showed a decrease in the values obtained as the dietary fat (Table 5.2) increased. This may suggest inefficient utilisation of dietary fat. Portman and Stare (1959) identified sex, age, and diet as factors influencing serum cholesterol levels.

Lombardi et al. (1962) however, indicated that diet is the most important factor regulating cholesterol level. The lower cholesterol levels especially on diets 2, 3 and 4 must have resulted from the high fibre content of the 3 diets. This will conform with the report of Woodman and Evans, (1984) that fibrous feeds may decrease digestibility of crude protein and ether extract. In the present study, the values of serum cholesterol obtained generally on all the treatments were lower than the normal value of 100 mg/100ml $\pm$ 23 for cockerel.

The GNC replacement with PKC did not appear to affect glucose levels. However, lower values were obtained on Diets 3 and 4 when compared with what was obtained on the control diet.

5.4.5 Economics of Production

In livestock production, feed alone can account for up to 80% of recurrent costs (Adeyanju et al, 1975b). In the present day Nigeria, some poultry farmers have resulted to using alternative energy and protein sources in poultry feeds in other to maximise profit. Cassava peels have been used to replace up to 20% of maize in poultry diets while cotton seed case has replaced GNC at different levels. In this study the GNC replacement with PKC has greatly reduced the cost/kg of feed in both the starter and finisher phases. The cost decreased with increase in PKC in the diet. The feed cost/kg liveweight also decreased with increase in levels of PKC in the diet. A sum of ₦10.17 was recorded on the control diet as feed cost/kg liveweight while the lowest sum of ₦3.41 was obtained on diet 4 where the whole of GNC in the diet was replaced with PKC. Presently, a ton of GNC sells for about ₦1,500 while that of PKC sells for ₦450.00. Apart from the lower cost of PKC when compared with GNC, PKC is high in calcium, phosphorus, magnesium, manganese and iron (Njike, 1979). From the report of this study the use of PKC as a complete replacement of GNC in cockerels fed cocoa husk based ration reduced the cost of production drastically. Consequently, the sum of ₦3.41 was the lowest feed cost/kg liveweight compared with the sum of ₦4.89 obtained in the previous study.

In conclusion diets 2 and 4 are the best for the starter and finisher phases respectively judging from the results obtained on performance of the cockerels, carcass characteristics and economic analysis.

CHAPTER SIX

EFFECTS OF ALKALINE TREATMENT OF COCOA HUSK ON THE PERFORMANCE OF COCKERELS

6.1 INTRODUCTION

It was established in the earlier studies that cockerels would tolerate 7% level of cocoa husk in the ration in the starter phase and 16% level at the finisher phase without adverse effects on performance. Replacement of the GNC of such diets with PKC at 33% and 100% levels (i.e. 20% and 37% of PKC in the ration) in the starter and finisher phases, respectively reduced the cost of production. The only limitation in the use of cocoa husk at higher levels in animal feeds is due to its high fibre content. Ogutuga (1975) reported that if cocoa pod husk could be processed to reduce its crude fibre content, it will be possible to feed it in the diet of both ruminants and non-ruminants with better results. Various researchers have treated fibrous materials chemically in order to improve the digestibility of such materials. Alkali treatment has been used extensively for increased digestible dry matter intake (Singh and Jackson, 1971; Klopfenstein et al 1972). Sodium hydroxide has been used successfully in Nigeria with improved growth rate (Omole and Onwudike, 1981).

Adebowale (1985) observed improved dry matter intake and daily weight gain in goats fed with maize straw treated with cocoa pod husk ash.

However, no literature is available on the chemical treatment of cocoa husk with a view of reducing its high fibre content. The purpose of this study, therefore, is to treat cocoa husk with the alkaline cocoa pod husk ash in order to include higher levels of cocoa husk in the cockerels ration. Cocoa pod ash, which is not as corrosive as Sodium hydroxide, can be obtained at no cost for the treatment of cocoa husk.

6.2. MATERIALS AND METHODS

6.2.1 Experimental Diets

Seven experimental diets were formulated separately for the starter and finisher phases. The cocoa pod ash was used to treat cocoa husk at 2% level. (Note: 25kg of cocoa husk produced 5kg cocoa pod husk ash). The procedure involved thorough mixing of 500g cocoa pod husk ash with 25kg of ground cocoa husk and soaking the mixture in 100 litres of water for 48 hours. The treated cocoa husk was sun dried and later incorporated at different levels in both the starter and finisher diets. The level of corn bran in the diets was gradually reduced with increase in the level of cocoa husk while all other ingredients remained fixed. The gross composition of the starter and finisher diets are shown respectively in Tables 6.1 and 6.2. All the experimental diets were made to be isonitrogenous and isocaloric.

6.2.2 Management of the birds

Two hundred and ten day-old cockerels obtained from Amo Farms, Awe, near Oyo were started on the starter diets containing 21% crude protein. There were 2 replicates per treatment with 15 birds in each replicate. All experimental birds were vaccinated on the third day with NDV (I/o) while Lasota was administered in water by the 4th week. Floxaid powder was administered as anti-stress for the first 7 days while Narcox powder (coccidiostat) was administered between the third and fourth week.

The starter phase lasted for 8 weeks at the end of which all the birds were mixed up and redistributed to prevent the carry over effect of the starter diets. There were also 2 replicates per treatment in the finisher phase which also lasted for another 8 weeks.

TABLE 6.1: GROSS COMPOSITION OF EXPERIMENTAL DIETS (STARTER)

INGREDIENTS (%)	EXPERIMENTAL DIETS						
	1	2	3	4	5	6	7
Maize	27.03	27.03	27.03	27.03	27.03	27.03	27.03
GNC	16.76	16.76	16.76	16.76	16.76	16.76	16.75
PKC	20.61	20.61	20.61	20.61	20.61	20.61	20.61
Corn Bran	17.55	17.55	14.05	10.55	7.05	3.55	-
Untreated Cocoa Husk	7.00	-	-	-	-	-	-
Treated Cocoa Husk	-	7.00	10.50	14.00	17.50	21.00	24.55
Fish Meal	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Blood Meal	1.80	1.80	1.80	1.80	1.80	1.80	1.80
Bone Meal	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Oyster Shell	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Minovit Super*	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Calculated Analysis							
CP (%)	21.31	21.31	21.17	21.03	20.89	20.75	20.60
ME (kcal/g)	2.49	2.49	2.50	2.50	2.50	2.50	2.51
CF (%)	9.47	9.47	10.52	11.56	12.59	13.63	14.69
Calorie/Protein Ratio	116.85	116.85	118.09	118.88	119.67	120.48	121.84
Cost/kg feed (₦)	1.49	1.49	1.46	1.43	1.40	1.37	1.35

*See Table 4.2 for Composition.

