REPLACEMENT VALUE OF MAIZE COB FOR MAIZE IN CHICK AND GROWER RATIONS

BY

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1986

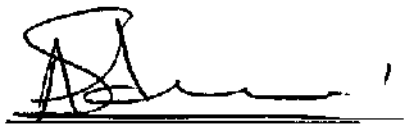
A THESIS SUBMITTED TO AHMADU BELLO UNIVERSITY,
IN PARTIAL FULFILLMENT FOR THE DEGREE
OF MASTER OF SCIENCE

DEPARTMENT OF ANIMAL SCIENCE
FACULTY OF AGRICULTURE
AHMADU BELLO UNIVERSITY, ZARIA
NIGERIA

1999

DECLARATION

This is to certify that this thesis has been written by me and that it is a record of my own research work. It has not been presented in any previous application for a higher degree. All quotations are indicated and the sources of information are specifically acknowledged by means of references.



Adamu Lauratu K.

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CERTIFICATION

This thesis "Replacement value of maize cob for maize in chick and grower rations" 1999, by Lauratu Adamu Kurawa meets the regulations governing the award of the degree, Master of Science of Ahmadu Bello University, and is approved for its contribution to knowledge and literacy presentations.

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DEDICATION

TO

My dear father, late Alkali Manzo, my mother Hajiya Maryam (Natu)

and

My husband Usman, for his support, patience and sharing the hard times of this research.

ACKNOWLEDGEMENT

I wish to express my appreciation to Professor S.O. Ogundipe for supervising every stage of this research and the time he patiently spent in scrutinizing the manuscript. Similarly, I extend my unreserved gratitude to Professor, T.F. Balogun as my supervisor and Head of Department whose immense assistance has undoubtedly made my programme a success. I am also very grateful to Dr. J.O. Hambolu for his contribution as my supervisor.

My appreciation is extended to Professor O.A. Osinowo for his helpful contribution. Special thanks are also due to Alh. Ahmed Falaki of Agronomy Department and to Professor Y.O. Aliu of Vet. Medicine for their guidance and valuable assistance in my programme.

I am very thankful to the entire staff of the Poultry Section of National Animal Production Research Institute (NAPRI) particularly Abdullahi Ahmed, Alh. Liman Mamman, Haliru Sule, Monday Garba, Ibukun Olowookere and Gopar Jang who assisted in the preparation of feeds and routine care of the experimental birds. Mention must be made of Mrs. A.A. Sekoni and Mrs. C. D. Tuleun, who contributed with their time, energy and advise. My appreciation also to the staff of NAPRI laboratory and Alh. M.A. Minna of Soil Science, Institute for Agricultural Research Samaru for their assistance in the analysis of feed samples.

My sincere gratitude is extended to Mr. E.O. Aduli for helping to analyse the data, to Mr. S. Duru for all his assistance and to Mr. S. Audu for the typing of the thesis.

Special acknowledgement must be made to members of my family particularly my brother Alh. Yahaya Adamu and sister Hajiya Nafi Ibrahim for their support and encouragement. A word of thanks also goes to my friends Fatima Bibi, Zaliha Ahmed, Halima Dimis, Amina Ali and Bunmi Oladimeji for their various contributions and a heart-warming stay with them during my programme

Finally, I give all thanks to the Almighty Allah who made everything possible.

ABSTRACT

Proximate analysis of maize cobs (MC) was carried out with samples from two different sites. The average values of CP, CF, NFE, EE, Ash, Ca and P were 2.47, 32.22, 57.73, 1.66, 5.16, 0.15 and 0.075 percent respectively. The apparent metabolizable energy of MC was found to be 751.68 Kcal/kg.

Two experiments were also conducted to evaluate the replacement value of MC for maize in egg-type chick and grower rations.

In experiment I, three hundred and fifteen day-old chicks were used. Seven isonitrogenous (20% CP) chick diets were formulated to contain graded levels of ground MC at 0, 5, 10, 15, 20, 25 and 30 percent of the diets. This feeding trial lasted from one day-old up to seven weeks of age.

For experiment two, there were two phases. The growing and the early laying phases. In the growing phase, seven 15% CP diets containing ground MC at 0. 10, 20, 30, 40, 50 and 60% levels were fed to two hundred and seventy three 8-weeks old pullets. At the end of the first phase which lasted for 12 weeks, two birds from each replicate group were sacrificed and length of the intestines and caeca were measured. A section of the duodenum was also taken and villi abrasion was assessed under photomicroscope.

In the second phase, two hundred and ten pullets from phase 1 were transfered in their original groups to the laying house. A common layer ration of 17% CP was offered to all the groups for four 28-day periods.

Results from the chick study indicate that the final body weight, weight gain and feed-gain ratio for the control group were significantly ($P<0.05$) superior to those of other groups that were fed various levels of MC. Feed

consumption increased significantly ($P<0.05$) with increase in the dietary level of MC as from 15% level. Feed cost per bird decreased with increase in the dietary level of MC above 10% and mortality was not affected.

Results for the growing phase showed satisfactory body weight gain and feed-gain ratio of pullets *fed* up to 20% dietary level of MC. Feed consumption increased significantly ($P<0.05$) with increase in dietary level of MC. The MC diets also increased significantly ($P<0.05$) the length of intestines and caeca as well as the abrasion of the Villi.

During the laying phase, pullets fed high levels of MC grower diets exhibited compensatory growth and attained similar body weights with those that were *fed* on control and lower dietary MC. Percent hen-housed egg production was satisfactory with the 10% and 20% MC diets when compared with the control group and the percent hen-day egg production was not affected up to 30% dietary MC treatment.

Based on these observations, it was recommended that MC should not be used in chick ration formulations while the grower diets may contain up to 20 percent of this agricultural by-product with no adverse effects on the performance of the birds. At 20% level of inclusion, MC replaced 31.05% of the dietary maize and reduced *feed* cost by about 8%.

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CHAPTER ONE

1.0 INTRODUCTION

In most developing countries like Nigeria there has always been a short supply of animal protein for the populace. This problem is further compounded by the accelerated increase in human population which create pressure on every form of food supply. The minimum requirement of 52g animal protein per capita per day recommended by F.A.O. (1974) is therefore never met. This necessitates the rapid expansion of animal production. The major constraint to animal production however, is feed supply especially for poultry.

The poultry industry in Nigeria is currently suffering from serious feed problem due to the high cost of feeds. Economic recession has forced the federal government to ban the importation of poultry feed ingredients forcing a greater dependency on local feedstuffs such as grains, oil seed cakes and agricultural by-products. Maize and to some extent guineacorn have been reported by Fetuga **et. al.** (1975) to form the major energy sources for poultry in Nigeria and they contributed about 60% to 80% of the total poultry and pig diets. Unfortunately, the rapid growth of human population has intensified the competition between man and livestock for these cereal grains thus resulting in high cost of feeds. The increasing cost of conventional feedstuffs coupled with high demand for grains for human consumption has stimulated interest in the use of non-conventional, readily available and cheaper sources of feedstuffs in animal rations.

Agriculture provides a variety of waste products that are underutilized. David (1992) estimated that for balanced poultry rations, about 15 to 30 percent

of the maize component can be replaced by agricultural by-products from rice, wheat and maize processing. Maize cob is one of the agricultural by-products that is produced in large quantities at the end of each year from the threshing of maize. Maize production has increased substantially since 1985 when the Federal government banned its importation in order to save foreign exchange and encourage local production so as to meet the rising demand for both human and livestock feeds and for industrial raw material (Elemo **et. al**. 1992). The cob has been reported by Alokan (1988) to constitute about 60 percent of the maize "ear". The Department of Agricultural Project Monitoring and Evaluation Unit estimated that about 5.4 million tonnes of maize was produced in Nigeria as at 1989 (Elemo **et. al**. 1992). This corresponds to 3.24 million tonnes of maize cob annually. The bulk of the cobs however, were either burnt off or dumped as waste to litter the environment.

The advantage of utilising cheap local materials and by-products like maize cob in livestock ration formulations is the reduction of feed cost. A reduction in feed cost will bring down the prices of animal products such as meat and eggs. Consequently, there will be increase in demand and consumption of animal protein. Poultry enterprise compared to other livestock has the quickest turn over. An expansion of the poultry industry therefore seems to be the fastest means of solving the problem of animal protein deficiency presently prevailing in the country. Unfortunately, progress in the poultry industry in Nigeria is hindered by four major problems as stated by Ademosun (1977) which include the following:

- Irregular and erratic supply of certain feed ingredients
- Lack of adequate information on nutritive value of local feed ingredients.
- Competition with humans for certain feed ingredients
- Slow progress in the exploration of the use of industrial and agricultural by-products as substitutes for the conventional feed ingredients.

Considering the problems outlined above and the large quantities of maize cobs available annually in this country it will be advantageous if this by-product can be utilized in poultry rations as a substitute for maize. At present, only a small fraction of the cob is used in ruminants feeding. This by-product has not yet found its place in poultry ration due to the limited knowledge of its nutritive value for the chickens.

1.1 Justification of the Study

Several studies have been conducted on the use of maize cobs in ruminants and swine feeding (Babatunde **et. al.**, 1975, Fetuga **et. al**; 1975, Zadravka and Platikanov, 1976; Escober and Combellas, 1983, Tuah **et. al.** 1987). There is however, very little work done with layers and pullets and virtually no report could be found in the literature on chicks. Chickens especially the chicks are not usually fed high fibre materials and consequently the knowledge of their ability to utilize maize cobs is limited. Feeding of maize cob at various dietary levels will therefore provide more knowledge on the ability of the chickens to utilize this by-product and will also help in establishing its optimal level of dietary inclusion for the birds.

Maize cob with its high fibre content will be expected to promote optimal gut motility and secretion thereby enhancing feed efficiency and performance through better digestive and absorptive processes.

Successful replacement of maize with maize cob in chicken rations can also help to reduce feed cost and also the competition with humans for maize. Similarly, the reduction of feed cost will bring about a fall in the prices of poultry meat and eggs which in turn will increase the availability of these products for the improvement of human nutrition.

Utilization of maize cob in poultry rations will also overcome its disposal problem by upgrading the by-product to edible form as an animal feedstuff.

It is with these benefits in mind that this study was carried out to investigate the effects of dietary levels of maize cobs on the performance of chicks and growers and to determine the carryover effects of maize cobs grower diets on the early laying performance of the pullets.

1.2 Statement of Objectives

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The objectives of this study are as follows:

1. Determination of the nutrient composition of maize cob as a feedstuff for chickens through proximate analysis and metabolizable energy (M.E.) study.
2. Determination of the optimum proportion of ground maize cobs that can replace maize in chick and grower rations and the effect of such a replacement on the performance of the birds.
3. Determination of the effects of maize cob as a source of fibre on the gastrointestinal development and physiological adaptation of the pullets.

4. Evaluation of the carry over effect of grower diets containing maize cobs on the early laying performance of the pullets.

5. Determination of the effect of dietary inclusion of maize cobs on the feeding cost of chicks and growers.

CHAPTER TWO

2.0 RIVIEW OF LITERATURE

2.1 Nutrient composition of maize cob

Maize cob is an agricultural by-products left after the grains have been removed or threshed from the the maize ears. Reports on chemical analyses from the literature as shown page 7 gave extremely variable values of nutrient composition for the cob. This variability according to Alokan (1988) is mainly due to pre and post harvest management processes.

Maize cob is a low quality roughage with a crude fibre range of 30 to 40% (Henry and Morrison, 1923; John, 1961; Alokan 1988; Kevelenge **et. al.**, 1984). Similarly, Zadravka and Platikanov, (1976) reported that maize cob contains 47.9 to 48.7% acid detergent fibre and 6.9% lignin. The cob is also very low in crude protein and most of the nitrogen free extract (NFE) was reported (Henry and Morrison, 1923) to be in form of pentosans. According to Bolton and Blair (1974), pentosans represent only a small portion of the carbohydrate content in most foods. In addition, the digestibility of the NFE and ether extract (EE) was found to decrease with increase in maize cob in swine rations (Babatunde et. al; 1975). Tuah and Orskanov (1985) cited by Tuah **et. al.** (1987) attributed the low dry matter digestibility of the cob to the binding of hemicellulose which is the major component of the cob with lignin. An **in vivo** experiment carried out by Kevelenge **et. al.**, (1984) with wether sheep also indicated that maize cob provided less than the required metabolizable energy (M.E.). However, the efficiency of ME utilization of the cob was found to be

Table 1: Nutrient Composition of ground maize cob from different sources

Source	DM %	CP %	CF %	EE %	ASH %	NFE %	GE Kcal kg	Ca %	P %	Mg %	K %	Na %	Mn %	Fe %	Zn %	Cu %	Cl %	S %	Carotene	Vit.A equi.
National Academy of Sci. Committee on Anim. Nutr. Agric. Board Joint USA and Canada (1964)	90.4	2.5	32.4	0.5	1.5	-	1662	0.11	-	-	-	-	-	-	-	-	-	-	-	-
Schrimpf (1966)	89.7	2.8	34.1	0.6	-	50.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Crampton and Harris (1969)	90.4	2.5	32.4	0.5	1.5	53.5	3998	0.11	0.04	0.06	0.76	-	5.6	0.021	-	0.06	-	.42	0.6	1.0
Fetuga et al. (1975)	95.5	2.5	32.5	0.9	3.9	60.1	4600	0.16	0.06	0.12	0.89	0.06	-	0.001	0.002	0.001	0.34	-	-	-
Babatunde et al (1975)	90	3.4	32.1	1.2	6.2	56.1	4683	0.16	0.06	-	-	-	-	-	-	-	-	-	-	-
Longe and Adetola (1983)	92.1	1.8	28.4	0.9	5.7	63.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alokan (1988)	88.35	3.34	41.44	1.33	2.25	51.64	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Comparable to that of yam peels and plantain peels for swine (Fetuga **et. al.**, 1975). An ME value of 708 kcal/kg was obtained by Longe and Adetola (1983) for the cob. The by-product is particularly high in calcium but low in other minerals including phosphorus.

