EFFECTS OF ENZYME SUPPLEMENTATION ON THE UTILIZATION OF FIBROUS FEED INGREDIENTS IN BROILER DIETS

BY

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DECLARATION

I hereby declare that this thesis had been written by me and that it is a record of my own research work and it had not been presented in any previous publication for a higher degree.

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CERTIFICATION

This thesis entitled “Effects of enzyme supplementation on the utilization of fibrous feed ingredients in Broiler diets” by NDUAKA UCHECHUKWU KINGSLEY meets the regulations governing the award of the degree of the Master of Science (M.Sc) in Animal science of Ahmadu Bello University, Zaria, and is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

This work is dedicated to the Almighty God for His great provisions and mercies during the period of this work.

It is also dedicated to my parents, Mr. and Mrs Ekeleme Nduaka for their support towards this work.

ABSTRACT

Effects of two enzymes, (Nutrase Xyla and Maxigrain) on the utilization of two fibrous feed ingredients, (Rice and Maize Offals) were studied in two broiler feeding experiments.

For experiment one, there were eight dietary treatments for both the starter and finisher phases. Diet 1 was the control (0% rice offal, no enzyme), while diet 2 was made up of 0% rice offal diet plus maxigrain enzyme. Diets 3 to 8 were made up of the 7.5% and 15% dietary levels of rice offal with each dietary level supplemented with either zero enzyme or xylanase or maxigrain enzymes respectively. Enzymes were supplemented at the rate of 100g/ton of diet. Results for the starter phase (0-4weeks) showed that both enzymes when supplemented in the 7.5% and 15% rice offal diets, improved the performance of broiler chicks for final weight and weight gain over the unsupplemented rice offal diets. Broiler chicks, however, could not effectively utilize rice offal at both 7.5% and 15% in the diets even when supplemented with either of the two enzymes especially when compared with the results for the control diet. At the finisher phase (5-9weeks), the results showed that both enzymes significantly improved ($p<0.05$) broiler performance at 7.5% and 15% rice offal dietary inclusion levels above the performances of the birds on the unsupplemented rice offal diets and of those on the control diet for final weight, weight gain and average daily gain.

Experiment two was also conducted using maize offal which was fed at 0 and 25% dietary levels. For each dietary level of maize offal, three enzyme sources were tested namely; zero enzyme, xylanase and maxigrain enzymes. Enzyme supplementations were also made at the manufacturers' recommended level of 100g/ton of diet for both enzymes. The broiler starter phase lasted from zero to 4weeks while the finisher phase lasted from 5 to 9 weeks. Results showed that both enzymes had no significant effect when supplemented in the control diet but they both significantly improved the performance of broilers on the 25% maize offal diet for final weight, weight gain, average daily gain and feed-to-gain ratio up to the levels obtained with the control diet. There were significant reductions in feed cost (₦/kg gain) in both experiments by enzyme supplementation.

Carcass analysis showed tendency for enzyme supplementation to reduce the size of the liver. Percent Breast also increased slightly due to enzyme supplementation of the finisher diets.

It was concluded that enzyme supplementation did not improve the utilization of energy rich diets but improved utilization of maize offal based diets at the broiler starter and finisher phases and of the diets containing up to 15% rice offal especially at the finisher phase. It was also concluded that broiler chicks cannot effectively utilize rice offal in their diet during the starter phase whether or not the diet is supplemented with enzymes.

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CHAPTER ONE

1.0 INTRODUCTION

Nigeria is currently faced with short supply and high cost of conventional feed ingredients for poultry rations. Over the years, there has been much effort directed towards the exploitation and the use of non-conventional ingredients in feed production. Although the nutritional values of these feedstuffs have been extensively studied (Aletor, 1986), and the levels of inclusion recommended, yet the levels of nutrient digestibility and utilization of these feedstuffs by the animal have not been maximized.

Assessment of the quality of some commercial livestock feeds have shown non-conformity of feed contents with recommended level of nutrients (Ogunwolere and Onwuka, 1997). Since sub-optimum levels of nutrient intake adversely affect the performance of livestock and poultry, simple and inexpensive strategy needs to be exploited for meeting the nutrient requirements of animals.

Energy, which is one of the basic requirements in poultry diets, is derived mainly from cereals. This is because they are rich in easily digestible carbohydrates. The types of cereal grains grown in the tropics include maize, sorghum, rice, millet and to some extent wheat (Maikano, 2005). Nigeria is however plagued by low production and high cost of feed ingredients, particularly maize which constitutes 50-60% of most feeds consumed by poultry (Olayemi, 1989). The situation is however much aggravated by the ever increasing demand for maize as staple food for man and as an industrial raw material.

Under the prevailing circumstances, the exploitation of some agro-industrial by-products for poultry feed formulation (maize offal, wheat offal, rice offal, brewer's dried grain (BDG) and others) is necessary (Devendra and Raghavan, 1979; Bird, 1979; Oluyemi and Roberts, 1979). Agro-industrial by-products are cheaper to use in poultry feeds since there is little or no existing competition for them for human use.