TABLE 6.2: GROSS COMPOSITION OF EXPERIMENTAL DIETS (FINISHER)

INGREDIENTS (%)	EXPERIMENTAL DIETS						
	1	2	3	4	5	6	7
Maize	10.39	10.39	10.39	10.39	10.39	10.39	10.39
GNC	-	-	-	-	-	-	-
PKC	37.00	37.00	37.00	37.00	37.00	37.00	37.00
Corn Bran	27.86	27.86	25.91	23.91	21.91	19.91	17.91
Untreated Cocoa Husk	16.00	-	-	-	-	-	-
Treated Cocoa Husk	-	16.00	18.00	20.00	22.00	24.00	26.00
Fish Meal	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Blood "	3.75	3.75	3.75	3.75	3.75	3.75	3.75
Bone "	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Oyster Shell	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Monovit Super*	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Salt	0.25	00.25	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Calculated Analysis							
CP (%)	16.30	16.30	16.23	16.14	16.07	15.99	15.91
ME (kcal/g)	2.20	2.20	2.20	2.20	2.20	2.20	2.21
CF (%)	15.61	15.61	16.28	16.87	17.46	18.06	18.65
Calorie/Protein ration	134.97	134.97	135.55	136.31	136.90	137.59	138.91
Cost/kg feed (₦)	0.82	0.82	0.80	0.79	0.77	0.76	0.74

*See Table 4.2 for Composition.

The 7 finisher diets were also made to be isonitrogenous and isocaloric. Feed and water were provided ad libitum. Weight gain, feed intake and mortality were recorded on weekly basis.

6.2.3 Balance Studies

At the end of each phase, 2 birds from each replicate were placed in the metabolic cages where feed and water were provided ad libitum. Daily feed intake and faecal output were recorded for the period of study. The total faecal collection lasted for 8 days with 3 days of preliminary adjustment. The faeces collected were dried in a forced drought oven at $70^{o}C$ and later bulked for chemical analysis.

Digestibility was evaluated as the efficiency at which the nutrient supplied is absorbed through the alimentary canal. Digestibility was determined according to Maynard and Loosli (1969) using the ratio of the indicator concentration in the diet and that of the faeces. Cr_2O_3 was used as the inert marker

Aparent Protein Digestibility (%)

$$= 100 - 100 \text{ X } \frac{(\text{indicator in feed (\%)}}{\text{indicator in faeces (\%)}} \times \frac{\text{crude protein in faeces)}}{\text{Crude protein in feed)}}.$$

Apparent dry matter digestibility was determined as the percentage of Cr_2O_3 in faeces compared to the percentage Cr_2O_3 in feed (Windell et al. 1978). Apparent Dry Matter Digestibility (%)

$$= 100 - 100\left(\frac{(\text{Indicator in feed \%)}}{\text{Indicator in faeces (\%)}}\right)$$

6.2.4. Chemical Analysis

The cocoa pod ash was analysed for mineral composition. The treated and untreated cocoa husk and the experimental diets were also analysed for their chemical composition according to the AOAC procedure (1975). Energy in the feed and faecal samples were determined with a ballistic bomb calorimeter.

6.2.5 Carcass Evaluation

At the end of the finisher phase, 2 birds per replicate were slaughetered for carcass analysis. Each bird was wet plucked, head and feet removed and the carcass was eviscerated. Eviscerated carcass was weighed for the calculation of dressing out percentage. The gizzard, small intestine, caeca, colon plus rectum were cleansed of internal contents and weighed respectively. Length of intestines and caeca was also recorded. Weight of total muscle and bones was also taken for the calculation of flesh/bone ratio.

6.2.6 Blood pH Determination

The blood used for pH determination in both the starter and finisher phases was drawn from the wing vein and stored in universal bottles containing heparin (anticoagulant). The blood samples were later centrifuged in an MSE microcentour centrifuge at 13,000 revolutions per minute for 10 minutes to separate the plasma from the formed elments. Blood pH was determined using pH meter No 7020.

6.2.7 Cost Analysis

The current prices of feed ingredients and the prevailing prices of fowls in the markets in Ibadan at the time of this study were used to estimate the feed cost and gross revenue.

6.2.8 Statistical Analysis

Complete Randomised design (CRD) was used in analysing parameters measured. The Duncan's multiple range test (Steel and Torrie, 1960) at 5 percent level of probability was used to access significant difference. A VAX 1 ØDRA - 1 programmable computer model BDP $\frac{11}{70}$ was used for the analysis.

6.3 RESULTS

6.3.1 Chemical Analysis

The mineral composition of the cocoa pod ash is presented in Table 6.3. The results of the mineral composition of the ash indicated that the ash of the cocoa pod contains more of potasium

TABLE 6.3: MINERAL COMPOSITION OF COCOA POD HUSK ASH .

Composition	Percentage
Calcium	5.29
Phosphorus	1.62
Magnesium	4.25
Potassium	15.15
Sodium	0.57
Manganese	0.13
Iron	0.74
Copper	0.03
Zinc	0.09

TABLE 6.4: CHEMICAL COMPOSITION OF UNTREATED COCOA HUSK COMPARED WITH COCOA HUSK TREATED WITH COCOA POD HUSK ASH.

Composition	Untreated Cocoa Husk (U C H)	Treated Cocoa Husk (T C H)
Moisture (%)	8.83	21.47
Crude Protein (%)	10.15	11.55
Crude Fibre (%)	33.42	22.00
Ether Extract (%)	1.70	2.20
Nitrogen free extract (%)	45.90	42.78
GE (kcal/g)	5.02	4.37
Ash (%)	15.25	15.80
Ca (%)	1.72	1.45
p. (%)	0.15	0.33
Mg. (%)	0.80	0.83
K (%)	2.56	2.02
Na. (%)	0.28	0.08

TABLE 6.5: CHEMICAL COMPOSITION OF EXPERIMENTAL DIETS (STARTER)

Composition	EXPERIMENTAL DIETS						
	1	2	3	4	5	6	7
Moisture (%)	9.11	11.30	11.66	10.05	11.17	11.55	12.21
Crude Protein(%)	16.60	19.80	19.80	18.75	18.32	21.52	21.13
Crude Fibre(%)	13.20	14.60	13.40	14.80	11.40	16.20	16.40
Ether Extract "	7.00	5.10	4.40	6.50	7.90	6.50	5.20
N.F.E "	54.09	49.20	50.74	49.90	51.21	44.23	45.06
GE (kcal/g)	4.43	3.95	4.16	4.43	3.47	2.65	3.40
Ash (%)	8.40	8.50	10.00	9.75	9.60	12.75	11.75
Ca (%)	0.72	1.23	1.10	1.30	1.42	1.13	1.59
P (%)	0.36	0.48	0.44	0.37	0.47	0.38	0.48
Mg "	0.29	0.30	0.30	0.30	0.33	0.33	0.37
K "	0.86	0.81	0.80	0.78	0.79	0.85	0.97
Na "	0.18	0.19	0.20	0.13	0.02	0.02	0.02