In spite of the general observations as highlighted above, that maize cob is of low feeding value, it has been used widely in ruminants and swine rations as an alternative source of roughage. On the account of its wide distribution, abundance and low cost of acquisition, maize cob may also be considered to have a potential value in poultry nutrition.

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2.2 Maize cob in livestock rations

Maize cob has been used satisfactorily in the feeding of ruminants. In dairy cows, fat content of milk was observed to be lower than control when 20% treated cob was included in the diet (Escober and Combellas, 1983). Maize cob has also been reported by Zadravka and Platikanov (1976) to be fully utilized in the fattening of calves in Bulgaria. An average daily weight gain of 1200g to 1300g was obtained by these workers when 50% of pelleted cob or stover were included in the diets of calves between the age of 7 and 14 months. Umunna **et. al.**, (1986) also found an increase in the dry matter (DM) intake and weight gain in lambs fed the processed cobs in their ration. In another experiment, Alokan (1988) observed no significant difference in dry matter intake, weight gain, efficiency of feed utilization and nutrient digestibility between sheep fed up to 25% untreated cobs and the control. However, the author observed a progressive decrease in weight of the animals as the level of maize cobs increased. Likewise, Babatunde (1986) found that the inclusion of maize cobs in swine ration at 15% level had no adverse effect on performance and there was

even a tendency for improved performance relative to the control group. Although there are some reports in the literature on the utilization of maize cobs in livestock rations, there is a dearth of information on the utilization of maize cobs as feed ingredient in poultry diets.

2.3 Effect of gound maize cobs on the performance of the chicken

Maize cob (MC) is not a common ingredient in poultry rations and only a limited information is available in the literature to this effect.

Feeding of MC as a source of fibre to laying hens was observed by Longe (1984) to increase weight of gizzard. The ME of the basal diet was also reduced from 11.82 to 10.08 MJ/kg by addition of MC at 200g/kg of diet. In spite of the lower ME, MC diet supported similar laying performance with that of the control. In addition the same worker obtained no significant difference in feed utilization (kg feed/kg egg) of diets containing MC, cassava peels and maize starch residues. In another experiment, MC in the growing diets at 50 to 200g/kg was found by Longe and Ogedegbe, (1989) to decrease the ME of the diet from 11.52 to 9.7 MJ/Kg. The neutral detergent fibre of the diet also increased from 182 to 330g/kg. Because of these two factors the ME intake was reduced significantly when the MC content was above 100g/kg diet. However, protein intake was not affected by the dietary MC and the pullets fed MC were observed to have attained sexual maturity earlier than the control group.

Hen-day egg production was found to improve by MC at 5 and 10% levels of the laying diet. (Annon, 1992). Percent hen-day egg production however, reduced when the MC level was increased to 20%. Above the 10% level of inclusion, MC was also reported by the same worker to reduce body weight and increase feed intake.

The decrease in body weight and egg production at high level of MC may be attributed to the effect of high level of fibre, which is known to limit the consumption of nutrients to meet the maintenance and production requirements of the birds.

During an experiment with cockerels to assess the metabolic endogenous energy losses with different sources of fibre, Muztar and Slinger (1981a) observed a greater feed retention with MC as a source of fibre than purified wood cellulose. From these reports, it is evident that MC has some potentials in poultry nutrition that are worthy of investigation.

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2.4 Methods of improving the nutritive value of maize cobs

The major limitation in the feeding of highly fibrous feed materials like maize cob to animals is their low digestibility. This limitation is partly due to its bulk and also because of the lignin fraction which binds up the cell wall content and make the material resistant to enzymatic action. As a result of this problem highly fibrous feeds are treated so as to improve their palatability and digestibility for effective utilization. Treatment of maize cob is commonly practiced for ruminant nutrition because they are mainly fed to these group of animals. Three methods of processing are generally employed. These include biological, chemical and physical processes.

2.4.1 Biological treatment

Biological processing involves the use of microbes such as bacteria, fungi and sometimes actnomycetes or enzymes.

From an experiment, Ward and Perry (1982) obtained a maximum production of glucose from the conversion of maize cobs to glucose by an enzyme from fungus, Trichoderma viridae Finely ground cobs were treated with a mixture of this enzyme

and water at a ratio of 1:6 and kept at a temperature of 23°C for 4 weeks. Addition of 40% treated maize cobs in the diet of cattle resulted in decreased digestibility of crude fibre but with an increase in the digestibility of DM, NFE and total digestible nutrients (TDN) which consequently improved growth performance.

This method of treatment is however expensive, takes a long time and requires professional experience. It is therefore not commonly used.

2.4.2 **Chemical treatment**

This method of treatment is cheaper and more effective than the former. Certain chemicals are used to release the energy or carbohydrate components in the fibrous feeds. The chemicals that have been used include:- sodium hydroxide, calcium oxide, calcium hydroxide, sodium metasulphite and some acids such as sulphuric, hydrochloric and acetic acids. Sodium hydroxide is the most effective out of all these chemicals. The aim of this treatment is to break the lignin bonds and by so doing, the energy content of the feedstuff is released for use by the animal to which it is fed.

Higher values of daily weight gain was obtained by Kristozov **et. al.** (1982) in wool lambs when 56% NaOH treated cobs was included in the diet. Feeding 61% maize cobs wetted with NaOH in the diets of different breeds of heifers also resulted in higher DM intake and better feed efficiency (Katagile, 1984). In dairy cows, Escober and Combellas (1983) observed improved feed intake and higher milk yield with lower fat content when 20-60% maize flour was substituted with alkali treated maize cobs.

The use of NaOH is limited because the chemical is expensive. Moreover, the alkali causes pollution through accummulation of sodium ions and is corrosive

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which makes it potentially dangerous to humans and animals. Other chemicals that are used for treatment of feedstuffs are also associated with one problem or the other. Addition of 1.5% sodium metasulphite for example, was observed to depress feed intake and this was attributed by Umunna **et. al.** (1986) to the deleterious effects of residual sulphur. For health and economic reasons it is therefore, not advisable to process the cobs with chemicals indiscriminately.

2.4.3 Physical treatment

Physical processing of the maize cobs entails applying some kind of pressure to modify the form of the material. Under this method of treatment the cobs may be steam treated or reduced in particle size by milling or grinding.

Steam processing alters the structure of the material by weakening the C-C bonds for enzymatic action. High temperature and pressure processing of maize cobs was found by Umunna **et. al.** (1986) to increase availability of energy by solubilization of the cell wall constituent as well as improve intake and weight gain in lambs. This method of processing was also reported by the same workers to reduce concentration of ADF thus enabling the treated material to digest faster. However, the processing failed to reduce acid detergent lignin.

Milling and grinding on the other hand, reduce the particle size of the material. Reducing the particle size gives the feed greater density thus it occupies less space and the animal spend less time eating. This enables the animal to eat more food in a limited time thereby, improving intake. Milling also breaks up the material into pieces and increase its surface area for digestion as enzyme will be able to cover more feed particles than when it was in the coarse form.

The ground material can be processed further by compacting it into pellets. Pelleting was observed by Zadravka and Platikanov (1976) to improve the energy availability of beef cattle ration containing maize cobs. The improvement according to these workers was brought about by pelleting through change in the crude fibre, ADF and lignin content of the cobs.

From the few research work conducted, maize cobs were fed to chickens in a ground or mashed form. The efficiency of the mash diet containing maize cobs may be improved by pelleting. This however, should be subject to cost, availability of facilities and the degree of improvement that could be achieved.

Savory (1974) reported that pelleting improved efficiency of feed utilization of fibrous diets in chickens. This worker explained further, that the birds fed the diet in pelleted form spent less time eating compared to those fed mash diet.

2.5 Fibre in the chicken diet

Crude fibre has been defined as the portion of a feedstuff that is insoluble, less digestible, ash free and the remain of rigorous boiling with dilute acid and alkali (Duane, 1971, Feltwell and Fox, 1978). Fibre represents the cabohydrates which are poorly digested and cellulose has been reported by Duane (1971) to be the main component of fibre. Ewing (1951) reported that fibre consists primarily of cellulose, hemicellulose and lignin which are known to be almost valueless to monogastrics. The monogastric is said to lack the necessary enzyme for degrading the cellulose (Albanese, 1963). Never-the-less a considerable quantity of the fibre in the feed is utilized by the chickens. It is generally believed that bacteria present in the intestine of monogastrics are capable of degrading the cellulose. This is supported by the findings of Tatsuo et. al., (1991) that fibre serves as a source of energy for chickens

fed diet deficient in energy. These workers explained that when a diet is deficient in energy, the intestinal microflora benefit the host by degrading the fibre and supplying energy which is reflected on growth or weight gain of the bird. If on the other hand the diet is sufficient in energy, no growth promotion would be observed, rather the extra energy is dissipated as heat. It is however a known fact that monogastrics are less efficient in digesting fibre than ruminants. A digestibility of only 13% of corn fibre was reported for poultry as against 33% for ruminants (Ewing, 1963).

Digestibility of fibre as shown by Farrel and Johnson (1972) is related to its source, amount of lignification and physical characteristics like particle size. One fibre source may be beneficial to certain group of animals while another may be detrimental to the nutritional status of the animals. In assessing the effect of different sources of fibre, Angele and Charles (1981) observed no significant differences with the control group in body weight, feed intake and tibia concentration of zinc, iron and manganese when 6% wheat bran, soya bran, oat hulls and cellulose were included in the diets of chicks. However, addition of rice bran at the same level was found to produce significantly lower results.

In feeding monogastrics especially poultry, it is important to know the fibre content of the various feed ingredients since fibres of different origin are often quite different naturally and are digested differently. Moreover, different parts of the same plant are also digested differently. Crampton and Harris (1969) reported that the fibre from wheat shorts and wheat offal which are presumably the same material to have digestibility range of 53 to 90%. The digestibility of fibre of the corn grain was also stated to be 57% by the same workers but that of the corn bran, corn gluten, corn oil and corn grain distillers grains range between 72 and 90% with an average

of 80% in ruminants. These values are likely to be considerably lower for poultry since they are less efficient in digesting fibre than the ruminants. Gohl (1975) advised that too much fibre should be avoided in a chicken diet as it renders the feed indigestible and low in available energy.

2.5.1 Effect of feed volume on the performance of chickens

Fibrous feeds are very bulky and the nutrient concentration per unit volume rather than per unit weight is low (Feltwell and fox, 1978). One of the disadvantages of fibrous feeds is that they are particularly low in energy resulting in restricted energy intake. Moreover, high fibre diets have relatively high heat increment and as such they contribute to heat stress in a warm climate. This has been shown by Stanely and Ishizaki (1982) to have adversely affected the performance of broiler chickens in the tropics.

Feed intake is regarded as one of the most important factors of consideration in poultry production. However, bulk was reported to be a limiting factor affecting feed consumption and growth of chicken (Farjo, **et. al.**, 1987). Reports from the literature showed a general trend of increase in feed intake and decrease in weight gain with increase in dietary fibre (Hill and Dansky, 1954; Scott and Forbes, 1958; Savory and Gentle, 1984; Dvorak and Barry 1979; Emmans, 1987; Karl **et. al.**, 1983). This increase in consumption of the fibrous diets was explained by Hill and Dansky (1954) and Scott and Forbes (1958) as an attempt to maintain constant energy level since chickens eat to satisfy their energy requirement. The total feed consumption of growing turkey hens fed high fibre diet was observed to increase by about 2.6 to 2.7% times that of the control (Karl **et. al.**, 1983). An increase of

12.3% and 21% feed intake were also obtained by El-Kotoury et. al. (1977) when the rations of Fayoumi (native fowl of Egypt) chickens were increased in volume with 12.3% and 21% coarse wheat bran respectively. Similarly, addition of cellulose to the basal diet elicited a linear increase in dry matter intake up to 24% but above this level the weight of feed consumed per chicken was depressed (Hill and Dansky, 1954; Scott and Forbes, 1958). Marked decrease in intake of broiler chicks was also observed by Sibbald and Morse (1984) as the level of cellulose increased from 100 to 300g/kg diet with a 50% reduction at 300g level. However, the feed intake increased later by about 60% when the feeding period was extended from 17 to 24 days. According to Emmans (1987), increasing the bulk of feed increases intake until the capacity to ingest the bulk is reached and further increases in the level of fibre will lead to a fall in feed intake. Therefore, another disadvantage of high fibre concentration in the diet is limiting feed intake which in turn imposes physical limitation upon the intake of digestible nutrients. This effect is usually manifested in form of lower weight gain and poor feed efficiency. A gradual decline in mean pen weight of chicks was observed by Sibbald and Morse (1984) when the dietary fibre was increased from 100 to 300g/kg diet. Dvorak and Barry (1979) also obtained a linear depression in growth rate and poor feed conversion efficiency when 10, 20 and 30% cellulose was included in the diets of broiler chickens. In turkeys, feeding high fibre rations also resulted in 12% to 14% decrease in body weight at 26 weeks of age (Karl et. al., 1983). In contrast, Summer and Leeson (1987) observed a linear reduction in body weight with increase in dietary fibre for broiler and turkey hens but this occured only when the level of fibre was up to 30% in leghorn diets.

Mortality was generally reported to be unaffected by fibre. However, Savory and Gengle (1976) found juvenile mortality to be higher among birds reared on high fibre diet up to 6 weeks in Japanese quail.

The poor growth performance and feed conversion efficiency that was generally observed with high fibre diets have been attributed to an increase in the rate of passage through the gastrointestinal tract (Southgate, 1973. Dvorak and Barry, 1979). This is said to reduce the transit time of exposure to the digestive enzymes and contact with absorptive surfaces. The overall effect is poor utilizaiton of nutrients due to the partial digestion of feed nutrients like protein and amino acids which leads to reduction in growth rate. However, Herd and Dawson (1984) reported that a considerable digestion of neutral detergent fibre (NDF) was achieved in emu, a large bird with a simple gut and high rate of passage, despite the rapid rate of passage through the gastrointestinal tract. These workers observed that the bird digested 35% to 45% of NDF in the diet and the energy from the digestion of NDF contributed up to 63% of the standard metabolism and 50% of maintenance requirements.