Most of the energy based ingredients and the agro-industrial by-products used in poultry feeds are of cereal origin. Whilst the majority of the starch present in cereals is readily digested by the monogastric animals, a large proportion of the contents are present as non-starch polysaccharides (NSP). The major cell wall polysaccharides of concern are the β- glucans in barley and oats, the arabinoxylans in wheat and possibly other carbohydrates such as pectin and the oligosaccharides of the raffinose family in other feedstuffs (Marquardt et al., 1996). The viscosity developed by arabinoxylans and β-glucans is the principal factor by which they exert their antinutritive activities. These polysaccharides may also act as a physical impediment to nutrient hydrolysis and utilization by digestive enzymes (Bedford, 1992). The presence of viscous carbohydrates has been shown to specifically reduce feed intake, weight gain, efficiency of feed utilization and apparent metabolizable energy (AMEn). They are also known to increase water intake, beak impaction and vent plugging, the size of the gastro-intestinal tract, the number of anaerobic microorganisms in the large intestine and water content of digesta and excreta (Marquardt et al 1996).

The effect of dietary enzymes is influenced by the type and concentration of the undesirable carbohydrate present in the feedstuff and the class and age of the livestock and poultry that consume it. Younger

animals are affected to a greater degree by the anti nutritional compounds than the older birds and swine. The enzymes required to digest cell wall material, including the β-glucan and arabinoxylans, include Endoglucanase, Cellobiase, Xylanase (endoxylanase- extra cellular enzyme), Acetyxylan esterase, Glucoronidase, Arabinofuranosidase and cellobiosidase/cellodextrinase (Forsberg et al, 1993)

The aim of this study is to determine the effects of two enzymes, Nutrase Xyla (a Xylanase based bacterial enzyme compound supplied by Bio-ingredients Ltd., Lagos) and Maxigrain (a multienzyme compound of β-Glucanase, Xylanase, Phytase, Arabinoxylanase and a mixture of Minerals and Yeast) on the performance of broiler chicks fed diets containing either rice offal at 0, 7.5 and 15% inclusion levels or maize offal at 25% dietary level as replacement for maize in broiler diets.

OBJECTIVES OF THE STUDY

The objectives of the study include the following:

1. To determine the effect of enzyme supplementation on the utilization of rice offal in broiler diets.
2. To determine the effect of enzyme supplementation on the utilization of maize offal in broiler diets.

3. To evaluate the economics of raising broiler chicks on enzyme supplemented broiler diets containing rice offal or maize offal.

JUSTIFICATION

This study was motivated by the fact that large quantities of agro industrial by-products are produced in Nigeria all year round but they are usually under-utilized. However, commercially prepared enzymes hold promise in improving the utilization of these by-products by the monogastric animals and thereby reduce the cost of feeding.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 INTRODUCTION

Enzymes are protein catalysts for chemical reactions in biological systems. They are made up of long chains of amino acids with highly complex molecular structures. They play a key role in digestive processes of the animal. Although enzymes are produced either by the animal itself or by the microbes that are naturally present in the digestive tract, specific activities necessary to break down some other compounds in feed are not found or are at low levels in the digestive tract. Therefore exogenous enzymes are added to the diet to break down these compounds. Enzymes used as feed additives are now produced through commercial fermentation processes.

Classen and Cooper (1998) categorized the use of feed enzymes into four areas.

1. Removal of anti nutritional factors (ANFs):
2. Increasing the digestibility of existing nutrients
3. Increasing the digestibility of Non-Starch Polysaccharides (NSP)
4. Supplementation of the activities of the host endogenous enzymes.

In the case of monogastric animals, digestive ability changes with age and may be inadequate in young poultry and pigs. Dietary constituents may

also affect the amount of effective endogenous enzyme output, necessitating supplementation.

Anti-nutritional factors (ANF) are common components of feedstuffs. It is important to note that compounds, which may be considered to have anti-nutritional effects, may not always have any measurable impact on animal feeding because of the low levels of such anti nutritional factors in the feed ingredients.

2.2 THE EFFECT OF ENZYMES ON NON-STARCH POLYSACCHARIDES (NSP), Beta-GLUCAN AND ARABINOXYLANS OF CEREAL GRAINS

The inclusion of some feed ingredients such as barley in broiler diets has been limited because of its low energy content, compared with wheat or corn, the limitation in fact relates to its high fiber content and the presence of specific non-starch polysaccharides termed beta-glucan (Fuente et al. 1995). Negative effects of β-glucan have been attributed to its capacity to increase the viscosity of the gastro-intestinal contents (White et al. 1981; Classen, 1991; McNab and Smithard, 1992). These polysaccharides may also act as a physical impediment to nutrient hydrolysis and utilization by digestive enzymes (Bedford, 1992).

Enzymes are used to remove the anti nutritional effects of NSP β-glucan and arabinoxylans found in the cell wall of cereal grains. Since monogastrics are not capable of hydrolyzing these carbohydrates, they may

prevent access of endogenous enzymes to the nutrients contained within the grain cells. Furthermore, fractions of the β-glucan and arabinoxylan become soluble after ingestion, causing an increase in viscosity of the grain while it is in the gut. The viscosity causes a number of negative effects, including poor absorption of nutrients, microbial growth in the small intestine and poor animal productivity (Classen and Cooper, 1998).