TABLE 6.6: CHEMICAL COMPOSITION OF EXPERIMENTAL DIETS (FINISHER)

Composition	EXPERIMENTAL DIETS						
	1	2	3	4	5	6	7
Moisture (%)	12.57	13.56	13.14	12.80	12.69	11.36	12.03
Crude Protein(%)	15.90	17.35	16.34	14.65	15.51	16.51	16.30
Crude Fibre "	19.60	13.60	17.40	12.40	17.40	17.40	15.00
Ether Extract"	6.50	3.70	4.90	3.20	5.80	4.10	2.80
N.F.E (%)	45.43	51.79	48.22	56.95	48.60	50.63	53.87
GE (Kcal/g)	4.57	4.16	3.75	4.28	4.23	3.95	4.09
Ash (%)	10.25	11.55	11.10	12.45	13.70	12.90	13.10
Ca "	2.17	2.05	1.47	1.47	2.16	3.95	2.20
P "	0.82	1.16	0.74	0.73	0.94	1.10	1.03
Mg "	0.34	0.37	0.37	0.37	0.39	0.38	0.42
K "	0.81	0.84	0.84	0.85	0.89	0.84	0.96
Na "	0.24	0.27	0.25	0.26	0.29	0.33	0.32

with low level of sodium. The value of 15.15% was recorded for potasium while 0.57% was obtained for sodium. The values obtained for calcium, phosphorus and magnesium are 5.29%, 1.62% and 4.25% respectively, while the values obtained for the micro nutrients were 0.13% for manganese, 0.74% for iron, 0.03% for copper and 0.09% for zinc.

The results of the proximate analysis of untreated cocoa husk (UCH) and those of the treated cocoa husk (TCH) are presented in Table 6.4. The UCH has a moisture contnet of 8.83% while the TCH has a higher value of 21.47%. There were slight variations in the results of the protein content. The UCH has crude protein content of 10.15% as against the value of 11.55% recorded for T.C.H. The fibre content of 33.42% obtained on UCH was higher than the value of 22.00% recorded for the TCH. The UCH has a lower content of ether extract (1.70%)while the TCH has a higher value of 2.20%. However, the UCH has higher gross energy value of 5.02 kcal/g as against the lower value of 4.37 kcal/g recorded for the TCH. The Ash content of the UCH (15.25%) is comparable with that of the TCH which is 15.80%

The results of the chemical composition of the starter and finisher diets are also presented in Tables 6.5 and 6.6 respectively.

The crude protein content of diets (starter) 2 - 7 containing TCH were generally higher than that of diet 1 containing UCH. There were variations in the results of the crude fibre content of the diets. The highest crude fibre content of 16.40% was recorded on Diet 7 while the lowest value of 11.40% was obtained on Diet 5. There was no correlation between the results of the gross energy level of the diets and the level of TCH in the ration. The highest gross energy value of 4.43 kcal/g was obtained on Diets 1 and 4 while the lowest value of 2.65 kcal/g was recorded on Diet 6.

Generally, the ash content of diets 2 - 7 containing TCH were higher than that of Diet 1 containing UCH.

T he results of the crude protein content of the finisher diets were very inconsistent. The highest value of 17.35% crude protein was obtained on Diet 2 while the lowest value of 14.65% was recorded on Diet 4. The crude fibre content of Diets 2 to 7 containing TCH were generally lower than that of Diet 1 containing UCH. The highest value of 19.60% crude fibre was obtained on Diet 1 as against the lowest value of 12.40% recorded on Diet 4. There was no correlation between the results of the gross energy values and the level of TCH in the diets. However, the ash contents of diets 2 - 7 containing TCH were higher than the value obtained on Diet 1 containing UCH.

6.3.2 Performance Characteristics

The results of the effects of alkaline treatment of cocoa husk on the performance of cockerels in the starter and finisher phases are shown in Tables 6.7 and 6.8 respectively.

In the starter phase, the mean values obtained on body weight gain and daily feed intake were not statistically significant ($P > 0.05$). However, the highest value of 8.79 g/bird daily body weight gain was obtained on Diet 4 while the lowest value of 7.41 g/bird was recorded on Diet 6. The best result of 42.83 g/bird daily feed intake was obtained on Diet 5 while the lowest value of 36.39 g/bird was recorded on Diet 6. The results of the efficiency of feed utilisation were very significant ($P < 0.05$). The best ratio of 4.45 was recorded on Diet 4. The highest value of 8.17 g/bird daily protein intake was recorded on Diet 7 containing TCH while the lowest value of 6.72 g/bird was obtained on Diet containing UCH. The mean values of protein efficiency ratio were statistically significant ($P < 0.05$). The best ratio of 0.95 was obtained on Diet 6 while the poorest ratio of 1.28 was recorded on Diet 1. Results of digestibility studies indicated

TABLE 6.7: EFFECTS OF ALKALINE TREATMENT OF COCOA HUSK ON THE PERFORMANCE OF COCKERELS (STARTER PHASE)

Parameters	1	2	3	4	5	6	7	Mean	±SE
Initial body weight (G/bird)	23.33	26.00	26.00	26.67	27.00	24.33	24.34	25.38	0.86
Final body weight (g/bird)	501.21	507.98	479.29	518.58	470.72	439.33	486.91	486.29	26.06
Body weight gain "	477.88	481.98	452.62	491.91	443.72	415.00	462.57	460.81	25.82
Daily Body weight gain "	8.54	8.61	8.08	8.79	7.93	7.41	8.26	8.23	0.46
Daily feed intake "	40.48	39.56	40.46	39.13	42.83	36.39	38.65	39.64	2.47
Feed conversion	4.74^{ab}	4.61^{b}	5.04^{ab}	4.45^{b}	5.39^{b}	4.91^{ab}	4.69^{ab}	4.83	0.20
Daily Protein intake (g/bird)	6.72	7.83	8.01	7.34	7.85	7.83	8.17	7.68	0.45
Protein Efficiency Ratio	1.28^{a}	1.10^{bc}	1.01^{c}	1.20^{ab}	1.01^{c}	0.95^{c}	1.01^{c}	1.08	0.04
Apparent Protein Digestibility (%)	63.78	62.96	64.75	69.14	61.92	62.10	64.14	64.11	3.75
Apparent dry matter digestibility (%)	43.61	48.24	52.65	56.34	51.41	51.35	47.08	50.10	2.85
Mortality (%)	0.72	0.96	0.48	0.48	1.19	-	0.24	0.58	0.37

a, b, c - superscripts with different letters in horizontal rows are significantly different ($P < 0.05$).