On the other hand, fibre has some beneficial effects on digestion and absorption. Bulkiness of fibre has been reported by King (1961) to aid digestion by stimulating peristaltic movement and secretion of enzymes as well as opening up of concentrated feeds so that digestive juices can come into contact with them. Bulk is also important from the standpoint that it increases the surface area of the feed particles in the digestive tract. Any or all of these factors could influence efficiency with which a diet is utilized and possibly improve performance. Ewing (1951) found that the amount of fibre in the ration of poultry can be increased to 8 or 9% with

desirable effect on chick growth mortality, feed consumption and egg production despite the opinions of many nutritionists that the fibre content of the ration should be kept below 7 percent. He however, reported further that the viability of chicks decreased rapidly when the fibre content was increased to about 10% of the total ration and that levels in excess of 10% were considered undesirable for the first twelve weeks. El-Abbady **et. al.** (1970) found that male Baladi white chicks could tolerate up to 12% fibre while the females could only tolerate 4% fibre although this level for the female could be increased to 7% by the age of 8 weeks without any detrimental effect on either mortality or body weight. In another report, chick growth was found to increase significantly with addition of 5 to 15% purified cellulose (Davis and Briggs 1944, cited by Angele and Charles, 1981). However, Aduku (1992) cited that ARC (1977) recommended 6% fibre for chicks and growing pullets and 7% for the layers.

It has been reported by Isaachs **et. al.** (1960) that the use of high levels of fibre during the growing period delayed sexual maturity and reduced body weight at maturity.

In laying hens, Deaton **et. al.** (1978) found no significant effect in body weight, hen-day egg production, egg weight, feed efficiency, shell strength and mortality rate when fine wood shavings were added at 15, 30 and 60g/kg to the diets of the birds. In another report, Deaton **et. al.** (1977, 1979) and Din **et. al.** (1979) observed that although the efficiency of feed conversion was reduced, egg production, egg weight, shell breaking strength and mortality were not affected by substituting part of the energy with crude fibre in layer ration. Bulk also has the ability of increasing the gut dimension hence affect its physiological functions.

2.5.2 **Gastrointestinal adaptation of chickens to fibrous diets**

Chickens like other animals exhibit a high degree of anatomical and physiological adaptations to changes in the dietary composition in order to compensate for variation in nutrient concentration of the diet. Addition of fibre was reported by Savory (1991) to have pronounced effect on gross dimensions of parts of the gastrointestinal tract. This is based on the laxative properties of fibre. Lloyd **et. al.** (1978) reported that feeds that are high in crude fibre have high fatty acid content or high water holding capacity and are the best laxatives. The ability of fibre to hold water can modify the gut function by increasing the bulk of the intestinal content. Consequently, the gut dimension increases and this improves feed inntake, absorption and elimination of feed residue from the gut.

Feeding high fibre diets to turkey growing hens was observed to increase the weights of oesophagus, crop, proventriculus, gizzard, small intestine, large intestine and the caeca (Karl **et. al.**, 1983). In their experiment with chickens and turkeys Kamar **et. al.** (1978) found that fibre in the ration increased the actual and relative volume of the intestines, as well as the actual and relative lengths of all parts of the digestive system, except the rectum. These workers however observed no clear trend in terms of weight of these parts with the bulky feed. Contrary to this observation Kondra **et. al.** (1974) obtained increases in weight and size of all components of the digestive system. In addition, the length of caeca was also increased.

The increase in size of the caeca was suggested by Kamar **et. al.** (1985) to increase the birds' ability to digest the fibre content of the diet. This is in agreement with the report of Mitchell (1964) that bacterial fermentation in the chicken takes place in those segments of the gastrointestinal tract in which ingesta stagnate and

mainly in the caeca and colon. A digestibility of 20 to 30% crude fibre was reported to occur in the caeca of poultry as opposed to only 16 to 18% and 3 to 25% in the caeca of rabbit and swine respectively (Lloyd **et. al.**, 1978). In another report, Savory (1991) explanined that the increase in length of small intestine he obtained with 200g cellulose per kilogramme diet was a potentiality for improving the total rate of absorption. However, Dvorak and Barry (1979) contended that the extent of digestion and absorption are reduced by high fibre rations. They explained that the cellulose distend the digestive tract sufficiently, thus limiting the mixing of ingesta with digestive secretions and reduced the proportion of the total ingesta making contact with absorptive surfaces.

On the other hand, histological studies have also revealed that chickens on high fibre diets make some anatomical adjustments. The chickens fed high fibre rations were observed to have the same number of Villi per unit area of the doudenum with control but the former showed increase in the length and total number of Villi due to increase in the length of the intestine (Kondra **et. al.** 1974). These adaptations would enable the chickens to sufficiently handle the fibrous feed so as to extract the nutrients as much as possible.

Mashall (1960) stated that the degree of cornification of the epithelial layer lining the avian gastroinstestinal tract is associated to a considerable extent with the type of diet. The abrasive nature of fibre as explained by Dvorak and Barry (1979) could bring frequent removal of the gut epithelial layer thus contributing to higher maintenance costs for its replacements. Hedge et. al. (1978) also reported that fibrous diet resulted in intestinal abrasion which impaired performance of chicks. Contrary to this, Rolls **et. al.** (1978) found addition of fibre in form of wheat bran

had no effect on the rate of epithelial renewal in both germ free and conventional birds. These workers however, observed a progressive decrease in villus height, crypt depth, mitotic index and cell turnover rate towards the distal end of the intestine. The greater mitotic activity, faster migration and rapid turnover of epithelial cells in the mucosa was attributed to microflora activities in the gut rather than fibre. Never-the-less the dietary fibre should be limited to a tolerance level. Arnall and Keymer (1975) reported that there was a tendency of crop, gizzard and intestine impactions when the percentage of dietary fibre was greatly increased. In addition, the low concentration of nutrients might retard performance.

2.5.3 **Effects of fibre on utilization of other nutrients**

Fibre has a depressive effect on the utilization of feed nutrients as indicated by lower gains per unit feed consumed. Ewing (1963) explained that fibre contribute little if any digestible nutrients and makes other nutrients less available. Amino acids, minerals and other nutrients were reported by El-Kotoury **et. al**. (1977) to be tied down by the dietary fibre. In examining the effects of extreme levels of fibre on layers' performance, Moran and Esseievan (1977) observed that there was difficulty in meeting lysine, isoleucine and methionine requirements with most high fibre feeds. Southgate and Durne (1971) as well as Ranjhan (1980) reported that as the intake of dietary fibre increased, apparent digestibility of the constituents of the ration decreased. Dammers (1965) and Tao **et. al**. (1971) had also implicated crude fibre as a factor depressing amino acid digestibility in protein feedstuffs.

According to Van Soest and Robertson (1976), vegetable fibre consisted of a heterogenous complex of polysaccharides and lignin capable of sequesting water

cations and anions by an adsorption mechanism depending on the chemistry of the constituent macromolecules. Nwokolo **et. al**. (1985) observed a significant negative correlation between crude fibre content of the diet and mineral availability in chickens. It seems therefore that dietary fibre sequesters amino acids, minerals and other nutrients rendering them unavailable. Nwokolo **et. al**. (1985) had indicated that the deleterious influence of dietary fibre on nutrient availability might be more pronounced in diets containing mainly vegetable feed ingredients than in those that are high in animal protein.

In a review work of the nutritional significance of dietary fibre, Ali **et. al**. (1981) concluded that the total faecal fat, nitrogen and total dry matter tended to increase with increasing levels of fibre in the poultry ration.

In laying birds, Hening **et. al**. (1981) observed that inclusion of 40g fibrous wheat bran per kg diet resulted in 19% and 39% increase in excretion of essential and non-essential amino acids respectively. Similarly, a significant decrease in nitrogen retention was also obtained by Longe and Ogedegbe (1989) when 200g/kg maize cobs was included in the diet of growing pullets.

In contrast, Muztar and Slinger (1981b) found no significant difference in the excretion of amino acids and nitrogen with 5% to 20% purified wood cellulose in the diets of mature roosters, however, there was an apparent trend to increase with 15% fibre. These workers contended that part of the faecal nitrogen may be contributed by non-amino acid nitrogen containing compounds. Moreover, they explained that the effect of fibre on the amino acids and nitrogen excretion vary with type and source of crude fibre.

Incorporation of feedstuffs high in fibre has been proved to affect physical texture of rations and increase feed intake of birds in an attempt to satisfy energy needs (Longe and Adetola, 1983). Diets that are high in fibre are usually low in energy and the NFE of the fibre as reported by Ray (1951) are highly loaded with hemicellulose and lignin. Therefore, a negative correlation between the quantity of fibre and digestibility of NFE is usually the case. According to Baird **et. al.** (1975), bulk of the diet does not affect rate of gain as much as the energy density.

2.6 Effects of dietary energy on the performance of chickens

Energy is an important component of poultry ration and is usually expressed in terms of metabolizable energy. Metabolizable engergy (ME) refers specifically to that portion of the dietary energy that is available to the animal for the production of meat and eggs and for maintenance of body temperature and other vital functions (ARC, 1975).

It has been postulated that the most efficient nutrition of the chicken is obtained when the nutrients contain the exact proportion of energy to other nutrients needed to produce the desired growth, egg production or body finish. Scott **et. al.** (1974) indicated that in diets containing adequate amounts of all nutrients, the efficiency of feed utilization depends upon the ME content of the diet. Both broiler and leghorn chicks were found to weigh less when fed low energy diets than those fed high energy control ration. However, Peterson (1975) as cited by Moran and Essievan (1977) observed that chickens obtained progressively lower ME values for feedstuffs as their fibre content increases.

The efficiency of utilization of ME above maintenance, for fattening and growth appears to be distinctively influenced by the compostion of diet (de Groote,

1974). The level of ME required on the other hand, determines the minimum levels of inclusion of amino acids and to a lesser extent minerals and vitamins in the ration. The energy level of the diet also influences the protein requirement for best performance. Combs (1962) established that as the energy level is raised, the protein requirement for best performance also increases. However, this is not the case for all classes of poultry. High level of energy in the diet of layer has a depressive effect upon egg production. Sugandi **et. al.** (1975) observed that ME of 3050 Kcal/kg depressed egg production while lower ME of 2650 and 2850 Kcal/kg supported egg production in the tropics.

It is generally known that chickens tend to adjust their daily consumption of feed so as to maintain an appropriate level of energy within a certain range (Hill, 1956; Wells, 1963). These authors however, found that the adjustment is not linear and that birds given high energy diets overcome it by depositing additional fat. Consequently, meat strain breeding hens tend to become obese when fed a high energy ration as observed by Hill (1963). In an attempt to establish protein and energy levels for broiler in the tropics, Olomu (1978) also observed the growth rate of broilers on a ration containing 2800 Kcal/kg feed to be slightly higher than those fed a ration containing 3000 Kcals/kg diet. Moreover, the ration with the lower energy was found to be cheaper than that of 3000 Kcals/kg diet. This requirement however, was said to depend on climatic conditions and other factors. Scott **et al.** (1974) also suggested that in hot climate, an energy level as low as 2400 Kcal/kg could be consumed in adequate amounts to permit hens to lay at satisfactory rate. In another report, it was observed by Kothyar (1978) that the reduction of ME in pullet diets gradually from hatch to 5 months of age had no significant effect on survival,

feed intake, digestibility and utilization of nitrogen and amino acids. In addition, 2 to 17% greater egg production was also observed with reduced energy by the same workers but slightly lighter eggs were produced at less feed per 10 eggs. Similarly Tak **et al.** (1978) found that when chickens were fed starting, growing, finishing and laying diets with 10 or 20% less energy or protein, sexual maturity was delayed by a few days and smaller egg weights were produced. The diets with the least energy gave lower egg production but without difference in egg weight These workers also reported that survival up to the laying period was not affected by energy supply but survival during the laying period was 3% less for the low energy diet.

From the above findings, it is quite clear that reducing the energy to a reasonable level could support satisfactory performance. The problem with fibrous feed therefore, may not necessarily be the energy density but its availability. The bulk of energy along with other nutrients might be locked up by the impervious lignin which makes them unavailable hence limiting their efficiency of utilization. The great differences in the available or utilizable energy content of different feed materials tend to result from the differences in the absolute content as well as chemical component of the fibre fraction (Fetuga, 1977). This author further reported that the differences in the overall energy value of different feeds may result from digestibility of these fractions which differ from material to material. It is therefore, important to supply adequate dietary ME as other nutrients are usually included in the diet in proportion to the available energy. Failure to meet the engergy requirement for a particular production may result in nutrients wastage and impaired performance. On account of this, it is necessary to determine the energy content of feedstuff before it is fed to the birds.

From another point of view, the inert nature of fibre and its low ME value are taken as an advantage to limit energy consumption in feed restriction programme.

2.7 Restricted feeding

Restriction of feeding by rearing pullets on a low plane of nutrition is a common practice in order to bring down the cost of feed and or delay sexual maturity for improving laying house performance of the birds. Restricted feeding results in lower nutrient intake and is usually achieved with one of four different methods as outlined by MacIntyre and Aitken (1959), these are

- Limiting feeding time
- Restricting quantitatively the intake of a standard ration
- Feeding low protein or imbalanced ration in respect of certain amino acids
- Feeding low energy diets

Restriction by whatever technique was found to reduce rearing cost, delay the onset of lay and often produce larger eggs and with more sustained laying ability (Holland and Gowe, 1961).

According to Gowe **et. al.** (1960) and Holland and Gowe (1961) restriction acts as a mild stress which stimulates greater development of endocrine glands. During the laying period this stress is removed and the birds respond by achieving a higher rate of lay and greater resistance to environmental stress. Snestsinger **et al** (1974) and Mbugua and Cunningham (1983) observed that egg production can be maintained when energy intake is restricted by not more than 6%, but beyond this a significant depression in production results.