The use of feed enzymes capable of hydrolyzing grain cell wall constituents can effectively eliminate these anti nutritional effects. The use of rice by-products, especially rice offal in poultry feeds has been limited by the presence of some deleterious factors such as the high fibre content, the presence of non-starch polysaccharides (NSP) and phytates. Salih et al. (1991) reported that when chicks were fed high barley diets, feed intake, growth rate and feed conversion were impaired. Additional problems observed were sticky droppings, which may be attributed to undegraded β-glucan concentration in faecal dry matter, and carcass quality reduction (Gohl et al. 1978; McNab and Smithard, 1992). However, β-glucanase addition to diets effectively alleviated much of this poor performance, increased the dry matter content of excreta, and decreased the incidence of sticky droppings (Hesselman et al. 1982; Petterson et al. 1991). The most common hypothesis regarding the β-glucanase effect is that the reduced

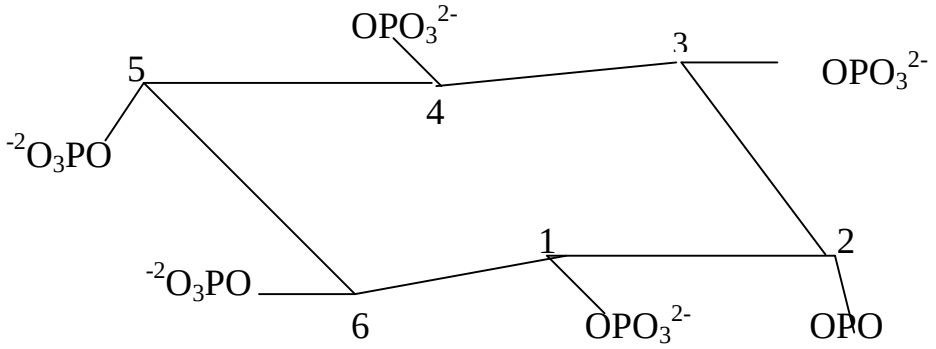
intestinal viscosity induced by the endo-activity of the supplementary enzyme allowed normal digestive function (McNab and Smithard, 1992). The improvement in nutrient digestibility (Hesselman and Aman, 1986; Edney et al. 1989) results in an increase in the metabolisable energy (Rotter et al. 1990; Friesen et al. 1992).

2.3 EFFECTS OF PHYTIC ACID AND PHYTATES ON FEED UTILIZATION

Previous research has shown that phytic acid and its salts, phytates occur widely in plant-derived feedstuffs. Phosphorus contained within the phytate molecule is poorly available to monogastric animals and the use of the enzyme phytase to hydrolyze phytic acid can therefore be included as an example of enzymes increasing utilization of existing nutrients. Phytates may also be classified as "Anti nutritional factors" because of their strong chelating ability and their negative effects on the retention of multivalent cations such as Ca^{2+}, Mg^{2+}, Fe^{2+} and Zn^{2+}. Phytates may also reduce protein availability and inhibit digestive enzymes (Bedford, 2000).

The use of phytase has received considerable attention because of the reduction in feacal phosphorus and the resulting lowered environmental impact of animal manure. Phytate (Fig 1), the target substrate of this enzyme is a fixed entity. It is presumed to be the plant storage form of phosphate

which also happens to have considerable anti nutritional effects for most animals (Bedford, 2000). Phytate itself is not a good source of phosphorus for non-ruminants, particularly the younger animals as they appear to lack the ability to utilise this compound, even though phytase have been isolated from the small intestines of broilers and laying hens (Maenz et al. 1997; Maenz and Classen, 1998).



Inositol hexakisphosphate (IP_6)

Fig 1. Phytic acid

Phytate contents of many ingredients vary considerably as shown in Table 1 and as reported recently; the availability of phytate to exogenous phytase hydrolysis varies from ingredient to ingredient (Ravindran et al. 1999). Phytase, however delivers economic benefits (reducing phosphorus pollution and feed formulation costs) through its ability to replace added inorganic phosphorus. This is achieved through its ability to increase the availability of plant phosphorus for the animal use, which in turn reduces the amount of excess phosphorus in the faeces added to the soil. As a result, the Ca: P balance of the soil is not altered by the use of the poultry faeces as manure. Also the cost

of adding inorganic phosphorus is removed since the phosphorus requirement of the animal is met through increased availability, thus reducing the cost of feed formulation.

Liebert et al. (1996) and Sebastian et al. (1998) reported that phytate itself is often present as a protein phytate complex, and when free in the intestine is thought to bind to proteins rendering them less susceptible to proteolysis. It also binds to digestive enzymes, rendering them less effective. As a result, several authors have reported improvements in amino acid digestibility when Phytase was used in poultry rations at varying degrees (Martin et al.1998; Namkung and Leeson, 1999; Ravindran et al.1999).

Table 1: Phytate phosphorus contents of various feed ingredients according to several sources

Ingredients	Mathaus (1997)	McKnight (1997)	Lantzsch et al. (1992)	NRC (1994)	Mean
Maize (%)	0.265	0.196		0.20	0.220
Wheat (%)	0.235	0.255		0.24	0.243
Barley (%)	0.223	0.230		0.19	0.214
Soybeans (%)			1.20		1.200
Rapeseed (%)			1.35		1.350
Soyabean meal (%)		0.372		0.40	0.306
Rapeseed meal (%)		0.870		0.87	0.87

Adapted from Bedford, (2000)

2.4 BENEFITS OF USING ENZYMES IN POULTRY DIETS

1. To increase the feeding value of feed stuffs

Many scientists have demonstrated performance benefits of enzymes when added to barley (Classen et al., 1985; Elwinger and Saterby, 1987; Broz and Frigg, 1990; Brenes et al., 1993; Marquardt et al., 1994), wheat (Classen et al., 1995; Bedford and Morgan, 1996; Hughes and Zviedrans, 1999), and more recently maize based diets (Wyatt et al., 1997$_{a,}$ 1999; Steenfeldt et al., 1998).