TABLE 6.8: EFFECTS OF ALKALINE TREATMENT OF COCOA HUSK ON THE PERFORMANCE OF COCKERELS (FINISHER PHASE)

Parameters	1	2	3	4	5	6	7	Mean	±SE
Initial body weight (g/bird)	471.43	514.29	492.86	477.14	478.57	562.86	502.86	499.99	30.67
Final body weight (g/bird)	950.00	1007.14	943.33	1023.57	887.15	970.00	972.86	964.86	51.34
Body weight gain (g/bird)	478.58	492.86	450.48	501.43	408.58	407.15	469.99	458.44	42.92
Daily Body weight gain (g/bird)	11.68	12.02	10.99	12.23	9.97	9.93	11.47	11.18	1.05
Daily feed intake (g/bird)	95.43	90.10	93.01	84.49	112.27	86.24	116.04	96.80	14.88
Feed Conversion	8.22	7.63	8.61	6.95	11.56	8.69	10.03	8.81	1.70
Daily Protein intake (g/bird)	15.19	15.63	15.20	12.38	17.41	15.24	18.92	15.57	2.39
Protein Efficiency Ratio	0.77	0.77	0.72	0.99	0.60	0.70	0.65	0.74	0.11
Apparent Protein digestibility (%)	58.72	60.00	65.21	67.00	62.12	66.14	61.53	62.96	3.45
Apparent dry matter digestibility (%)	46.13	50.15	49.35	51.64	47.49	50.46	48.72	49.13	2.64
Mortality (%)	1.02	-	1.02	-	1.02	-	1.53	0.66	0.75

Mean values not followed by superscripts in horizontal rows are not significantly different ($P > 0.05$) from each other.

better protein digestibility by birds on Diet 4 where the highest value of 69.14% was recorded as against the lowest value of 61.92% obtained on Diet 5. The best result of dry matter digestibility of 56.34% was also observed on Diet 4 while the lowest value of 43.61% was recorded on Diet 1. Mortality was not recorded at all on birds fed diet 6 while the highest mortality record of 1.19% was obtained on the birds fed diet 5. The results of the performance of the birds in the finisher phase were generally not statistically significant ($P > 0.05$) However, the best result of 12.23 g/bird daily body weight gain was obtained on Diet 4 while the lowest value of 9.93 g/bird was recorded on Diet 6. The highest value of 116.04 g/bird daily feed intake was observed on Diet 7 while the lowest mean value of 84.49 g/bird was recorded on Diet 4. The best result of efficiency of feed utilisation was recorded on Diet 4 where a ratio of 6.95 was obtained. The poorest ratio of 11.56 was obtained on Diet 5.

The mean value of 18.92 g/bird was the highest daily protein intake recorded on Diet 7 while the lowest value of 12.38 g/bird was obtained on Diet 4. The best result of efficiency of protein utilisation was recorded on Diet 5 where a value of 0.60 was obtained. The mean values of 67% and 51.64% were the best results of protein and dry matter digestibilities respectively obtained on Diet 4 while the lowest value of 58.72% and 46.13% in both cases were obtained on Diet 1. The highest mortality record of 1.53% was recorded on Diet 7 while mortalities were not recorded on Diets 2, 4 and 6.

6,3.3 Carcass Characteristics and Gut Morphology

Table 6.9 shows the results of the alkaline treatment of cocoa husk on the carcass and gut morphology of cockerels. Generally, the results obtained on all parameters measured were not statistically significant ($P > 0.05$) except on the percent dressed carcass where the highest value of 95.90% was recorded on Diet 2. The highest value of 67.32% eviscerated carcass was obtained on Diet 4 while the lowest value of 58.60% was obtained on Diet 3. The best result of flesh/bone ratio of 2.80 was observed on Diet 6 as against the poorest ratio of 1.95 recorded on Diet 3. Traces of fat noticed on the carcasses were very negligible. The highest value of 2.46% liver was recorded on Diet 4.

There were some inconsistencies in the results of the gut morphology. However, highest values in most cases were obtained on diets containing TCH. The highest value of 4.39% gizzard was

TABLE 6.9: EFFECTS OF ALKALINE TREATMENT OF COCOA HUSK ON CARCASS CHARACTERISTICS OF COCKERELS AT 16 WEEKS

Parameters	1	2	3	4	5	6	7	Mean	±SE
Liveweight (kg)	1.42	1.30	1.12	1.14	1.24	1.15	1.26	1.23	0.08
Dressed carcass (%)	84.51	95.90	92.96	94.71	89.08	93.45	89.78	91.48	1.11
Eviscerated carcass (%)	61.27	66.07	58.60	67.32	61.30	67.24	61.21	63.29	2.56
Flesh/Bone ratio	2.74	2.43	1.95	1.96	2.41	2.80	2.15	2.35	0.35
Liver (%)	1.73	2.13	2.03	2.46	1.85	2.23	1.96	2.05	
Gizzard (%)	3.38	3.60	3.46	3.53	3.68	3.56	4.39	3.66	
Length small int. "	9.30	10.62	11.81	10.33	10.48	10.70	9.16	10.34	1.51
Weight " " "	2.86	3.28	3.07	2.83	3.31	3.54	3.30	3.17	0.33
Length caeca "	1.22	1.13	1.16	1.16	1.12	1.20	1.10	1.15	0.09
Weight caeca "	0.43	0.35	0.52	0.39	0.38	0.53	0.48	0.44	0.06
Length large intestine "	0.65	0.60	0.64	0.57	0.62	0.48	0.48	0.58	0.07
Weight large instestine "	0.30	0.24	0.30	0.26	0.25	0.32	0.29	0.28	0.03

Mean values not followed by superscripts in horizontal rows are not significantly different ($P > 0.05$) from each other.

TABLE 6.10: EFFECTS OF ALKALINE TREATMENT OF COCOA HUSK ON BLOOD pH OF COCKERELS

Experimental Diets	Mean Values of Blood pH	
	Starter Phase	Finisher phase
1	7.38	7.88
±SE	0.08	0.08
2	7.75	7.80
±SE	0.45	0.20
3	7.53	8.00
±SE	0.08	0.20
4	7.50	7.60
±SE	0.15	0.10
5	7.60	7.78
±SE	0.05	0.13
6	7.65	7.83
±SE	0.05	0.08
7	7.63	7.73
±SE	0.08	0.13

TABLE 6.11: EFFECTS OF ALKALINE TREATMENT OF COCOA HUSK ON ECONOMIC ANALYSIS OF COCKERELS.