Restricting energy often involve inclution of low energy ingredients such as

fibre to act as diluent in the diet. Unfortunately, moderate reduction in energy content of the diet are usually offset by higher feed intake which may sometimes result in a greater rearing feed cost. Moreover, diets sufficiently low in energy to cause decrease in caloric intake will involve purchasing and handling of very large proportion of non-nutritive or fibrous material that will serve as diluent. In a reivew work, Lee **et. al**. (1971) reported that high levels of diluents is required to bring about delay in sexual maturity. At this level of inclusion, the authors explained that the total cost of rearing is greater than with normal diet unless the diet can be obtained for less than 10% of the cost per unit weight of a grower diet. Feeding low energy fibrous diet is therefore, not an economical venture. A cost saving of only 18.8% was observed by El-Kotoury **et. al**. (1977) with bulky feed compare to 36.4% for the control feed in Fayoumi chicks.

However, restriction is usually accompained by decrease in body weight which is reported (MacIntyre and Aitken, 1959) to be rapidly made up when the birds go on full feed in the laying house and subsequently lay at a higher rate. Therefore, including fibre as means of restricting energy has some beneficial effect.

2.7.1 Effects of restriction with fibre on growing pullets

The main objective of feed restriction is to reduce body weight of the pullets at maturity. Dilution of rations by inclusion of high levels of fibre has been reported to reduce body weight by several researchers (Issachs **et al**., 1960; MacIntyre, and Aitken, 1959; Sibbald and Morse, 1984; Kondra **et. al**., 1974; Dvorak and Barry, 1979). At lower mature body weight, less feed will be required for body maintenance thus improving the efficiency of conversion of feed to eggs. The laying performance of restricted birds was reported by Cumming (1972) to vary with their

weight at the end of restriction period. This author suggested that in any feed restriction programme, the objective should be to produce pullets of 25% less weight than full fed birds at point of sexual maturity. The benefit derived from the restriction is usually carried over to manifest in the laying house. The level of rearing restriction was however, reported by Watson (1974) to be unimportant over a wide range in bringing about production response.

The delay in sexual maturity observed in birds fed high fibre diet may possibly be due to the low concentration of energy and other nutrients in the fibrous diet which could bring about slow physiological development. The advantage of the delay is that the birds become fully mature before they embark on productive activities which enables them to lay at a higher rate. Age at first egg and age at specified level of egg production such as 5%, 25% or 50% may be taken as measures of sexual maturity (Sekoni, 1987). Some reports however, have shown that restricted feeding does not affect the ages of attaining these levels of production. Hutchai and Al-Neor (1987) observed no significant differences among restricted and unrestricted birds with respect to age at first egg and age at 50% production. This is in agreement with earlier findings of Ewing (1963) and Obeka (1985) who reported no significant differences in the age at 50% egg production between birds fed various levels of fibrous rice offal to replace up to 80% maize in the diet.

At any rate, the extent of delay in sexual maturity was reported (Abu-Serewa, 1975; Mbungua and Cunningham, 1983) to depend on the type of birds and severity of restriction. When the level of fibrous material reached 40-50% of the total diet, Isaachs **et. al**. (1960) observed retarded growth and delay in onset of lay. However, including rice offal at a level of 27.9% in grower diet was found to have no adverse

effect on growth rate or age at sexual maturity (Obeka, 1985). Similarly, Bullock **et. al**. (1963) observed that including 30% fibre in form of oat husks resulted in no delay of sexual maturity. It seems therefore, that the delay in sexual maturity is dependent upon severity of restriction or level of fibre included. On the other hand, Lee (1971) in a review work reported that there is a significant association between weight at the end of the rearing period and delay in sexual maturity.

Most workers reported no significant effect of restriction on mortality. However, Bullock (1962) cited by Lee (1963) reported that restricted birds had lower mortality in the laying house.

Following the several studies on feed restriction during rearing, there is a general agreement among researchers that feed restriction particularly with fibre reduces body weight of birds and results in delayed sexual maturity. The level of restriction determines the level of reduction in the mature body weight and the degree of delay in sexual maturity (Bullock **et. al.**, 1963; Cunning, 1972; Watson, 1974; Kondra **et. al**., 1974; Mbugua and Cunningham, 1983).

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2.7.2 Effect of restriction with fibre on laying house performance

Pullets that have reduced body weight resulting from high fibre rearing diets exhibit compensatory growth and lay eggs at a higher rate when they go on full feed in the laying house.

Addition of 40% fibre to the diet of both the meat and egg type chickens between the age of 15-21 weeks was observed to increase the body weight and rate of lay during the laying phase irrespective of whether a high or low fibre diet was fed during the laying period (Kondra **et. al**, 1974). In contrast, Waldroup **et. al.** (1966)

found that feeding 15% fibre at growing stage had no effect on the performance of broiler chickens in the laying phase. These authors also reported that high fibre growing diets resulted in significantly higher hen-housed egg production and lower mortality. Smilarly, Bullock **et. al.** (1963) reported no significant effect on egg production of pullets that were previously restricted in energy and protein intake during the growing phase. However, the restricted birds reached a higher peak though later than the control group and thereafter showed slower decline. Contrary to this, Wells (1980) found egg production to be influenced more by pattern of growth during rearing phase than the body weight attained at the end of the rearing period. He also observed that the heaviest birds between 18-20 weeks came into lay first and produced the highest number of eggs between 20-40 weeks. In another experiment, Shanawany (1983) reported egg production to be related to age at 50% lay. He obtained a linear regression of egg output on age at 50% lay between 142-160 days, thereafeter only a little further change was observed.

Reports from various sources have shown that restriction is only beneficial when it is administered during the rearing period (Kondra **et. al.**, 1974; Balnave 1978; Aukland and Wilson, 1975; Robinson **et. al.**, 1978). Feeding high fibre diets during the laying period usually results in impaired performance. In the study carried out by Balnave (1978), restricted feeding during laying period subsequently reduced the feed intake and also had a detrimental effect on rate of egg production and total weight of eggs produced when compared with those restricted during the growing phase. Robinson **et. al.** (1978) also observed that birds that were restricted in the rearing period laid 7.3% more eggs on hen-day basis, suffered 8.3% less mortality and produced 19.3% more eggs per hen-housed than those restricted in the laying

period. In another experiment, Aukland and Wilson (1975) found that daily energy restriction of 11 to 13% from 32-48 weeks of age resulted in depressed rate of lay of light hybrid strain by 11% and that of medium hybrid by more than 5%. Correspondingly, the egg weight were depressed by 4% and 2% respectively. The reports from Kondra **et. al.** (1974) also revealed that the birds fed high fibre diet during the growing period and later fed basal ration in the laying house converted feed to eggs more efficiently than those fed high fibre ration during the laying phase. In addition these authors found feeding up to 20% fibre during breeding period depressed rate of lay and feed efficiency but had no effect on the weight, quantity, fertility and hatchability of the eggs.

From the several reports reviewed, it is obvious that fibre has some beneficial effects in poultry feeding. In order to exploit these benefits and particularly reduce feed cost so as to bring down the prices of poultry products, various fibrous feed ingredients are being evaluated by researchers for their potentialities as substitutes for grains in poultry nutrition.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Proximate analysis and Metabolizable energy determination of Maize Cobs (MC)

3.1.1 Proximate analysis

The maize cobs used for this analysis was collected from National Animal Production Research Institute (NAPRI) maize farm and a private farm, both in Shika, Zaria.

From each of the two sites, three samples were taken randomly from different sides of the pile. The subsamples from each site were bulked and milled in a hammer mill. The two samples of the MC were analysed for nitrogen (N) by the automated Kjedahl method. Crude protein was then calculated by multiplying the percent nitrogen by 6.25. The samples were also analysed by the method of Association of Analytical Chemists, (A.O.A.C., 1975) for dry matter, ether extract (EE), ash and crude fibre. Nitrogen free extract (NFE) was calculated by difference.

Neutral detergent fibre (NDF), Acid detergent fibre (ADF) and lignin were also determined by the method of Van Soest (1963). The hemicellulose and cellulose were calculated as the difference between NDF and ADF and the difference between ADF and lignin respectively. In addition the samples were digested with perchloric acid and analysed for phosphorus by colorimetary. Calcium, mangnesium, sodium, manganese, zinc, iron, copper and potassium were also determined by atomic adsorption spectrophotometry.

3.1.2 Metabolizable Energy Determination

Metabolizable energy was determined by the conventional total faecal collection method.

Eighteen cocks were fed a commom diet for an adjustment period of four days followed by 24 hours fasting to empty the gut of food residues. The birds were then randomly allocated to three groups of six cocks. Each group of six cocks was for each of the three treatments. Every treatment group was subdivided into three to permit 2 cocks per replicate. The cocks were caged individually leaving an empty cage space between each replicate of 2 cocks. Feathers around the vent of the birds were removed to prevent contamination of droppings by feathers. Polythene sheets were securely tied under each cage housing the cocks to collect all the excreta.

The first group (control) was fed the basal diet, the second group a diet containing 60% basal diet and 40% MC while the third group was given a negative treatment (that is, no feeding for 3 days in addition to the initial 24 hours fasting period for all the groups). Composition of the basal diet and that of 60% basal + 40% MC are given in table 2 . Weighed quantities of the basal and test diets were fed to the first and second groups respectively for 3 days. This was followed by another 24 hours of fasting for all the groups so as to allow the guts to be completely emptied. Faecal droppings from each cock were collected on the polythene sheets daily starting immediately when the feeding commenced and continued for four days up to 24 hours after feeding had stopped. The collection of the faeces was terminated exactly 24 hours after the feeding was stopped.

Table 2

Composition of the basal diet for the ME study

Ingredient	Quantity (%)
Maize	78.17
Groundnut Cake	18.28
Bone meal	3.00
Salt	0.30
Vit/trace minerals premix	0.25
Total	100.00

The experimental diet for the ME study was mixed with 40% ground maize cob and 60% basal diet.

The daily faecal collection for the four days for each replicate group were bulked and dried in the oven at 70°C for 24 hours. The dried faecal samples and samples of the two diets were ground and analysed for nitrogen. The samples were also combused in a Gallenkamp automatic adiabatic oxygen bomb calorimeter for gross energy determination. The metabolizable energy of the basal diet was then calculated by the following equation (Sibbald, 1975).

$$ME_X = \frac{FE_X - EE_X}{FC_X}$$

where

ME_x = Metabolizable energy of basal diet

FE_x = gross energy of the total feed consumed (Kcal/kg)

EE_x = gross energy of the total excreta output(Kcal/kg)

FC_x = total feed consumption (kg)

The metabolizable energy of the treatment diet (60 percent basal diet and 40 percent MC) was determined by the following equation (Din **et. al.**, 1979).

$$ME_Y = \frac{FE_Y - EE_Y}{FC_Y}$$

where

ME_y = Metabolizable energy of 60 % basal + 40% Mc diet

FE_y = gross energy of the total feed consumed (Kcal/kg)

EE_y = gross energy of the total excreta output (Kcal/kg)

FC_y = total feed consumption of the 60% basal diet and 40% maize cob (kg)

If the ME of the basal diet x = a Kcal/kg and the ME of the 60% basal + 40% MC diet y = bKcal/kg, the apparent metabolizable energy (AME) of MC was calculated using a simple algebraic equation (Offiong 1984).

$100X = aKcal$

$$X = \frac{aKcal}{100}$$

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$60X + 40y = bKcal$

$$60\ \frac{a}{100} + 40y = bKal$$

$0.6a + 0.4y = bKcal$

$$y = \frac{b - 0.6a}{0.4}$$

$$\therefore \ AME \ of \ MC \ (ME_m) = \frac{b - 0.6a}{0.4}$$

The AME was corrected for nitrogen to get the Apparent metabolizable energy nitrogen corrected (AMEn) using the formula given by Sibbald (1979)

AMEn = AME - (gN/g feed - gN/g faeces)Kcal/kg

True metabolizable energy nitrogen corrected (TMEn) was also calculated with the following formula (pearson 1982)

$$TME_n = \frac{FE_t - (EE_t + 8.22N_t) + (EE_u + 8.22N_u)}{FC}$$

where

FE_t = Gross energy of the total feed consumed

EE_t = Gross energy of excreta from the fed birds

EE_u = Gross energy of excreta from unfed birds

N_t = Nitrogen retained by fed birds

N_u = Nitrogen retained by unfed birds

FC = Weight of feed consumed by fed birds.

EXPERIMENT I

3.2 Determination of the replacement value of maize cobs (MC) for maize in chick diets

This experiment was carried out with egg-type chicks from day-old to seven weeks of age to determine the replacement value of MC for maize in chick diets.

Three hundred and fifteen chicks were allocated randomly to twenty one floor pens. Each pen with a space of $4.27m^2$ contained fifteen chicks. Wood shavings served as the litter material and old zinc sheets were used to cover the open sides of the house in order to conserve heat. In addition, one 100-watts electric bulb was placed in each of the pens and four kerosine stoves in the middle passage of the pens to provide heat for the chicks in the brooder pens.

Seven chick diets were formulated to contain 20% CP with MC included at 0, 5, 10, 15, 20, 25 and 30 percent levels. These levels replaced 0, 9.46, 18.68, 28.0, 37.26, 46.54 and 55.80 percent maize respectively. The ingredient composition, chemical analysis and calculated analysis of the experimental diets are given in table **3**.

statistically tested for significance using Duncan's multiple range test as described by steel and Torrie (1967) at 5% level.

EXPERIMENT II

3.3 Determination of replacement value of maize cobs for maize in the grower diets.

This experiment was divided into two phases. There was the growing phase from 8 - 20 weeks of age during which the experimental diets were fed. The laying phase was the second phase when a common layer ration was fed to all the groups from 20 to 36 weeks of age in order to determine the effect of the growing phase MC dietary treatments on the subsequent early laying performance of the pullets.