Phytases are routinely utilized particularly in environmentally sensitive areas of the world due to their ability to increase the phosphorus availability from vegetable ingredients (Jongbloed et al., 1997, Kornegay et al., 1997; Kemme et al., 1999). The consequences of such observations are two-fold, the targeted ingredient is used in greater abundance than would otherwise be the case, and secondly the costs of diet manufacture are reduced due to decreased utilization of scarce, high value ingredients such as fat and fish meal.

Bedford (2003) reported that the use of enzyme enables the feed compounder to minimise feed costs through reduced usage of expensive ingredients. He reported that phytase releases phytate phosphorus which, when accounted for, replaces inorganic phosphate sources and at the same time reduces formulation costs. He stated that fibre degrading enzymes increase digestibility of the entire ration through degradation of anti nutrients (arabinoxylans in the case of wheat and β-glucans in the case of

barley, oats and corn) and enables the feed compounder to utilise more cereal and less fat and protein supplements, depending upon the value credited to the enzyme. Again, this reduces feed costs as those expensive ingredients are replaced by cereals.

2. To reduce variation in nutrient quality of ingredients

The response to the use of enzymes is greatest on the poorest quality raw materials (Classen et al.,1995; Scott et al.,1998a; 1998b ; Bedford et al, 1998). As a result, variations in subsequent bird performance are reduced allowing for a more uniform flock and also less variation in productivity from flock to flock.

Silva and Smithard, (2002) reported that the antinutritive effects of non-starch polysaccharides (NSP) have been successfully ameliorated using exogenous enzymes in rye or wheat-based diets. In addition, Silva et al (2003) carried out an experiment using three commercial enzymes: Phyzyme 5000g (phytase 5000PPU/g), Grindazym GP5000 (endo 1, 4 beta-xylanase 12000 FXU/g, endo 1,4 beta-glucanase 5000BGU/g) and a multienzyme Natuzyme (cellulase 4200U/g, xylanase 2500U/g, β-glucanase 500U/g, α-amylase 950U/g and pectinase 70U/g). They reported that Grindazym and a combination of Grindazym and Phyzyme were effective in improving growth performance and the efficiency of feed utilization of broiler chicks fed rice by-product based diets.

In addition, Friesen et al, (1992) in another study where two barleys (Scout variety, with high soluble β-glucan content and Bedford variety, with low soluble β-glucans content) and oats were compared, enzyme

supplementation to the diet dramatically improved the performance of broiler chicks fed all cereals.

3. To increase precision and flexibility of least-cost feed formulation

The nutritive value of cereal grains for poultry varies greatly and no suitable assays are currently available for rapid-in-mill testing. Enzymes also allow the use of a wide range of ingredients without compromising bird performance and hence provide great flexibility in least-cost feed formulation (Choct, 1997).

4. Increased nutrient digestibility and decreased faecal output

Dry matter digestibility (DMD) of feedstuffs by animals range from 50% to 80%. the remainder of the dry matter is lost via the excreta. In recent years enzymes have been used in monogastric diets to increase nutrient digestibility and to decrease nutrient waste in the excreta. The effect, however, depends on the type of diet and the type of animal. Increases in DMD range from 0.9% (Schutte and Langhout, 1999) to 17% (Annison and Choct, 1993) in poultry and from 0% (Taverner and Campbell, 1998) to 5.2% (Schmitz, 1995) in Pigs. Enzymes have been demonstrated to increase the digestibility of poorly digested cereals to a much greater extent than well-digested cereals (Classen et al., 1995; Scott et al., 1998a,b).

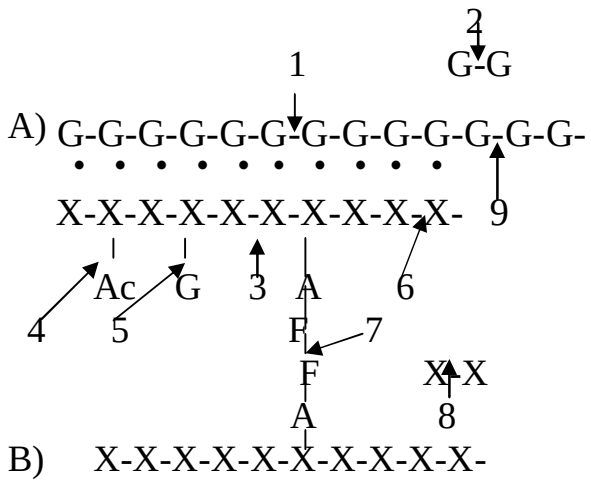
5. **To reduce the incidence of wet litter (faecal moisture)**

Feeding diets rich in barley, oats and to a lesser extent wheat often results in the production of viscous wet manure (Classen et al., 1985; Elwinger and Teglof, 1991; Newman et al., 1992; Bedford and Morgan, 1996). A reduction in the moisture content of poultry faeces is often noted when glucanases are included in the diet (Choct, 1997).