Parameters	EXPERIMENTAL DIETS								
	1	2	3	4	5	6	7	Mean	±SE
Liveweight (kg)	0.95	1.01	0.94	0.98	0.89	0.97	0.98	0.96	0.06
Total feed intake (kg)	6.19	5.91	6.08	5.65	7.18	5.54	6.92	6.21	0.53
Feed cost (₦)	6.59	6.33	6.36	5.86	6.90	5.49	6.45	6.28	0.41
Feed cost/kg live-weight (₦)	6.93	6.30	6.78	6.04	7.81	5.67	6.63	6.59	0.58
Estimated Gross Revenue (₦)	48.45	59.93	48.11	58.23	45.48	57.72	45.65	51.94	7.30
Gross Revenue less feed cost (₦)	41.87	53.60	41.75	52.37	43.58	52.23	39.20	46.37	6.82
Revenue/feed cost (₦)	6.37	8.46	6.56	8.95	5.65	9.52	6.53	7.43	1.50

Mean values not follwed by superscripts in horizontal rows are not significantly different $(P>0.05)$ from each other.

recorded on Diet 7 containing highest amount of TCH while the lowest value of 3.38% was obtained on the control diet (Diet 1) containing UCH.

The longest small intestine with a value of 11.81% was observed on Diet 3 containing TCH. The highest value in respect of weight of small intestine, caeca and large intestine was obtained in all cases on Diet 6 containing TCH. However, highest value for length of caeca and length of large intestine was recorded in both cases on Diet 1 containing UCH.

6.3.4 Blood pH Measurement

The results of the Blood pH of the birds in both the starter and finisher phases are presented in Table 6.10. In the starter phase, the highest mean value of 7.75 was recorded on the birds fed Diet 2 containing TCH while the lowest value of 7.38 was obtained on Diet 1 containing UCH. In the finisher phase, the highest mean value of 8.00 recorded on Diet 3 and the lowest value of 7.60 obtained on Diet 4 were both observed on diets containing TCH. In the starter phase, there was no correlation between the results of the blood pH and the levels of TCH in the diets.

6.3.5 Economic Analysis

Results of the economy of feed conversion are presented in table 6.11. Generally the results were not statistically different (P>0.05) from each other. However, the cost/kg of feed decreased with increasing levels of TCH in the diets (Tables 6.1 and 6.2). The results of the feed cost/kg liveweight were inconsistent. The highest value of ₦7.81 was obtained on Diet 5 while the lowest value of ₦5.67 was recorded on Diet 6. The opposite was the case in the result of Revenue/Feed Cost when the highest value of ₦9.52 was obtained on Diet 6 while the lowest value of ₦5.65 was recorded on Diet 5.

6.4 DISCUSSION

6.4.1 Chemical Analysis

The result of the mineral composition of the cocoa pod ash used in this study showed the high content of potassium in the ash. The 15.15% potassium recorded is comparable with the value of 11.23% obtained by Oladokun (1986). Other workers have reported the richness of cocoa pod ash in potassium. Dittmar (1958) and Ankrah (1974) indicated that the ashes of cocoa pod husk, plantains and banana peels possess strong caustic properties, potash being the largest component forming about 30 - 40% of the ash. The 5.29% calcium content is lower than the value of 1.79% recorded by Adedokun (1986). The author also obtained the values of 0.16% and 3.50% respectively for phosphorus and Magnesium while the values of 1.62% and 4.25% were recorded in both cases in this study. Of all the macro elements determined in the cocoa pod ash, sodium has the lowest level of 0.57%. However, Adebowale (1985) analysed cocoa pod ash from rain forest zones and reported that the alkali concentrations of the ash were close to that of caustic soda. The author indicated that 1kg sodium hydroxide was equivalent to 4.4kg of cocoa pod husk ash.

The result of the chemical composition of the UCH and TCH showed the increase in the crude protein content of the latter when compared with that of the former. This is contrary to the report of Adegbola and Omole (1973) when cocoa beans were treated with sodium hydroxide. The authors observed decrease in protein content of cocoa beans with increase in concentration of the alkali. The decrease in protein content was attributed to the hydrolysis and general oxidative decomposition of protein in cocoa beans. Adebowale (1985) also observed decrease in crude protein content of maize straw treated with cocoa pod ash.

The alkaline treatment of cocoa husk with the ash reduced the crude fibre content of UCH from 33.42% to 22%. This is in agreement with Adegbola and Omole (1973) who observed reduction in crude fibre content of cocoa beans treated with sodium hydroxide. The authors also observed reduction in the ether extract content of the treated sample contrary to increase in ether extract of TCH observed in this study. However, the Gross Energy of UCH was higher than that of the TCH. The ash content of UCH was slightly lower than that of TCH. The phosphorus and Magnessium levels increased while the levels of calcium, potassium and sodium declined in the treated sample. The increase in Ash content of TCH is in agreement with Adebowale (1985) who also reported increase in ash content of maize straw treated with cocoa pod husk ash.

6.4.2 Performance Characteristics

The best results of daily body weight gain and efficiency of feed utilisation obtained in the starter phase on birds fed diet 4 containing TCH showed the significant effects of alkaline treatment of cocoa husk on the performance of the cockerels. The best result of daily feed intake was obtained on Diet 5 which also contained TCH. This observation is in agreement with

Adebowale (1985) who also reported increased daily body weight gain by the goats fed maize straw treated with cocoa pod husk ash. The treatment of cocoa husk with cocoa pod ash also had significant effects on protein intake and protein digestibility in the starter phase. In both cases, best results were obtained on birds fed diets containing TCH. The highest value of 56.34% dry matter digestibility was recorded on Diet 4 which also contained TCH. Compared with the control diet which contained UCH, all the best results obtained on diets containing TCH in the starter phase could be attributed to better utilisation of the nutrients of TCH. The treatment of the cocoa husk with cocoa pod husk ash has reduced the fibre content of the husk (Table 7.4). This is probably why the birds fed diets containing TCH were able to digest more nutrients in the TCH. The implications of high fibre diets have been reported in the previous studies. Woodman and Evans (1984) indicated that fibrous feeds may decrease the digestibility of crude protein and ether extract. Spencer and Akin (1980) treated coastal Bermidagrass with potasium hydroxide and found out that the treatment disrupted the tissues and separated lignified thick-walled cells (bundle sheath and sclerenchyma) which resulted in their being digested faster than their untreated counterpart. Jackson (1977) also indicated that sodium hydroxide teatment improved digestibility through the reduction in the strength of inter-molecular hydrogen bonds which bind cellulose molecules together.

Compared with the control diet, the best result of feed intake recorded on bird fed diet 5 could be attributed to the higher mineral content (particularly calcium and phosporus) of this diet (Table 6.5). The effects of mineral content of the diet on feed intake and digestibility have been reported by various authors. Byers (1950) determined the influence of calcium and phosphorus on the digestibility of alfalfa hay by dairy steers. The author found that 1 Ib. of $CaCO_3$ per day increased the digestibility of energy, crude protein and crude fibre of alfalfa hay.