- **Growing phase (8 - 20 weeks)**

Two hundred and seventy three, 8-week old pullets were utilized for this experiment to determine the optimum level of MC for the grower diets. Thirteen pullets each were randomly allocated to one of the 21 deep litter floor pens. Seven isonitrogenous (15% CP) grower diets were formulated with MC included at graded levels of 0, 10, 20, 30, 40, 50 and 60 percent of the diets. These levels replaced 0, 15.52, 31.05, 46.56, 62.09, 77.61 and 93.13 percent maize respectively. Each of the seven experimental diets were assigned at random to three pens which stood as the number of replicate for each of the dietary treatments. The ingredient composition, chemical analysis and calculated analysis of the experimental diets are shown in Table 4 Feed and water were provided **ad libitum**. The feeding trial lasted for 12 weeks. Feed intake, body weight gain and feed conversion efficiency were determined every two weeks. Feed cost was also calculated and mortality was recorded as it occured.

At 20 weeks of age when the feeding trial was terminated, two pullets from each replicate were randomly selected, weighed, sacrificed and dissected. The intestines and caeca were removed and cleaned of their contents. Length of the straightened out intestines as well as the length of the caeca were measured. In addition, a cross section of the duodenum was taken at the same position for all the samples. Slides of the duodenal sections were prepared and examined under a photomicroscope for villi abrasion. Pictures of the villi abrasions were taken from the slides on the photomicroscope.

Laying phase (20 - 36 weeks)

In the laying phase, the number of pullets for each replicate group from phase I were reduced to a uniform number of 10 per replicate and transfered in their original groups into battery cages. Each cage accommodated two birds and they were fed a common 17% layer diet. Ingredient composition, chemical composition and calculated analysis of the diet are shown in table 5. This phase of the experiment lasted for four 28-day periods. Feed intake was determined at 28-day interval and mortality was recorded daily as it occured. For three consecutive days towards the end of each 28-day period, all eggs laid by each replicate were collected and weighed. Other parameters measured include final body weight, percent change in body weight, ages at 10% and 50% egg production, age at peak of egg production, percent egg production at peak, percent hen-day and hen-housed egg production as well as feed conversion efficiency and feed cost per 10 eggs produced.

The data collected from the two phases were subjected to the analysis of variance and the means were separated by Duncan's multiple range test (Steel and Torrie, 1967).

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Table 4: **Composition of the grower rations for Experiment II fed between 8 - 20 weeks**

	Treatment/Level of maize cob meal (%)						
Ingredients	0	10	20	30	40	50	60
Maize cobs	0	10	20	30	40	50	60
Maize	76.23	64.40	52.56	40.74	28.90	17.07	5.24
Groundnut cake	8.67	10.51	12.34	14.17	16.00	17.83	19.66
Soyabean cake	10	10	10	10	10	10	10
Bone meal	3	3	3	3	3	3	3
Limestone	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Salt	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Vitamin/trace minerals premix	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Calculated analysis							
Metabolizable energy (Kcal/kg)	3111.14	2929.17	2743.61	2558.73	2343.17	2189.95	2002.73
Crude protein %	15.00	15.001	15.004	15.006	15.00	15.00	15.02
Crude fibre %	1.98	5.15	8.31	11.49	14.65	17.83	20.99
Calcium %	0.94	0.95	0.96	0.97	1.25	1.26	1.27
Phosphorus %	0.70	0.69	0.67	0.65	0.63	0.61	0.49
Lysine %	0.65	0.67	0.69	0.71	0.73	0.75	0.77
Methionine %	0.26	0.31	0.35	0.39	0.44	0.48	0.52
Chemical analysis							
Crude protein	15.05	15.01	15.08	15.04	15.09	15.03	15.07
Crude fibre	2.67	5.33	9.12	12.09	15.64	18.25	23.55
Ether extract	4.00	4.18	4.25	4.29	4.34	4.51	4.65
*Nitrogen free extract	67.46	60.29	53.36	48.93	39.92	35.50	29.97
Ash	7.86	10.98	13.93	14.64	17.35	18.81	19.28

* Calculated by difference

Pfizer Agricare grower premix furnished the following ingredients per kg ration: Vit. A, 12000IU; Vit. D3 2640kg, Vit.E, 121IU; Vit. K, 2.4mg, Vit B1 0.6mg; Vit B2 0.4mg, Vit B6, 3.6mg; Nicotinic acid, 26.4mg; calcium pantothenate, 9.6mg, Vit. B12.4 mg; choline chloride 240 mg; Mn, 120mg, Fe, 60mg; Zn, 54mg; Cu,2.4mg, I, 1.8mg, Co, 0.27mg, Se, 0.12mg

Table 5: **Composition of ration fed during the laying phase of expeiment II**

Ingredients	Quantity (%)
Maize	44.07
Maize offal	20.00
Groundnut cake	24.73
Bone meal	3.00
Limestone	7.50
Salt	0.30
Methionine	0.15
Vitamins/trace minerals premix	0.25
Total	100.00
Calculated analysis	
Metabolizable energy (Kcal/kg)	2252.55
Crude protein %	17.05
Crude fibre %	6.72
Calcium %	3.26
Phosphorus %	0.81
Lysine %	0.4
Methionine %	0.38
Chemical analysis	
Crude protein	17.73
Crude fibre	6.81
Ether extract	5.91
*Nitrogen free extract	47.66
Ash	17.62

* calculated by difference

Pfizer Agricare layer premix furnished the following ingredients per kilogram of ration: Vit. A, 10,000IU; Vit. D, 2500IU; Vit. E, 12IU, Vit. K,, 2mg, Vit. BI, 1mg; Vit. B2 45mg, Nicotinic acid, 25mg, calcium D pantothenate 10mg; Vit.B6, 3mg, choline chloride, 300mg, Vit. B12 14.4 IUg, Folic acid 0.3mg, Mn, 100mg; Fe, 50mg, Zn 45mg, Cu, 2mg, I, 1.55mg, Co, 0.25mg, Se 0.1mg

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Metabolizable energy and nutrient composition of maize cob (MC)

The results of the chemical analysis of the MC is presented in Table 6. The apparent metabolizable energy (AME) apparent metabolizable energy nitrogen corrected (AMEn) and true metabolizable energy nitrogen corrected (TMEn) of the cobs were found to be 751.68 Kcal/kg, 705.57 Kcal/kg and 688.96 Kcal/kg respectively.

The AME value is higher than that of AMEn because correction was not made for nitrogen. However, body nitrogen when catabolised is excreted as energy containing product as such when the AME was corrected to bring the AME to a nitrogen equilibrium it reduced from 751.68 kcal/kg to 705 kcal/kg. In the AME, it was also assumed that all energy excreted in the faeces comes directly from the feed. It was however reported by Sibbald (1977) that metabolic faecal energy (FEm) comes from metabolic products like bile, digestive juice and cells linining the gastrointestinal tract. Urine also contain additional products of tissue break down during maintenance or endogenous urinary energy (UEe). When AME was corrected for FEm and UEe loss at nitrogen equilibrium TMEn value of 688.96Kcal/kg which is lower thanAME and AMEn was obtained. The AME value of 751.68 Kcal/kg obtained in this study is higher than 708 Kcal/kg reported by Longe and Adetola (1983). Different methods were probably employed in processing the maize ear for the cobs utilized in the two studies hence the differences in the ME values.

Result of the nutrient composition of MC indicates that MC is very low in protein and high in fibre. The average crude protein and crude fibre contents of

2.47% and 32.22% are very close to those reported by National academy of Science, U.S.A. and Canada (1964), Crampton and Harris (1969), Fetuga **et al.**(1975) and Babatunde et **al** (1975). However, these values are higher than 1.8% and 28.4% obtained by Longe and Adetola (1983) and lower than 3.34 and 41.44 percent reported by Alokan (1988).

For NFE, the value of 57.73% is close to 56.1% reported by Babatunde **et.al** (1975) but higher than 50.4% and 51.64% obtained by Schrimpf **et.al.** (1966) and Alokan (1988) respectively. Ether extract content of 1.66% and 5.16% ash are higher than all the values reported in the literature except 5.7% and 6.2 % ash obtained by Longe and Adetola (1983) and Babatunde **et al** (1975). The calcium and phosphorus values of 0.15% and 0.075% are close to 0.16% and 0.06% reported by Fetuga **et al.** (1975) and Babatunde **et al** (1975). Other minerals determined also had similar values with those reported by Crampton and Harris (1969) and Fetuga **et al** (1975). It is therefore obvious that the nutrient composition of MC in this study is similar to what was obtained in the literature. The similarities may be due to the same or similar methods of harvesting and threshing the crop. Alokan (1988) had reported that pre and post harvesting management processes are responsible for variation in the nutrient composition of maize cobs.

In conclusion, the nutrient composition of the MC from the two samples (NAPRI and Private farm) were similar in most respect to what is in the literature. However, it is still advisable to subject samples of MC from different sources to chemical analysis to determine the exact composition so that balanced rations can be formulated with this byproduct.

Table 6. Nutrient composition of maize cobs

	Sample source		
Nutrient (%)	NAPRI	Private farm	Mean
Dry matter (DM)	94.28	95.25	94.77
CP	2.54	2.40	2.47
CF	32.19	32.25	32.22
NFE	58.95	56.50	57.73
EE	1.5	1.82	1.66
Ash	5.3	5.01	5.16
P	0.08	0.07	0.075
Ca	0.14	0.16	0.15
Mg	0.09	0.05	0.07
Zn	0.004	0.003	0.0035
Mn	0.0025	0.003	0.0028
Fe	0.02	0.027	0.024
Cu	0.001	0.001	0.001
K	0.84	0.96	0.9
Na	0.08	0.06	0.7
NDF %	82.88	84.7	83.79
ADF %	46.59	46.5	46.55
Lignin %	9.72	9.81	9.77
Hemicellulose %	36.29	38.20	37.24
Cellulose %	36.87	36.69	36.78

4.2 Effect of maize cobs on the performance of chicks

The results of the feeding trial with chicks from day old to 7 weeks of age is presented in Table 7. The overall result indicates that MC has negative effects on the performance of chicks for all parameters tested except feed cost and rate of mortality. Feed intake increased with increase in the level of MC but there were no significant ($P>0.05$) differences in the feed consumption of the control group and those fed 5 and 10 percent MC. Feed intake of the chicks fed 5 percent MC was also significantly ($P<0.05$) different from those of 10, 15 and 20 percent. There were also no significant ($P>0.05$) differences in feed intake of chicks fed 20, 25 as well as 30 percent MC. Mean final body weight and weight gain values of 466g and 423g for the control birds were significantly ($P<0.05$) higher than those fed the different levels of MC. There were no significant differences ($P>0.05$) for final weight and weight gain of chicks fed diets containing 5, 10, 15 and 20 percent MC. The values of feed intake, final body weight and weight gain of chicks fed 20 percent MC were significantly ($P<0.05$) better than of those fed 25 and 30% MC diets.

Feed Gain Ratio (F.G.R.) got poorer with increasing level of MC in the diet. The chicks fed control diet had significantly ($P<0.05$) better F.G.R. compared to the chicks fed various levels of MC. However, feeding 5 to 20 percent of MC gave no significant ($P>0.05$) differences in the F.G.R. The F.G.R. value of chicks fed 20% MC was significantly ($P<0.05$) better than for those fed 25 percent MC which was not significantly ($P>0.05$) different from those fed 30 percent MC diets.

Mortality was generally low and occured only in chicks fed 15 and 25 percent MC diets.

Table 7: Performance of chicks fed graded levels of ground maize cob from 0 - 7 weeks

	Treatment/Level of MC (%)							
Parameter	0	5	10	15	20	25	30	SEM
Number of birds	15	15	15	15	15	15	15	-
Feed intake(kg/bird)	1.42[a]	1.45[ab]	1.48[ab]	1.50[bc]	1.53[bcd]	1.57[d]	1.56[d]	0.08
Initial weight (g/bird)	43	43	43	43	43	43	43	-
Final weight (g/bird)	466[a]	427[b]	420[b]	415[b]	402[b]	373[c]	353[c]	0.007
Weight gain (g/bird)	423[a]	384[b]	377[b]	372[b]	359[b]	330[c]	310[c]	0.007
F.G.R.	3.37[a]	3.80[b]	3.92[b]	4.03[bc]	4.26[bc]	4.77[d]	5.06[d]	0.01
Feed cost (₦/bird)	9.96[d]	9.94[d]	9.82[cd]	9.71[bc]	9.61[bc]	9.55[ab]	9.19[a]	0.80
Mortality (no of birds)	0	0	0	1	0	1	0	-

1. Means on the same row with different letter superscripts differ significantly ($P<0.05$).
2. SEM = Standard error of the mean
3. F.G.R = Feed Gain Ratio

The feed cost (₦/bird) decreased with increase in the level of MC. Feed cost of the control diet was not significantly ($P>0.05$) different from the values obtained for the 5 and 10 percent MC diets. Higher levels of MC (15% and above), resulted in significantly ($p<0.05$) lower feed cost per bird when compared with control diet.

The chicks in this study were obviously unable to tolerate up to 4% crude fibre in the diet when MC is the source of fibre. This observation is contrary to the report of Ewing (1963) that the amount of fibre in the ration of poultry can be increased to 8 or 9 per cent with desirable effect on chick growth, mortality, feed consumption and egg production. The present observations also contradicts El-Abbady et. al. (1970) who reported that female Baladi white chicks could tolerate between 4 to 7 per cent fibre until the age of 8 weeks without adverse effect on either mortality or body weight. However, it is in close agreement with findings of Sibbald and Morse (1984) who obtained graded decline in mean pen weight of the birds with increase in dietary fibre.

The reduced body weight gain and poor F.G.R. observed with MC diets is probably due to the deleterious effect of the fibre in the diet.