Enzymes have been used to degrade different structural carbohydrates found in cereals, particularly those that are not digested by avian and mammalian enzymes, and those that are highly viscous and have high water-binding capacity. Various companies have recently developed enzyme sources to improve the nutritional value of corn/soya-bean meal-based diets for poultry. At this time, there is little published information on the efficacy of these products, but commercial evidence points to an economical improvement in feed conversion ratio as the primary benefit. The mechanism of action of these enzyme products is thought to include improved nutrient utilization especially the energy component and the reduction of anti-nutritional factors in soyabean meal. Enzyme products have been reported to include fibre-degrading enzymes, as well as protease, amylase and/or α-galactosidase activity.

The range of feedstuffs that can be improved through the use of enzymes include: rice offal, maize offal, brewers' dried grain, wheat offal and legumes (Classen and Cooper, 1998).

An overview of the enzymes required to digest cell-wall material, including the β-glucans and arabinoxylans in cereals is shown in Fig 2.



(A) β – Glucan
(B) Pentosan (arabinoxylan)

Fig 2: Major Chemical Bonds of Plant Cell Walls

Carbohydrate and Their Cleavages`[1]

Specific enzymes that appear to be beneficial for non-ruminant animals are the xylanases, or more specifically the endoxylanases for wheat, triticale, rye and the β-glucanases or Cellulases for barley and oats. Some commercial enzymes, such as Maxigrain contains a spectrum of different enzymes including xylanases and β-glucanases and therefore can be used effectively with most of the cereals.

The use of enzymes in non-ruminant feeds has been reviewed by Campbell and Bedford (1992). These workers reported that some factors need to be considered when using enzymes. These factors include the following:

Sub-units
G- Glucose; X – Xylose; AC – Acetic; G – Glucuronic; A – Arabinose;
F – Ferulic; •H^+ bonding

Enzymes
1= Endoglucanse; 2.= Cellobiase; 3= Xylanase (Endoxylanase) extra cellular enzyme; 4= Acetylxylan esterase; 5= Glucuronidase;
6= Arabinofuranosidase (intracellular enzyme); 7= Ferulic acid esterase;
8= Xylosidase; 9= Cellobiosidase/ Cellodextrinase

+Data adapted from Forsberg et al. (1993). Enzymes, 1, 3 and possibly 6 are particularly important for reduction of viscosity in cereals.

1. The enzyme supplement must contain the proper spectrum and adequate amount (activities) of enzymes so that anti-nutritive effects of target substrate will be neutralized (i.e. β-glucanase for barley and oats, xylanase for wheat, rye, β-galactosidase and amylase for corn, and Phytase for release of phytate phosphorus.

2. Different cereals contain different amounts of the enzyme-sensitive anti nutritional factors. Therefore, the response to enzyme treatment may vary within a given cereal (i.e. barley, corn and probably wheat).

3. The enzymes must not be inactivated by processing or by low pH or by the digestive enzymes in the gastrointestinal tract.

4. Results are affected by class and age of poultry. The responses in swine are usually less dramatic than those of poultry and have not been clearly established. Results are affected by class and age of poultry.

2.5 ENZYME TREATMENT OF DIETS CONTAINING BARLEY, RYE, WHEAT, OATS AND CORN

Several studies carried out by Friesen et al. (1992) and Marquardt et al. (1994) have shown that the nutritive value of barley, oats and rye, and in many cases, wheat can be considerably improved by the dietary inclusion of a commercially available crude enzyme preparation from trichoderma viride. Dramatic improvements in chick performance were obtained when a crude enzyme was added to barley and rye-containing diets. The hulless barley used in the study had a high viscosity and a high concentration of soluble β-glucans, whereas the rye, had a high concentration of the highly viscous and soluble arabioxylans (Pentosans). The net improvements in weight gain, feed-to-gain ratio, apparent protein digestibility (APD), AMEn, and decrease in water content of the digesta were respectively 19%, 6%, 6%, 12% and 6% for barley, 27%, 12%, 6%, 14% and 4% for rye and 6%, 4%, 1%, 4% and 5% for wheat fed chicks. Essentially no response was obtained when enzyme was added to the corn diet.

Enzyme treatment has also been shown to affect the relative size of the digestive tract and certain organs such as the pancreas and the liver in chicks fed wheat and scout barley. (Brenes et al., 1993). For example, relative reductions in organ size in birds fed an enzyme-supplemented barley-based diet compared with the unsupplemented diet were: Pancreas, 24%; liver, 8%; proventriculus, 39%; duodenum, 16%; jejunum, 20%; ileum, 18%; colon, 29%. Relative crop and gizzard weights were not significantly affected by enzyme addition. Overall organ weight was reduced by 13% with enzyme supplementation, which represents 1% of the total weight of the bird. The results demonstrate that the relative size of the intestinal tract and organs such as the liver and pancreas can be considerably reduced in poultry by the inclusion of enzymes in certain cereal diets. This implies higher dressed weight and dressing percentage, which translates into higher income for the poultry farmer. It also demonstrates that the addition of an appropriate enzyme preparation to cereal-based diets can result in significant improvements in the performance of growing chicks. In addition, the degree of response is influenced by the concentration of the highly viscous and water soluble anti nutritional factors present in the cereal, as well as the type and the amount of enzyme used.

2.6 CATEGORIES OF ENZYMES USED IN THE POULTRY INDUSTRY

The enzymes currently being utilized in the poultry industry are divided into three distinctive categories (Bedford, 2000).