The results of the performance of the cockerels in the finisher phase are comparable with the results obtained in the starter phase. The best results of daily body weight gain and feed efficiency were also obtained on Diet 4 containing TCH. The highest values of daily feed intake and daily protein intake were recorded on Diet 7 which also contained TCH. The high level of calcium and phosphorus in Diet 5 must have been responsible for the highest value of feed intake recorded on the birds fed this particular diet.

As observed in the starter phase, best result of protein and dry matter digestibility recorded on diet 4 in the finisher phase could be due to the low fibre content of this diet resulting in the availability of more nutrients to the birds. Acton et al. (1982) observed decrease in apparent protein digestibility in high fibre diets in the study on the effects of dietary fibre constituents on the in vitro digestibility of casein. Judging from the results of the performance of the cockerels in the present study, 14% and 20% TCH in the ration can be recommended for the starter and finisher phases respectively.

6.4.3 Carcass Characteristics

The best result of dressing percentage obtained on Diet 4 can be attributed to the best result of efficiency of feed utilisation of the birds fed this diet. The lowest crude fibre content of diet4 (Table 6.6) is probably the factor which has caused more nutrients to be available and digestible by the birds fed this diet thereby resulting in better dressing percentage when compared with others. The implication of fibrous feeds on the availability and digestibility of nutrients has been reported by various authors. Nwokolo et al. (1984) indicat that fibrous feeds may impede mineral absorption. Adeyanju et al. (1975) in a study on cocoa husk in poultry diets observed that chickens fed high fibre cocoa husk diets dressed slightly lower that those fed on low fibre cocoa husk diets.

Most of the results of gut morphology were comparable with one another. There was no particualr relationship between the level of TCH in the diet and the length and weights of intestines and caeca. However, the highest mean values for length of caeca and that of large intestine was recorded on Deit 1 which contained the highest amount of fibre (19.60%). This observation is in conformity with the report of Savory and Gentle (1976) who observed increased intestinal length with increasing dietary fibre.

6.4.4 Blood pH Measurement

The pH of a solution is the measurement of the acidity or alkalinity and it is of great importance both in chemical and biological processes. The hydrogen ion exponent pH was introduced by a Norwegian biochemist Sorensen (1909). The values can be expressed by series of positive numbers between 0 and 14. In the present study, the range of the blood pH mean values in the starter phase is 7.38 - 7.75 while that of the finisher phase is 7.60 - 8.00. The higher values obtained in the finisher phase could be due to the higher levels of TCH in the finisher diets.

Wilcox (1959) obtained blood pH value of 7.47 for a normal chicken at 7 weeks of age. In a study on the performance of White Leghorns fed acid and alkaline diets, the author reported a lower blood pH value of 7.48 on diet containing 2% Ammonium Sulphate and a higher blood pH value of 7.61 on diet containing 3.8% sodium hydroxide while the blood pH of the control diet was 7.51. McWhirter (1956) had earlier indicated that changes in dietary regime could alter blood pH in mammals.
Forrest et al.(1975) also reported that growth of molds is generally more favoured by an acid pH. The authors further indicated that yeasts would grow best in an intermediate acid (pH 4.0 - 4.5) range while bacterial growth is generally favoured by near neutral pH values. All the blood pH mean values obtained in this study were generally in the alkaline region where microbial growth has been reported to be markedly reduced.

6.4.5 Economic Analysis

The cost/kg feed in both the starter and finisher diets (Tables 6.1 and 6.2) decreased with increasing level of TCH in the diets. Similar result was observed in the previous study when wheat offal was replaced with different levels of cocoa husk (untreated) in cockerel rations. Adeyanju et al. (1975) reported 3.2, 6.3 and 11.1% savings in the cost/1,000kg feed in diets containing 10, 15 and 20% cocoa husk, respectively. There was no correlation between the results of the feed cost/kg liveweight and the level of TCH in the diets. The sum of ₦7.81 obtained as the highest feed cost/kg liveweight on birds fed Diet 5 could be attributed to the highest feed intake value of 7.18kg recorded on this diet. However, the lowest feed cost/kg liveweight obtained on Diet 6 may suggest that this particular diet was the most economical in this study.

The overall results of the performance of the cockerels, carcass evaluation and economic appraisal have indicated the superiority of TCH over the UCH. It can now be concluded that the recommended levels of 14% and 20% TCH in the starter and finisher diets respectively will give satisfactory results. However, if economy of feed conversion is to be given the highest priority, 24% of TCH can be incorporated in cockerels rations in the finisher phase.

CHAPTER SEVEN

7.1 GENERAL SUMMARY AND CONCLUSION

A total of four studies were carried out aimed at:

1) Evaluating the chemical composition and metabolisable energy values of cocoa by-products.
2) Determining the effects of replacing wheat offal with cocoa husk in cockerel rations.
3) Investigating the effects of replacing groundnut cake with palm kernel cake in cocoa husk based rations.
4) Assessing the effects of alkaline treatment of cocoa husk on the performance of cockerels.

In the first study, investigations were conducted on the chemical composition of four cocoa by-products (cocoa shell, cake, dust, and husk) with a view to determining their usefulness as feed ingredients in poultry ration. Results of their chemical compositions revealed that cocoa cake used in the study had the highest crude protein content of 24.51% while cocoa husk had the highest crude fibre content of 43.92%. The highest values for ether extract and gross energy were obtained on cocoa cake while the cocoa husk was observed to contain the highest amount of minerals. The results of the theobromine determination of the four by-products indicated that cocoa cake had the highest content of the alkaloid with a value of 2.16%. The theobromine content of cocoa shell, dust and husk were 1.84%, 1.74% and 0.42% respectively. The results of the metabolisable energy determinations using the formula of Ham et al (1976) showed the superiority of cocoa shell over cocoa husk. The ME value of 2.51 kcal/g was obtained for cocoa shell while a value of 2.06 kcal/g was recorded on cocoa husk. At the end of the study, cocoa husk was considered to be more superior to the other by-products judging from its high content of minerals, low theobromine content and availability in abundance in cocoa plantations.