MC being fibrous could cause poor F.G.R. and reduced weight of the chicks due to its high rate of passage and poor digestibility. Ranjhan (1980) attributed the poor digestibility and absorption of fibrous diet to its laxative effect which causes a high rate of passage and does not allow enough time for the digestive and absorptive processes. Digestibility of fibre was also reported by Farrel and Johnson (1972) to depend on its source and amount of lignification. The lignin content may block other nutrients in the MC and render them unavailable. This will undoubtedly result in poor F.G.R. and reduced body weight. According to Tuah and Orskov (1985) as reported by Tuah **et al**. (1987), binding of hemicellulose with lignin is responsible for the low dry matter digestibility of maize cobs in ruminants. Moreover, El-Kotoury **et al**. (1977) reported amino acids, minerals and other nutrients to be tied down by dietary fibre.

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On the other hand, the increase in the feed consumption of the chicks fed the MC diets could be attributed to the gradual decrease in the ME of the diets. The calculated ME of the rations dropped gradually from 3007.97 Kcal/kg for the control to 2451.30 Kcal/kg for the diet containing the highest level (30%) of MC. This is in conformity with the findings of Hill and Dansky (1954), Scott and Forbes (1958), Dvorak and Barry (1979) and Abdulsamie **et al** (1983). These workers reported increase in feed intake with increase in the dietary fibre in an attempt by the birds to maintain a constant level of energy intake. The feed consumption observed with MC diet beyond 25% level is in close agreement with reports of Scott and Forbes (1958) that addition of fibre in form of cellulose was accompained by a linear increase in dry

matter intake up to 24%, but above this level, the weight of feed consumed per chicken decreased. This decrease in feed intake observed at 30% dietary MC level may be due to the limitation of the gut to accomodate the bulky feed.

Mortality observed in this experiment showed no relationship with the dietary treatments. The decrease in cost (₦/bird) of feed for raising a chick up to seven weeks of age is because MC is cheaper than the maize it largely replaced in the diet. However, it is not economical to use MC in the diet since it has resulted in poor performance of the chicks.

In conclusion, although dietary level of MC resulted in reduced feed cost per bird reared from 0 to 7 weeks of age, poor performance of the chicks in terms of reduced growth rate and poor F.G.R. observed in this experiment makes the MC undesirable feed ingredient for chick ration formulations.

4.3 Performance of Pullets fed graded levels of maize cobs (MC) between 8 and 20 weeks

The performance of pullets fed various levels of MC during the rearing period is presented in table 8 and the photomicrographs of villi abrasion on pages to (plates i - vii).

Regression analysis of feed consumption showed a significant ($P<0.05$) increase in feed intake with increase in dietary level of MC. The predictive equation is

$$Y = 5.98 + 0.013(X-\overline{X})$$

where

Y = is the feed intake to be predicted

5.98 = mean of Y or $\bar{Y}$

X = any level of MC that feed intake is required to be predicted for.

$\bar{X}$ = mean of X = 30

0.013 = regression coefficient

R^2 (Coefficient of determination) value which gives an estimate of the accuracy of the prediction is 0.81 or 81%.

The final body weight, weight gain and FGR were not significantly ($P>0.05$) affected by dietary MC up to 20% level. Dietary levels of MC between 30 to 60 percent resulted in significantly $P<0.05$) lower gains and poorer FGR than the control.

Pullets fed MC diets had significant ($P<0.05$) increase in length of intestines and caeca. There were however, no significant ($P>0.05$) difference between the length of intestines of pullets fed 50% and 60% MC in the diet. The caeca became significantly ($P<0.05$) longer than that of the control group when the dietary MC reached 20% level and it continued to increase up to the highest level of 60% MC. Cross section of the doudenum showed a progressive increase in the villi abrasion with increase in the dietary level of MC. This trend of increased abrasion with increase in the level of MC is obvious from the photomicrographs. (plates i-vii)

Mortality occured only in the control group and also in the group with highest level (60%) of MC in the diet. Feed cost was significantly ($P < 0.05$) reduced by dietary levels of MC. The control diet resulted in significantly ($P < 0.05$) higher feed cost (₦/bird) compared to all the other diets.

From these observations, it is very clear that MC at 10 and 20 percent levels supported satisfactory growth and FGR of the pullets. The amount of crude fibre contributed to the diets at the lower levels of dietary inclusion of MC could have promoted enzymatic digestion and consequently resulting in better absorption of the feed nutrients hence similar perfomance with control. Fibre in the feed has been reported by King (1961) to stimulate peristaltic movements and enzymatic secretion and also helps to open up concentrated feeds so that digestive juices can make better contact with them.

Pullets fed MC showed a high degree of anatomical adaptation through increases in the lengths of intestines and caeca. The adaptation observed with MC diets has undoubtedly contributed to the ability of the pullets to tolerate up to 20% dietary level of MC which was not possible for chicks between 0 and 7 weeks of age. Similar increases in lengths of the intestines and caeca were also obtained by Kondra **et al** (1974), Kamar **et al** (1978) and Savory **et al** (1992) in growing chickens and turkeys fed fibrous diets. At high dietary levels of MC considerable villi abrasions observed must have interfered with absorption of nutrients and hence poor performances of the birds. In conformity with this result, Hedge **et al**. (1978) reported that gut abrasion as a result of fibrous diets impaired performance of chicks.

Table 8: **Performance of Growing Pullets fed graded levels of ground maize cobs from 8 - 20 weeks**

Parameter	Treatment/level of MC(%) 0	10	20	30	40	50	60	SEM
Number of birds	13	13	13	13	13	13	13	-
Initial weight -(g/bird)	740	740	740	740	740	740	740	-
Feed intake (kg/bird)	5.62a	5.75^{b}	5.88^{c}	5.66^{ab}	6.13^{d}	6.36^{e}	6.37^{e}	0.03
Final weight (g/bird)	1532.67^{a}	1556.32^{a}	1528.00^{a}	1349.00^{b}	1337.67^{b}	1355.00^{b}	1231.00^{c}	1.57
Weight gain (g/bird)	792.67^{a}	816.32^{a}	788.00^{a}	609.00^{b}	597.67^{b}	615.00^{b}	491.67^{c}	7.87
FGR	7.10^{a}	7.040^{a}	7.45^{a}	9.86^{b}	10.25^{b}	10.34^{b}	12.96^{c}	0.17
Feed cost (N/bird)	35.24^{f}	33.83^{e}	32.40^{d}	29.04^{c}	29.10^{c}	27.79$_{b}$	25.43^{a}	0.14
Mortality (no. of birds)	1	-	-	-	-	-	3	-
Length of Intestine (cm)	115.67^{f}	121.79^{e}	126.2^{d}	140.0^{c}	148.47^{b}	150.70^{a}	150.93^{a}	1.1
Length of caeca(cm)	12.79^{d}	13.12^{d}	13.90^{c}	14.80^{b}	15.07^{b}	15.27^{b}	17.22^{a}	0.28

Means on the same row with different letter superscript are significantly different ($P < 0.05$)
SEM = Standard error of the mean
FGR = Feed Gain Ration.

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On the contrary, Rolls **et al** (1978) attributed the villi eruption to other factors like microbial activities rather than dietary fibre.

MC at lower levels does not appear to have any effect on mortality. The death of one bird from the control group was attributed to mild coccidiosis because blood stained dropping was observed only in a particular pen under that treatment. The death of three birds from 60% MC group is likely to be due to the severity of the treatment. The reduction of rearing feed cost observed with the MC diets in this study agrees with the reports of Holland and Gowe (1969) who stated that fibrous

diets significantly reduced the rearing cost of pullets.

From the results obtained in this experiment, it can be concluded that MC above 20% dietary level for growing diets has adverse effects on the performance of the birds. Such high MC levels resulted in higher increase in feed consumption, lower weight gains and poorer feed-gain ratio. The main advantage of the MC diets appears to be the reduction of rearing feed cost. However, because of the poor performance at high dietary levels, it is recommended that MC should not exceed 20% level in the growing diets.

Photomicrographs showing Villi abrasion from the duodenum of the Pullets fed graded levels of MC from 8 to 20 weeks

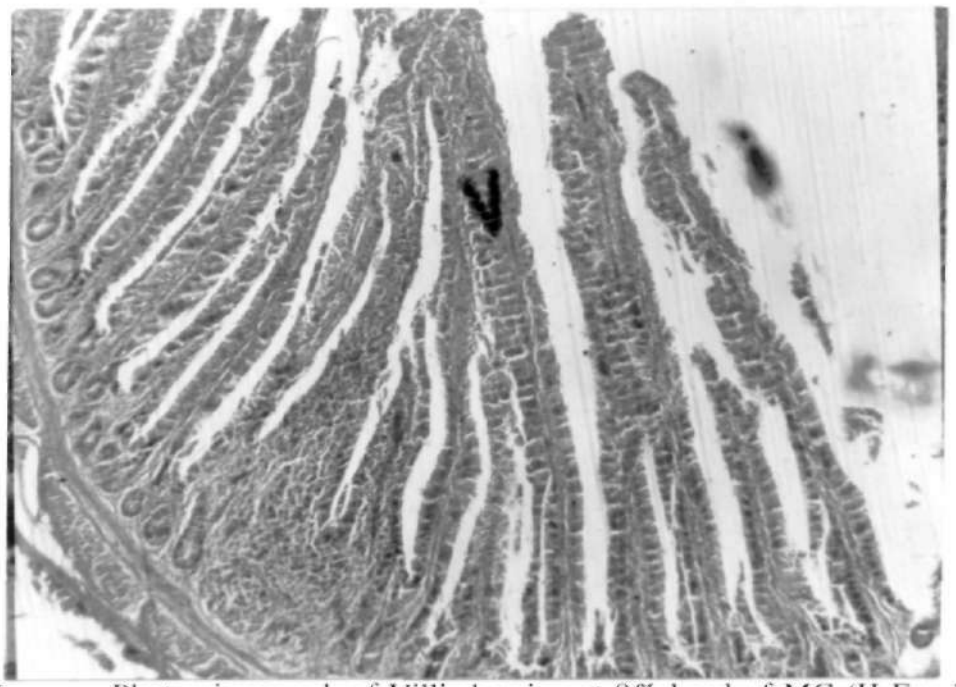


Plate I Photomicrograph of Villi abrasion at 0% level of MC (H.E x 100)

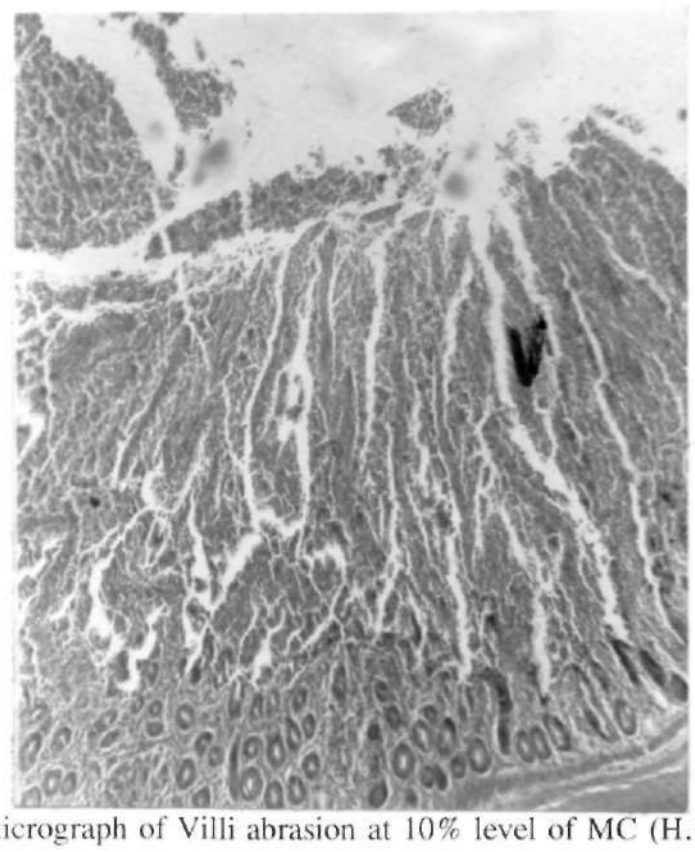


Plate II Photomicrograph of Villi abrasion at 10% level of MC (H.E. x 100)

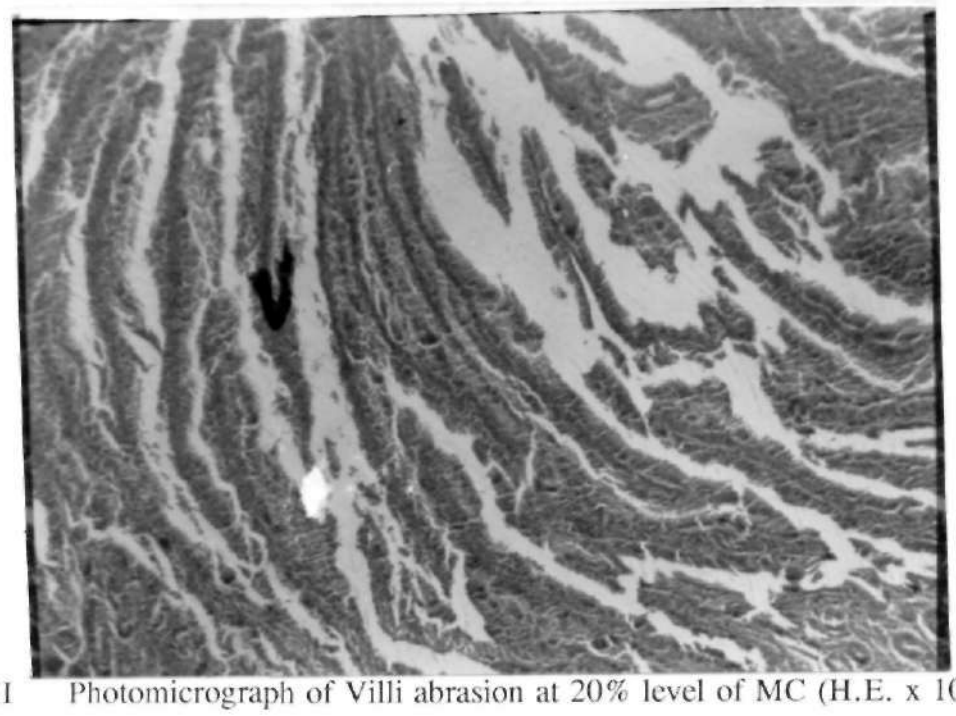


Plate III Photomicrograph of Villi abrasion at 20% level of MC (H.E. x 100)