1. Viscous grain targeted, i.e. Rye, wheat, oats, and barley
2. Non-viscous grain targeted, i.e. Corn and Sorghum
3. Phytase.

Categories 1 and 2 are generally carbohydrate-based products

2.6.1 Viscous Grain Enzymes:

Viscous grains induce a condition of increased intestinal viscosity, which effectively slows down the rate of digestion. The physical structure of the endosperm cell walls of these grains may also impede access to their contents by digestive enzymes. Addition of the appropriate enzyme diminishes these constraints and allows digestion to occur more rapidly and completely.

2.6.2 Non-Viscous Grain Enzymes:

Variability in the nutrient content of Maize has been demonstrated to be as great as that observed for wheat and barley (Leeson et al., 1993; Collins et al., 1998). Enzymes can reduce these variations and accelerate the rate of digestion of Maize and Sorghum based diets (Wyatt et al., 1997a, 1999; Pack et al., 1998a), but the exact mechanism of action is yet to be confirmed.

The result of enzyme supplementation is an increase in the rate of nutrient digestibility. This is important since it moves the site of digestion and absorption of starch and protein to a more anterior site wherein the bird has a greater competitive edge over its resident micro flora. This is more the case as the bird ages and its intestinal tract matures and becomes more heavily populated, and is most significant when antibiotics are not utilized (Bedford, 2000).

Enzymes have clearly been demonstrated to increase the digestibility of poorly digested cereals to a much greater extent than the well digested cereals (Classen et al. 1995; Scott et al. 1998a). There are two consequences of such an effect of enzyme addition as far as the feed compounder is concerned.

a. Variation between the best and worst samples of a given grain is reduced.
b. In practice, the average nutrient content of the cereal is greater in the presence of enzyme than in its absence. As a result, addition of an enzyme allows feed formulation nutrient matrix values to be elevated.

The response to enzyme addition is mediated through improvements in nutrient extraction in the small intestine by the host through accelerated digestion, reduced microbial activity as a result of substrate limitation in the ileum and active feeding of specific bacterial species. Essentially, the

activity of the enzyme on viscous polymers and cell wall carbohydrates produce sugars and oligomers, which are utilized preferentially by certain ileal and caecal bacterial species. These bacterial species flourish at the expense of other, possibly detrimental species as far as optimal growth or health of the animal is concerned (Apajalahti and Bedford, 1999).

However, it is useful to note that the consequences of a poorly digested diet, and hence the benefits of enzyme addition to such a diet, is more apparent in conventional compared with germ free chicks (Langhout, 1998; Schutte and Langhout, 1999). Since the microflora increase in numbers as the animal progresses from essentially germ free state at time of hatching to fully populated state some three weeks later, it is likely that the benefit of added enzymes is mediated through the micro floral route in older birds, whereas in young animals which have a poorly developed digestive system, the effect is probably more direct (Kirjavainen and Gibson, 1999).

It is suggested that until the bird reaches 8 days of age, the output of pancreatic enzymes may well limit digestion (Lindermann et al.,1986; Kregdahl and Sell, 1989). The addition of a relevant exogenous enzyme at the very early age is, therefore, likely to supplement the lower digestive capacity of the younger bird, and again the response to such will be more apparent with poorly digestible compared to the highly digestible diets.

2.6.3. Phytase

Phytate is the target substrate of the enzyme Phytase in animal feeds. It is presumed to be the plant storage form of phosphate, which also happens to have considerable antinutritive effects for most animals. Phytate itself is not a good source of phosphorus for non-ruminants, particularly the younger animals. This is because they lack meaningful ability to utilize this compound, even though phytases have been isolated from the small intestines of broilers and laying hens (Maenz et al., 1997; Maenz and Classen, 1998). Phosphorus deficiency would therefore, often result if inorganic sources were not routinely added to most non-ruminant diets. Consequently, most non-ruminant diets contain far more phosphorus than the animal actually needs. The excess phosphorus is simply excreted and this can result in phosphorus pollution of the environment. This situation is of concern in most environmentally sensitive countries.

The application of this enzyme allows the animal to access much of the plant Phytate phosphorus, and thus, reduce reliance on inorganic phosphate sources. This can significantly reduce phosphorus pollution of the environment. Phytase activity is not entirely predictable, however. The benefit achieved is known to depend upon several factors, including the raw materials used, the source of the Phytase, the age of the animals, dietary content of calcium, phosphorus and vitamin D and the level of Phytase

activity present in the ingredients used. The benefit of using exogenous Phytase is that variation in P retention between cereal samples is reduced.

2.7 LIMITATIONS IN THE USE OF ENZYMES

Bedford, (2003) reported three areas of limitations in the commercial use of enzymes which need further improvement. These include; the efficacy of an enzymes preparation and prediction of the enzyme effect, the analysis of enzyme activity in finished feed and thermotolerance of the enzyme preparation..

Classen et al. (1995) reported that the efficacy of an enzyme preparation is very much tied to the matching of the correct activities with the antinutrients in the ration employed. Even if the right enzyme activity exists, the dosage may be insufficient to effect an optimal response. Also, many products do not consist of single activities but are a mixture of many. As a result, understanding the relative contributions of each constituent activity is almost impossible.

In addition, the current feed enzyme analytical methods are not particularly robust, often requiring a blank sample of feed, which is impractical under commercial conditions.