The second study covered a period of 20 weeks during which one hundred and thirty day old cockerels were raised on five experimental diets in which the wheat offal was replaced with cocoa husk at 0, 25, 50, 75 and 100% levels. The diets were made to be isocaloric and isonitrogenous. The starter phase lasted for 8 weeks while the finisher phase lasted for 12 weeks. Results of the performance of the cokerels at the end of both phases indicated a continuous depression in growth rate with increase in level of cocoa husk in the diets. The depressed growth rate was attributed to the high fibre content of cocoa husk. The highest daily body weight gain of 10.08 g/bird and the best result of efficiency of feed utilisation in the starter phase were obtained on Diet 2 in which 25% of the wheat offal was replaced with cocoa husk. Compared with the control diet, the highest daily body weight gain of 12.33 g/bird recorded in the finisher phase and the best result of efficiency of feed utilisation were both obtained on Diet 2. The highest dressing percentage and best result of flesh/bone ratio were also obtained on birds fed Diet 2. Although most of the results of the blood metabolites were statistically difference from each other, the creatinine levels appeared to decrease with increase in level of cocoa husk in the ration indicating the gradual protein catabolism. The lowest feed cost/kg live-weight of ₦4.89 was obtained on birds fed Diet 2. Judging from the results obtained in this study it was established that 25% of wheat offal could be replaced with cocoa husk satisfactorily in cockerel rations in both the starter and finisher phases. This represents about 7% and 16% of cocoa husk in the starter and finisher diets respectively.

The third study focussed on the effects of replacing groundnut cake (GNC) with palm kernel cake (PKC) at 0, 33, 66 and 100% levels in cocoa husk based rations on the performance of cockerels. A total of one hundred and sixty day old cockerels were initially raised on the starter diets containing 7% cocoa husk while 16% cocoa husk was incorporated in the finisher diets. The starter phase lasted for 8 weeks at the end of which all cockerels were mixed together and redistributed for the finisher phase which also lasted for another 8 weeks. At the end of the starter phase, best results of daily body weight gain and efficiency of feed utilisation were obtained on Diet 2 in which 33% of the protein of GNC was replaced with that of PKC. Body weight gain decreased with increase in level of PKC in the ration. At the end of the finisher phase, best result of feed efficiency was obtained on Diet 4 in which the whole of GNC in the ration was replaced with PKC. This suggests that cockerels could tolerate high fibre diets at the finisher phase. Compared with the result obtained on the control diet. The highest dressing percentage of 58.16% was obtained on Diet 4. The microscopic examination of the brain, liver and kidney tissues from all the treatments showed some pathological lesions which resembled those reported in theobromine poisoning in poultry. However mortalities recorded in this study were only attributed to other disease conditions. These was increase in the level of total protein with increase in PKC in the diet. This suggests incomplete protein catabolism. The most economical diet in this study was Diet 4 where the least sum of ₦3.41 was obtained as the feed cost/kg liveweight. The overall performance data indicated that Diets 2 and 4 in the starter and finisher phases respectively were the best. This suggests that 20% and 37% of PKC can be used in the starter and finisher diets respectively for cockerels without adverse effects on performance.

In the last study, the effects of alkaline treatment of cocoa husk on the performance of cockerels were determined. Cocoa husk was treated with 2% cocoa pod husk ash and later incorporated in the cockerel rations at different levels. Two hundred and ten day old cockerels were used in the study which lasted for 16 weeks. The chemical analysis of both the untreated and the treated cocoa husk samples showed the reduction in the crude fibre content of the latter. At the end of the starter and finisher phases, best results of body weight gain, feed efficiency, protein and dry matter digestibilities were obtained on birds fed Diet 4 containing treated cocoa husk. The highest dressing percentage of 67.32% was also obtained on Diet 4. The blood pH of the cockerels in the starter phase ranged between 7.38 - 7.75 while the range in the finisher phase was 7.60 – 8.00. The result of the economic analysis indicated that Diet 6 was the most economical because birds fed on this diet had the lowest feed cost/kg liveweight of ₦5.65. However, the general performance of the cockerels in this study suggests that 14% and 20% of treated cocoa husk can be incorporated satisfactorily in the starter and finisher diets respectively.

The series of studies detailed above revealed that:

- Cocoa husk is richer in minerals, contains very little theobromine and is more readily available when compared with the other cocoa by-products.
- 25% of wheat offal in cockerel rations can be replaced satisfactorily with cocoa husk, representing about 7% and 16% cocoa husk in the starter and finisher diets respectively.
- Cocoa husk in cockerel rations above the recommended levels will depress body weight gain due to the high fibre content of cocoa husk.
- 33% of the protein of GNC in cocoa husk based rations can be replaced with PKC in the starter phase, representing 20% PKC in the ration.

- high level of PKC beyond the recommended level will depress body weight gain.
- the whole of GNC in cocoa husk based rations can be replaced completely with PKC in the finisher phase, representing 37% PKC in the ration.
- cocoa husk can be treated with the alkaline cocoa pod husk ash in order to improve it's digestibility.
- cockerels will tolerate 14% of treated cocoa husk satisfac-rorily in the starter phase.
- 20% of treated cocoa husk in the finisher phase can be tolerated by the cockerels for satisfactory performance. However, if economy of feed conversion is to be given the highest priority, 24% of treated cocoa husk will be required for the finisher phase.
- Mortalities recorded on cockerels fed cocoa husk based rations could not be attributed to theobromine poisoning but the microscopic examination of organs of such cockerels may exhibit pathological lesions resembling those of chronic theobromine poisoning.

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APPENDIX I

Analysis of variance of performance of cockerels fed cocoa husk diets with wheat offal replacement (Starter Phase).

Source of variation	df	MEAN SQUARES								
		IBW	FBW	BWG	DBWG	DFI	FE	DPI	PER	MORT
Treatment	4	9.76*	23132.61*	23175.32*	9.26*	156.82	0.28	6.86	0.01	1.91
Error	4	1.57	2595.54	2477.36	0.98	56.51	0.54	1.25	0.03	1.30
Total	9	5.06	11549.16	11512.15	4.60	95.20	0.37	3.61	0.01	1.43

*Significant at 5%.

APPENDIX II

Analysis of variance of performance of cockerels fed cocoa husk diets with wheat offal replacement (Finisher Phase)

Source of variation	df	MEAN SQUARES								
		IBW	FBW	BWG	DBWG	DFI	FE	DPI	PER	MORT
Treatment	4	66357.52	116025.99	9522.44	3.80	374.43	5.92	21.90	0.00	0.08
Error	4	66 5.19	42161.91	38499.13	15.39	230.09	17.44	4.43	0.04	0.08
Total	9	29790.83	71727.31	22897.18	9.15	276.46	11.45	11.83	0.02	0.08

APPENDIX III

Analysis of variance of carcasses of cockerels fed Cocoa husk diets with wheat offal replacement.

Source of variation	df	MEAN SQUARES											
		LW	DC	EC	FBR	LIV	GIZ	LSI	WSI	LC	WC	LLI	WLI
Treatment	4	0.27*	2.99	18.92	0.20	0.13	0.35	10.99	0.78*	0.15*	0.04*	0.03	0.01
Error	4	0.01	3.30	4.36	0.09	0.08	0.10	2.42	0.03	0.01	0.00	0.02	0.36
Total	9	0.13	2.88	10.39	0.14	0.09	0.20	5.97	0.37	0.07	0.02	0.01	0.00

*significant at 5%

APPENDIX IV

Analysis of variance of Blood Metabolites of cockerels fed Cocoa husk diets with wheat offal replacement.