Plate IV Photomicrograph of Villi abrasion at 30% level of MC (H.E. x 100)

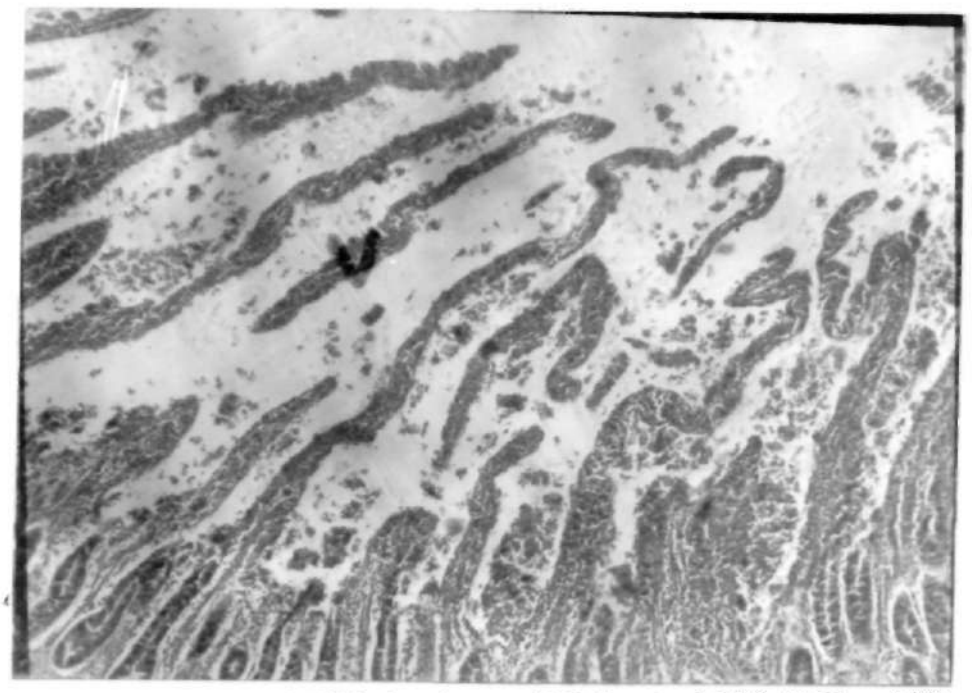


Plate V Photomicrograph of Villi abrasion at 40% level of MC (H.E. x 100)

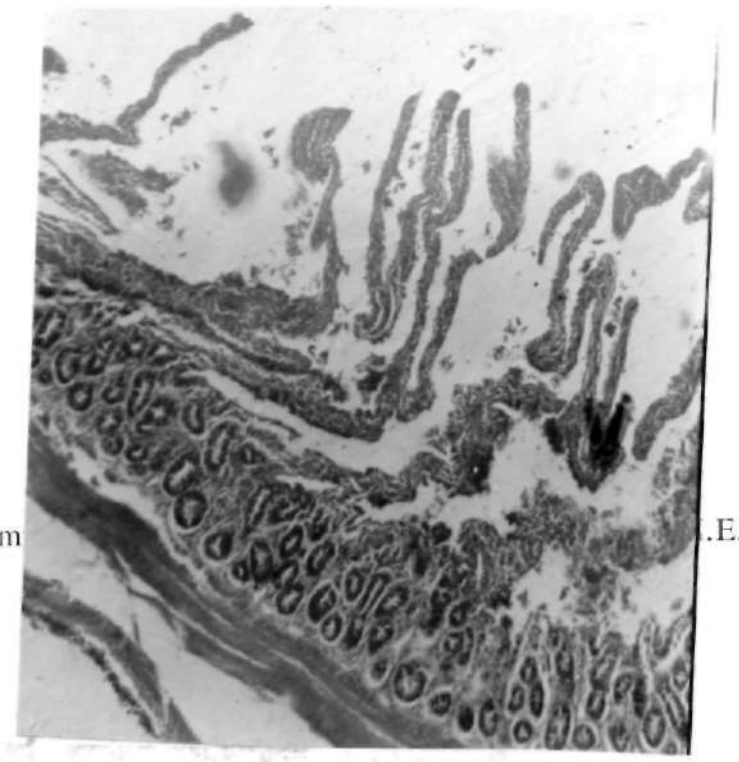


Plate VI Photom .E. x 100)

Plate VI Photomicrograph of Villi abrasion at 50% level of MC (H.E. x 100)

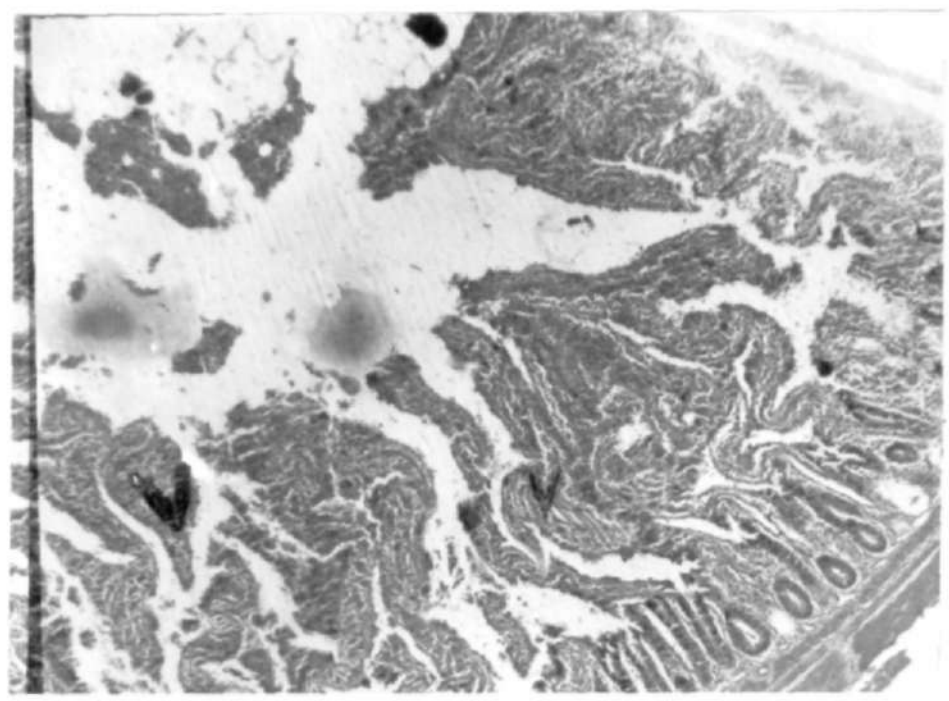


Plate VII Photomicrograph of Villi abrasion at 60% level of MC (H.E. x 100)

V = Villi

H.E =Haemotoxin and eosin stains

4.3.1 Effect of maize cobs growing diets on the subsequent early laying performance of pullets

The results obtained in the early laying phase of the pullets is summarized in table 9.

This table shows that feed intake during the early laying phase increased significantly with increase in the level of MC in their previous grower diets. The birds fed 60% MC grower diet had the highest feed intake ($P<0.05$). Feed intake of the birds previously fed 20% MC grower diet did not differ significantly ($P>0.05$) from the values obtained for the 30%, 40% and 50% dietary MC treatments. Dietary levels of MC above 20% of the grower diets had significant effect on body weight at 20 weeks of age. Pullets fed 60% MC grower diet had significantly ($P<0.05$) the lowest body weight compared to other groups. However, final body weight at 36 weeks of age was not significantly ($P>0.05$) affected by MC grower diets.

It was observed in this experiment that pullets fed high MC grower diets (30 - 60 percent) had higher percent change in body weight. Body weight change of 80.4%, 73.45%, 71.58% and 92.27% were obtained for 30%, 40%, 50% and 60% MC diets respectively, while the corresponding values were only 52.8, 52.3 and 60.4 percent for the control, 10% and the 20% MC diets. It is therefore, evident that pullets fed high dietary levels of MC in the growing diets exhibited compensatory growth. The explanation for this could be that the high MC grower diets were inadequate compared to those containing lower levels of MC and control, in maintaining satisfactory growth of the pullets during the growing phase. However, in the laying phase when the birds were switched over to the more nutritious 17% CP diet they grew very fast in an attempt to make up for the deficiencies of the growing phase. Evidence of compensatory growth is also obvious from the fact that those

pullets fed 30 to 60 percent MC grower diets were very light at 20 weeks of age, (weighing less than 1.4 kg for each treatment). By 36 weeks of age however, nearly all the treatments had made up for weight losses which brought them to the level of the control. This observation agrees with the report of MacIntyre and Aitken (1959) that body weight of restricted pullets is rapidly made up when they go on full feed in the laying house.

Age at 10% egg production was not significantly ($P>0.05$) affected by MC up to 20% level in the growing diets. Dietary MC level from 30% and above significantly ($P<0.05$) delayed age of attaining 10% egg production. There were no significant ($P>0.05$) differences for age at 50% egg production between groups fed the control diet and the MC diets up to 50% level. Only the group fed 60% MC grower diet had a significant delay ($P<0.05$) in attaining the age at 50% production. For the age at peak of egg production and production at peak, these two parameters were not significantly ($P>0.05$) affected by the growing phase dietary MC treatments. Percent hen-day egg production was satisfactory with dietary MC up to 30% level in the grower diets. For hen-housed egg production, there was a significant ($P<0.05$) improvement for the 20% dietary level of MC. As from 30% MC level upwards, there were significant reductions ($P<0.05$) in percent hen-housed egg production. For egg weight, birds fed 60% MC diet produced significantly ($P<0.05$) larger eggs than those fed other MC diets. The egg weight of the control group was however, not significantly ($P>0.05$) different from that of the 60% MC diet.

Table 9: **Effect of maize cobs growing diets on the subsequent early laying perfomance of pullets from 20-26 weeks.**

Parameter	Level of maize cob growing diets (%) 0	10	20	30	40	50	60	SEM
Number of birds	10	10	10	10	10	10	10	-
Initial wt (kg/bird at 20wks)	1.34[a]	1.36[a]	1.34[a]	1.16[b]	1.15[b]	1.16[b]	1.04[c]	0.018
Feed intake (g/bird/day)	132.86[a]	134.95[ab]	137.53[bc]	140.33[c]	140.50[c]	139.07[c]	151.5[d]	1.2
Final wt. (kg/bird at 36 weeks)	2.05	2.07	2.14	2.09	1.96	1.98	2.00	0.079
Change in body weight (%)	52.80[c]	52.30[c]	60.40[c]	80.40[b]	73.45[b]	71.58[b]	92.27[a]	3.74
Age at 10% egg production (days)	149.00[a]	146.00[a]	150.67[ab]	158.00[bc]	158.67[bc]	163.33[c]	165.33[c]	2.41
Age at 50% egg production (days)	173.33[a]	171.00[a]	169.00[a]	172.67[a]	173.33[a]	173.00[a]	182.67[b]	2.16
Age at peak of egg production (days)	235.69	228.76	233.31	242.69	238.00	240.31	247.31	0.29
Production at peak (%)	78.41	79.36	79.65	78.28	78.09	78.31	74.28	3.75
Hen day egg production (%)	56.47[a]	57.49[a]	57.14[a]	56.56[a]	50.89[b]	51.47[b]	49.28[c]	1.17
Hen-housed egg production (%)	54.49[b]	55.45[ab]	57.14[a]	52.74[c]	50.89[cd]	49.64[de]	47.85[e]	0.44
Mean egg wt. (g/egg)	58.21[b]	55.51[d]	56.77[c]	56.87[c]	56.34	58.41[b]	60.83[a]	0.20
F.C.E. (kg/feed/10 eggs)	2.17[a]	2.17[a]	2.15[a]	2.40[b]	2.59[c]	2.50[bc]	3.17[d]	0.24
Feed cost (₦/10 eggs)	12.75[a]	12.73[a]	12.89[a]	14.06[b]	14.67[b]	14.65[b]	16.83[c]	0.17
Mortality (no. of birds)	-	1	-	2	1	1	1	-

Means on the same row with different letter superscript are significantly ($p < 0.05$) different

SEM = Standard error of the mean

F.C.E. = Feed conversion efficiency

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Feed conversion efficiency (kg feed/10 eggs) was significantly ($P<0.05$) poorer when the MC exceeded 20% level in the diet. The 60% MC diet gave the poorest feed conversion efficiency ($P<0.05$). Feed cost (₦/10 eggs produced) was not significantly ($P>0.05$) affected by dietary MC up to 20% level but feed cost per 10 eggs produced were significantly ($P<0.05$) higher as from 30% dietary inclusion and above.

The birds that were heavier at 20 weeks of age attained 10% level of egg production earlier than the lighter birds. This suggests a positive correlation between body weight at 20 weeks and age of attaining 10% level of egg production. Lee (1971) also reported that there is a close association between body weight at the end of the rearing period and sexual maturity. The late attainment of 10% egg production by the 50% and 60% dietary MC treatment groups is likely to be due to the carry over effects of the high levels of MC growing diets that the birds had to overcome.

For age at 50% egg production, only the group fed 60% MC attained this level of production at a later age. However, the birds fed higher levels of MC were able to catch up with other groups and also reached the peak of egg production at about the same time with those on lower dietary levels of MC.