Furthermore, activity at 40^0C and tolerance to temperatures as high as 90^0C is very difficult to achieve. Most thermotolerant enzymes are not particularly active at the temperatures encountered in monogastric intestines and enzymes active at intestinal temperatures are not inherently stable to very high temperatures.

2.8 COMMERCIAL ENZYMES USED IN THE EXPERIMENTS.

2.8.1 Nutrase Xyla

Nutrase Xyla is a bacterial enzyme preparation for poultry feed supplementation It is a bacterial endo-1, 4-β-Xylanase designed to be used in Non-Starch Polysaccharide (NSP) rich feed. The Xylanase activity level is 9000i.u/gram (xylazyme method, pH = 6). The manufacturer recommends a dosage of 100g/ton of complete feed.

It is produced by BELDEM – BELGIUM.

Its modes of action are described as follows:-

- Efficient cleavage of non starch polysaccharides (NSP)
- Decrease of intestinal viscosity
- Increased availability of nutrients
- Increased energetic value of the ration

- Less digestive problems (less diarrhea, dry litter)

2.8.2 Maxigrain

Maxigrain (a multienzyme) is a concentrated blend of Phytase (2500FTU), alpha-Amylase, Acid protease, Lipase, Beta-Glucanase (200i.u), xylanase (10,000i.u), Pectinase, cellulase, mannanase, with yeast extract and minerals.

It is recommended at 50gram to 100gram per ton of feed. It is produced by POLCHEM HYGIENE LABORATORIES PVT. LTD. HOLLAND.

The following have been claimed by the manufacturer as the benefits of using the enzyme maxigrain:-

- Optimisation of metabolisable energy and feed conversion ratio (FCR)
- Increased use of low cost non- conventional feed ingredients
- Reduction in the requirement of Dicalcium phosphate DCP) or bone meal in feed.
- Significant improvement in the quality and consistency of droppings
- Improvement in weight gain
- Improvement in egg production and shell quality.

The Modes of action of maxigrain were also described as follows:-

- *The cellulase breaks down cell wall for more energy and releases locked nutrients*
- The Xylanase and β-glucanase degrade non-starch polysaccharides in feeds
- And the phytase efficiently release bound phosphorus from plant phytate and also liberates minerals and amino acids.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Location of the Study

This study was conducted at the poultry unit of the Animal science Department, Ahmadu Bello University, Zaria.

3.2 Determination of the Chemical Composition of Feed Ingredients Used

Rice and Maize offals used in this study were collected from a rice mill and a maize mill in Zaria city. Samples of these materials were taken for proximate and chemical analysis by the A.O.A.C (1990) methods. The analysis was done to know the nutrient composition (crude protein, ether extract, dry matter, crude fibre, ash and the nitrogen free extract) of each of the rice and maize offals in order to permit their effective usage for poultry ration formulations.

Protein was determined by Kjedahl procedure. Ether extract was determined by subjecting the sample to petroleum ether extraction at 60-80^{0}C, using the soxhlet extraction apparatus. Dry matter was determined by oven drying the sample at 100^{0}C over a 12-hour period. Crude fibre was determined by boiling the sample under reflux in weak sulphuric acid

(0.255N H_2SO_4), then in weak sodium hydroxide (0.312N NaOH) for 1 hour. The residue which consists of cellulose, lignin and mineral matter was dried and weighed. The ash content was determined by igniting a weighed sample in a muffle furnace at 600^0C. The nitrogen free extract (NFE) was obtained by the difference after the percentages of the other fractions were subtracted from 100%.

EXPERIMENT 1

3.3 Determination of the Effects of Enzymes (Nutrase xyla and Maxigrain) on the Utilization of Rice Offal in Broiler Diets

Starter phase (0-4weeks)

Three hundred and sixty day old broiler chicks of mixed sexes and of Aboricae strain purchased from FIDAN farms Ltd. Ibadan were used for this experiment. The birds were weighed at day old and randomly assigned to eight dietary treatments. The treatments were replicated three times with fifteen chicks per pen. The starter phase of the experiment lasted from zero to four weeks. The chicks were brooded conventionally in a deep litter house. Kerosene lanterns and stoves were used as sources of heat. The birds were kept under constant light throughout the duration of the experiment. Three corn-soybean/groundnut cake basal broiler starter rations, which made

up the eight dietary treatments, were formulated to be isonitrogenous at 24% crude protein. The treatments for this phase were as follows:

Treatment 1 (control diet), no rice offal and no enzyme supplementation.

Treatment 2, control diet (diet 1) plus the enzyme Maxigrain.

Treatment 3 contained 7.5% rice offal with no enzyme supplementation.

Treatment 4 contained 7.5% rice offal plus Nutrase Xyla enzyme supplementation.

Treatment 5 contained 7.5% rice offal plus Maxigrain enzyme supplementation.

Treatment 6 contained 15% rice offal plus no enzyme supplementation.

Treatment 7 contained 15% rice offal plus Nutrase Xyla enzyme supplementation.

Treatment 8 contained 15% rice offal plus Maxigrain enzyme supplementation.