Source of Variation	df	MEAN SQUARES						
		TP	ALB	GLO	BU	CR	CH	GL
Treatment	4	9.84*	1.01*	7.03*	0.09	1.58*	680.97	1335.64
Error	4	1.01	0.15	0.71	0.05	0.12	8.56	2502.24
Total	9	4.83	0.55	3.51	0.08	0.76	306.96	1756.48

*significant at 5%

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APPENDIX V

Analysis of variance of Economic Analysis of cockerels fed cocoa husk diets with wheat offal replacement.

Source of Variation	df	MEAN SQUARES						
		LW	TFI	FC	FC/KLW	EGR	GRLFC	REV/FC
Treatment	4	0.12	2.29	2.22	0.43	1821.57*	1720.41*	17.63*
Error	4	0.04	1.35	0.61	0.13	37.07	36.37	2.61
Total	9	0.07	1.65	1.27	0.26	827.54	782.01	9.01

*significant at 5%

APPENDIX VI

Analysis of Variance of Performance of cockerels fed Cocoa husk based rations with GNC replacement with PKC (Starter Phase)

Source of Variation	df		MEAN SQUARES							
		IBW	FBW	BWG	DBWE	DFI	FE	DPI	PER	MORT
Treatment	3	10.67	19967.78	19642.67	5.48	211.19	0.70	16.94*	0.06	2.48
Error	3	5.83	6849.57	6625.10	1.84	33.10	1.48	1.71	0.03	0.84
Total	7	7.71	11502.28	11262.54	3.14	107.02	0.94	8.12	0.04	1.45

*significant at 5% level.

APPENDIX VII

Analysis of Variance of Performance of cockerels fed cocoa husk based rations with GNC replacement with PKC (Finisher Phase).

Source of Variation	df	MEAN SQUARES								
		IBW	FBW	BWG	DBWE	DFI	FE	DPI	PER	MORT
Treatment	3	4119.01	8295.34	1292.70	0.52	1541.42	26.78	61.48	0.10	12.84
Error	3	1655.73	39866.75	49818.90	19.94	0.73	30.13	0.02	0.05	5.09
Total	7	2519.53	20695.48	22102.94	8.85	661.02	25.45	26.36	0.06	7.69

APPENDIX VIII

Analysis of variance of carcasses of cockerels fed cocoa husk based rations with GNC replacement with PKC

Source of Variations	df	MEAN SQUARES												
		LW	DC	EC	FAT	FBR	LIV	GIZ	LSI	WSI	LC	WC	LLI	WLI
Treatment	3	183079.17	48.94	8.76	0.05	0.18	0.40	0.13	16.03*	2.98	0.39	0.09*	0.15	0.01
Error	3	28012.50	8.67	25.88	0.02	0.15	0.47	0.35	0.60	0.52	0.15	0.01	0.03	0.00
Total	7	91255.36	29.18	21.45	0.05	0.15	0.37	0.21	7.20	1.50	0.24	0.05	0.08	0.01

*significant at 5%

APPENDIX IX

Analysis of variance of Blood Metabolites of cockerels fed cocoa husk based rations with GNC replacement with PKC.

Source of Variations	df	MEAN SQUARES						
		TP	ALB	GLO	BU	CR	CH	GL
Treatment	3	2.11	2.45*	4.40*	1.76	0.13	329.46*	521.87
Error	3	0.27	0.16	0.05	0.91	0.02	30.73	85.92
Total	7	1.03	1.12	1.93	1.17	0.08	161.17	379.36

*significant at 5%

APPENDIX X

Analysis of variance of Economic Analysis of cockerels fed cocoa husk based rations with GNC replacement with PKC.

Source of Variations	df	MEAN SQUARES						
		LW	TFI	FC	FC/KLW	EGR	GRLFC	REV/FC
Treatment	3	0.01	7.84*	17.67	15.31	1866.24*	2213.12*	265.60*
Error	3	0.04	0.12	0.17	3.74	151.98	143.46	2.28
Total	7	0.02	3.42	7.67	8.31	869.47	1013.88	114.87

*significant at 5%

APPENDIX XI

Analysis of variance of the performance of cockerels fed different levels of treated cocoa husk (Starter)

Source of Variations	df	MEAN SQUARES								
		IBW	FBW	BWG	DBWG	DFI	FE	APD	ADMD	MORT
Treatment	6	3.81	1410.88	1389.27	0.44	7.79	0.19	0.49	0.03	0.33
Error	6	1.49	1358.62	1332.99	0.43	12.21	0.08	0.41	0.01	0.28
Total	13	2.57	1415.92	1388.37	0.44	9.50	0.13	0.43	0.02	0.28

APPENDIX XII

Analysis of variance of the performance of cockerels fed different levels of treated cocoa husk (Finisher).

Source of Variations	df	MEAN SQUARES								
		IBW	FBW	BWG	DBWG	DFI	FE	APD	ADMD	MORT
Treatment	6	2004.13	4016.26	2917.53	1.74	311.11	4.78	8.93	0.03	0.82
Error	6	1881.30	5271.33	3683.67	2.19	442.71	5.76	11.42	0.02	1.11
Total	13	1880.09	4441.84	3143.03	1.87	351.54	4.88	9.51	0.03	0.89

APPENDIX XIII

Analysis of variance of carcasses of cockerels fed varying levels of treated cocoa husk.

Source of Variations	df	MEAN SQUARES											
		LW	DC	EC	FBR	LIV	GIZ	LSI	WSI	LC	WC	LLI	WLI
Treatment	6	23130.95	31.08	24.66	0.24	0.12	0.23	1.63	0.13	0.01	0.01	0.01	0.01
Error	6	13245.24	2.47	13.08	0.25	0.23	0.14	4.55	0.21	0.02	0.01	0.01	0.01
Total	13	16833.52	15.59	17.43	0.27	0.17	0.17	2.88	0.16	0.01	0.01	0.01	0.01

APPENDIX XIV

Analysis of variance of Economic Analysis of cockerels fed varying levels of treated cocoa husk.

Source of Variations		MEAN SQUARES						
	df	LW	TFI	FC	FC/KLW	EGR	GRLFC	REV/FC
Treatment	6	0.01	0.78	0.44	0.96	81.63	74.45	4.53
Error	6	0.01	0.56	0.33	0.67	106.71	93.13	4.52
Total	13	0.01	0.63	0.36	0.76	87.04	77.59	4.18