Although percent hen-day egg production was satisfactory with dietary MC up to 30% level, percent hen-housed egg production was only satisfactory up to 20% MC level . From this observation, it appears that the maximum dietary crude fibre level (mostly from MC) that can be tolerated in the grower diet is limited to 8.31%. Beyond this level, the early laying perfomance of the pullets is adversely affected. Contrary to this observation, broiler birds gave higher hen-housed egg production with up to 15% dietary fibre in their growing diets (Wadldrop, 1960). It was also observed in this experiment, that body weights at 20 weeks

of age were closely associated with the rates of egg production. Birds that were fed 20% or less of MC in the grower diets were heavier at 20 weeks of age and maintained higher rates of lay. In agreement with this observation, Wells (1980) also reported that heavier birds between the age of 8 to 20 weeks produced higher number of eggs. The larger eggs produced by the birds fed high levels of MC may be due to the delay in their ages at which egg production started but this explanation may not hold for the birds on the control diet which also produced large eggs despite the earlier onset of egg production.

The birds that were reared on 30% or more dietary levels of MC in the grower diets had high demands for feed for their compensatory growth. The need for compensatory growth is likely to be responsible for higher feed consumption of those groups of birds. In spite of the high intake, the feed conversion efficiencies (kg feed per 10 eggs) of the pullets were poorer. This may be explained by the fact that some of the feed consumed were being diverted for growth which is not being considered as a measure of the efficiency of feed utilization in this phase. It appears that a major portion of the feed consumed by those lighter pullets at the point of lay were diverted for rapid growth. This is evident from the fact that their low body weights were almost fully compensated for by the end of 36 weeks of age when the feeding trial was terminated.

Higher feed intake of the birds fed high levels of MC also resulted in high cost of feed per 10 eggs produced by these birds. The cost of feed for 10 eggs produced showed an inverse relationship with weight of the birds at the end of the rearing period because the ligher birds consumed more feed in order to satisfy their needs for active growth and egg production. Mortalities in the laying house were generally very low and did not show any relationship with MC dietary treatments.

Based on the obervation made in this study, it can be concluded that the grower phase dietary levels of MC had significant carryover effects on the subsequent laying house performance of the birds. Final weight, age at 10% egg prduction, percent hen-day and hen-housed egg production, feed intake, feed conversion efficiency and feed cost per 10 eggs were found to be closely associated with weight of the birds at 20 weeks of age which marked the end of the rearing period. It was also observed that MC in the growing diets up to 20% level supported satisfactory performance in the laying phase when compared with the performance of the birds on the control diet. Dietary levels of MC above 20% resulted in lower hen-housed egg production increased feed intake, poor efficiency of feed conversion to eggs and increased feed cost per 10 eggs produced. On the basis of these observations, it is suggested that MC should not be above 20% level in grower diets.

SUMMARY AND CONCLUSION

Inclusion of maize cobs in the diets of chicks and pullets were observed to have a significant effect of reducing the cost of raising the birds. Mortality of the chicks and pullets in the rearing and laying phases were also not affected by the MC diets. However, MC at all levels had adverse effects on the growth and feed gain ratio of the chicks. Feed intake also increased significantly by dietary levels of MC above 5% of the diet. For pullets between 8 to 20 weeks of age, dietary levels of MC resulted in anatomical adaptation of increasing the lengths of the intestines and caeca. Dietary level of MC up to 20% in the grower diets also supported satisfactory performance. Above this level there were considerable villi abrasion which could have reduced efficiency of feed utilization and the growth of the pullets. In addition, dietary levels of MC at 30% levels and above in grower diet had adverse effects on the subsequent laying house performance of the pullets. Age at 10% egg production was delayed by 9 to 16 days, percent hen-day and hen-housed egg production were depressed and feed cost per 10 eggs produced was also increased.

Based on these observations, it is recommended that MC should not be utilized in formulating chick rations while for grower diets, up to 20% dietary level of MC may be fed without any adverse effect on the growth and subsequent laying house performance of the pullets. At 20% level of inclusion MC replaced 31.05% of the dietary maize which could amount to a substantial cost savings for the farmer.

Appendix 1: CALCULATION OF METABOLIZABLE ENERGY OF MC

The Apparent metabolizable energy (AME) of the MC was calculated by the following formula.

ME of the basal diet (ME_x) = $\frac{FE_X - EE_X}{FC_X}$ *Kcal/kg*

Where

FE_X = Gross energy of the total feed consumed (Kcal/kg)

EE_X = Gross energy of the total excreta output (Kcal/kg)

FC_x = Total feed consumed (kg)

$ME_x = \frac{4752 - 3800}{0.30} = 3173.33 Kcal/kg$

ME of the 60% basal + 40% MC (ME_y) = $\frac{FE_y - EE_y}{FC_y}$ *Kcal/kg*

where

FE_y = Gross energy of the total feed consumed (Kcal/kg)

EE_y = Gross energy of the total excreta output (Kcal/kg)

FC_y = Total feed (60% + 40% MC) consumed (kg)

$\therefore ME_y = \frac{4031 - 3303.46}{0.30} Kcal/kg$

= 2204.67 Kcal/kg

If the ME of basal diet is a Kcal/kg and that of 60% basal + 40% MC is b Kcal/kg

AME of MC (ME_m) = $\frac{b-0.6a}{0.4}$

$$\frac{2204.67-0.6x3137.33}{0.4}$$

$$= \frac{2204.67-1903.98}{0.4}$$

= 751.68 Kcal/kg
or 0.751 Kcal/g

Apparent metabolizable energy nitrogen corrected (AMEn) was calculated as follows.

AMEn = AME - 8.22 (gN/g feed - gN/g faeces)

= 751.68-8.22 (1.87-7.48)
= 751.68 - 8.22 (-5.61)
= 751.68 - 46.11
= 705.57 Kcal/kg

The true metabolizable energy nitrogen corrected (TMEn) was also calculated

$$TMEn = \frac{FE_f-(EE_f+8.22N_f)-(EE_u+8.22NUe)}{FC}$$

$$= \frac{4031-(3303.46+8.22X7.48)+(436.762+8.22X2.75)}{0.30}$$

$$= \frac{4031-(3364.946)+(459.367)}{0.30}$$

$$= \frac{206.687}{0.30}$$

= 688.96Kcal/kg

Appendix 3: Analysis of variance for final body wieght of chicks from 0-7 weeks

Source of variation	Degree of freedom	Sum of Squares	Mean of Squares	F
Treatment	6	0.024	0.004	17.639*
Error	14	0.003	0.000	
Total	20	0.027	0.004	

* = Sinificant ($p < 0.05$)

Appendix 4: Analysis of Variance for weight gain of chicks from 0 - 7 weeks

Source of variation	Degree of freedom	Sum of Squares	Mean of Squares	F
Treatment	6	0.024	0.004	17.82*
Error	14	0.003	0.000	
Total	20	0.027	0.004	

* = Significant ($p < 0.05$)

Appendix 5: Analysis of variance for feed intake of chicks from 0 - 7 weeks

Source of variation	Degree of freedom	Sum of Squares	Mean of Squares	F
Treatment	6	0.056	0.009	10.96*
Error	14	0.012	0.001	
Total	20	0.068	0.010	

* = Significant ($p < 0.05$)

Appendix 6: Analysis of variance for feed conversion of chicks from 0 7 weeks

Source of variation	Degree of freedom	Sum of Squares	Mean of Squares	F
Treatment	6	6.142	1.024	24.258*
Error	14	0.591	0.042	
Total	20	6.733	1.016	

* = Significant ($p < 0.05$)

Appendix 7: Analysis of variance for feed cost of chicks from 0 - 7 weeks

Source of variation	Degree of freedom	Sum of Squares	Mean of Squares	F
Treatment	6	1.291	0.215	8.561*
Error	14	0.352	0.025	
Total	20	1.643	0.240	

* = Significant ($p < 0.05$)

Appendix 8: Analysis of variance for final body weight of pullets from 8 - 20 weeks

Source of variation	Degree of freedom	Sum of Squares	Mean of Squares	F
Treatment	6	0.165	0.0280	10.394*
Error	14	0.037	0.0026	
Total	20	0.202	0.0306	

* =
Significant ($p < 0.05$)

Appendix 9: Analysis of variance for weight gain of pullets from 8 - 20 weeks

Source of variation	Degree of freedom	Sum of Squares	Mean of Squares	F
Treatment	6	282319.143	47653.190	145.077*
Error	14	4540.667	324.333	
Total	20	286859.810	47377.523	

* = Significant ($p < 0.05$)

Appendix 10: Analysis of variance for feed intake of pullets from 8 - 20 weeks

Source of variation	Degree of freedom	Sum of Squares	Mean of Squares	F
Treatment	6	1.852	0.309	70.148*
Error	14	0.062	0.004	
Total	20	1.914	0.313	

* = Significant ($p < 0.05$)

Appendix 11: Analysis of variance for feed conversion efficiency of pullets from 8 - 20 weeks

Source of variation	Degree of freedom	Sum of Squares	Mean of Squares	F
Treatment	6	87.321	14.553	201.189*
Error	14	1.013	0.072	
Total	20	88.354	14.625	

* = Significant ($p < 0.05$)

Appendix 12: Analysis of variance for feed cost of pullets from 8 - 20 weeks

Source of variation	Degree of freedom	Sum of Squares	Mean of Squares	F
Treatment	6	222.442	37.074	359.73*
Error	14	1.443	0.103	
Total	20	223.885	37.177	

* = Significant ($p < 0.05$)

Appendix 13: Analysis of variance for length of intestine of pullets from 8 - 20 weeks

Source of variation	Degree of *freedom*	Sum of *Squares*	Mean of *Squares*	F
Treatment	6	3972.270	662.045	85.741*
Error	14	108.100	7.721	
Total	20	4080.370	669.766	

* = Significant ($p < 0.05$)

Appendix 14: Analysis of variance for length of caea of pullets from 8 - 20 weeks

Source of variation	Degree of freedom	Sum of Squares	Mean of Squares	F
Treatment	6	41.167	6.861	9.956*
Error	14	9.648	0.689	
Total	20	50.185	7.550	

* = Significant ($p < 0.05$)

Appendix 15: Analysis of variance for initial weight of pullets from 20 - 36 weeks

Source of variation	Degree of freedom	Sum of Squares	Mean of Squares	F
Treatment	6	0.282	0.047	155.825*
Error	14	0.004	0.000	
Total	20	0.286	0.047	

* = Significant ($p < 0.05$)

Appendix 16: Analysis of variance for final body weight of pullets from 20 - 36 weeks

Source of variation	Degree of freedom	Sum of Squares	Mean of Squares	F
Treatment	6	0.303	0.051	1.319 N.S.
Error	14	0.537	0.038	
Total	20	0.840	0.089	

N.S. = Not significant ($p > 0.05$)

Appendix 17: Analysis of variance for percent change in body weight of pullets from 20 - 36 weeks

Source of variation	Degree of freedom	Sum of Squares	Mean of Squares	F
Treatment	6	3943.162	657.194	14.635*
Error	14	628.671	44.905	
Total	20	4571.833	702.049	

* = Significant ($p < 0.05$)

Appendix 18: Analysis of variance for age at 10% egg production of pullets from 20 - 36 weeks

Source of variation	Degree of freedom	Sum of Squares	Mean of Squares	F
Treatment	6	967.905	161.317	7.562*
Error	14	925.667	21.333	
Total	20	993.572	182.650	

* = Significant ($p < 0.05$)

Appendix 19: Analysis of variance for age at 50% egg production of pullets from 20 - 36 weeks

Source of variation	Degree of freedom	Sum of Squares	Mean of Squares	F
Treatment	6	334.476	55.746	3.383*
Error	14	230.667	16.476	
Total	20	565.143	72.222	

* = Significant ($P < 0.05$)

Appendix 20: Analysis of variance for percent peak production of pullets from 20 - 36 weeks

Source of variation	Degree of freedom	Sum of Squares	Mean of Squares	F
Treatment	6	194.373	32.395	0.439N.S.
Error	14	1032.375	73.741	
Total	20	1226.748	106.136	

N.S. = Not Significant ($p > 0.05$)

Appendix 21: Analysis of variance for percent hen-day egg production of pullets from 20 - 36 weeks

Source of variation	Degree of freedom	Sum of Squares	Mean of Squares	F
Treatment	6	218.496	36.416	6.396*
Error	14	79.710	5.694	
Total	20	298.206	42.110	

* = Significant ($p < 0.05$)

Appendix 22: Analysis of variance for percent hen-housed egg production of pullets from 20 - 36 weeks

Source of variation	Degree of freedom	Sum of Squares	Mean of Squares	F
Treatment	6	199.795	33.299	25.42*
Error	14	18.339	1.310	
Total	20	218.134	34.609	

* = Significant ($p < 0.05$)

Appendix 23: Analysis of variance for egg weight of pullets from 20 - 36 weeks

Source of variation	Degree of freedom	Sum of Squares	Mean of Squares	F
Treatment	6	63.609	10.600	110.727*
Error	14	1.340	0.096	
Total	20	64.949	10.696	

* = Significant ($p < 0.05$)

Appendix 24: Analysis of variance for feed intake of pullets from 20 - 36 weeks

Source of variation	Degree of freedom	Sum of Squares	Mean of Squares	F
Treatment	6	3169.069	528.169	105.868*
Error	24	69.845	4.989	
Total	20	3238.914	533.158	

* = Significant ($p < 0.05$)

Appendix 25: Analysis of variance for feed conversion efficiency of pullets from 20 - 36 weeks

Source of variation	Degree of freedom	Sum of Squares	Mean of Squares	F
Treatment	6	2.347	0.391	110.248*
Error	14	0.050	0.004	
Total	20	2.397	0.395	

* = Significant ($p < 0.05$)

Appendix 26: Analysis of variance for feed cost of pullets from 20 - 36 weeks

Source of variation	Degree of freedom	Sum of Squares	Mean of Squares	F
Treatment	6	85.738	14.290	90.072*
Error	14	2.221	0.159	
Total	20	87.959	14.449	

* = Significant ($p < 0.05$)

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