Both enzymes (nutrase xyla and maxigrain) when required in the diet were supplemented at the level of 100g/ton of feed as recommended by the manufacturers. The enzymes were first thoroughly mixed with a little quantity of the required finished basal ration. The quantity of the rations were gradually increased until all were thoroughly mixed with the enzymes. The treatments were arranged in a completely randomized design. The compositions of the basal rations were as provided on Table 2. The diets and water were supplied ad libitum. The first and the second gumboro vaccines and the lasota vaccine were administered on the 10^{th}, 24^{th} and 28^{th}

day respectively. Mortality was recorded as it occurred. The weights of birds and of leftover feeds were taken weekly. Live weight, weight gain, average daily gain, feed intake, feed-to-gain ratio and feed cost (₦/ kg gain) were determined at weekly intervals.

Table 2: Percentage composition of the basal diets used for the broiler starter enzyme supplemented rice offal study (0-4 weeks)

	Percent Rice Offal in basal ration		
Ingredients	**0%**	**7.5%**	**15%**
Maize	43.9	35.7	27.4
Soyabean Meal (Fulfat)	12.0	12.0	12.0
Palm kernel cake (Oily)	7.5	7.5	7.5
Groundnut cake	28.5	29.2	30
Fish meal	3.5	3.5	3.5
Rice Offal	0	7.5	15
Bone Meal	3.5	3.5	3.5
Salt	0.3	0.3	0.3
Vitamin TM Premix*	0.3	0.3	0.3
L-Lysine	0.28	0.27	0.27
D-L-Methionine	0.18	0.19	0.20
Total	100.00	100.00	100.00
Calculated Analysis			
CP (%)	24	24	24
ME (Kcal/kg)	2878	2709	2540
EE (%)	6.39	6.54	6.69
CF(%)	4.21	6.99	9.78
Ca (%)	1.21	1.22	1.23
Available P (%)	0.70	0.70	0.71
Lysine (%)	1.30	1.30	1.30
Meth +Cys	0.90	0.90	0.90
Cost ₦/ kg	44.33	40.86	37.45

*Bio-mix Premix supplied per kg ration: Vit A 12000 I.U; Vit D_3 2400 I.U: Vit E 27.6mg; Vit K_3 2.4 6mg; Vit B_1 2.14mg: Vit B_2 6mg Vit B_6 3.6mg; Niacin 3.3mg; Pantothenic acid 9mg; Biotin 0.07mg; Vit B_{12} 0.02mg; Folic acid 0.9mg; chloline chloride 360mg; Manganese 48mg; Iron 24mg; Zinc 36mg; copper 3.6mg; Iodine 1.2mg; cobalt 0.23mg; selenium 0.23mg; Antioxidant 1.5mg.

Note: Treatment diets for experiment 1 were derived from the three basal rations as follows:

Treatment 1 - 0% rice offal basal + no enzyme=Control
Treatment 2 - 0% rice offal basal + maxigrain
Treatment 3 - 7.5% rice offal basal + no enzyme
Treatment 4 - 7.5% rice offal basal + nutrase xyla
Treatment 5 - 7.5% rice offal basal + maxigrain
Treatment 6 - 15% rice offal basal + no enzyme
Treatment 7 - 15% rice offal basal + nutrase xyla
Treatment 8 - 15% rice offal basal + maxigrain

Finisher phase (5-9weeks)

At the end of the starter phase the birds were pooled, fed on a common diet for one week and then reassigned to the experimental pens, balancing for mean weights in each of the 24 experimental pens. There were also 8 treatments for the finisher phase. The treatments were similar to those employed in the starter phase. Each treatment was replicated three times with twelve chicks per pen. Three isonitrogenous basal broiler finisher rations were formulated to contain 21% crude protein. The compositions of the basal rations were as provided in Table 3. Feed and water were supplied ad libitum. Mortality was recorded as it occurred. Weekly records of live weight, weight gain, average daily gain, feed intake, feed-to-gain ratio and feed cost (₦/ kg gain) were kept. The finisher phase of the experiment lasted from 5 to 9 weeks.

Table 3: Percentage Composition of the Basal Diets Used for the Broiler Finisher Enzyme Supplemented Rice Offal Study (5-9 weeks)

	Percent Rice Offal in Basal Ration		
Ingredients	**0%**	**7.5%**	**15%**
Maize	50.29	41.99	33.79
Soyabean Meal (Fulfat)	12.0	12.0	12.0
Palm kernel cake (Oily)	5	5	5
Groundnut cake	23.1	23.9	24.6
Fish meal	3.5	3.5	3.5
Rice Offal	0	7.5	15
Palm Oil	1.5	1.5	1.5
Limestone	0.4	0.4	0.4
Bone Meal	3.25	3.25	3.25
Salt	0.3	0.3	0.3
Vitamin TM Premix*	0.3	0.3	0.3
L-Lysine	0.2	0.2	0.2
D-L-Methionine	0.16	0.16	0.16
Total	100.00	100.00	100.00
Calculated Analysis			
CP (%)	21	21	21
ME (Kcal/kg)	3021	2851	2683
EE (%)	7.54	7.69	7.84
CF(%)	3.75	6.09	8.42
Ca (%)	1.27	1.28	1.29
Available P (%)	0.65	0.66	0.66
Lysine (%)	1.14	1.15	1.15
Meth +Cys	0.83	0.82	0.81
Cost ₦/ kg	46.85	43.36	39.89

*Bio-mix Premix supplied per kg ration: Vit A 10800 I.U; Vit D_3 1800 I.U: Vit E 12.0mg; Vit K_3 1.8mg; Vit B_1 1.92mg: Vit B_2 480mg Vit B_6 1.8mg; Niacin 44.40mg; Pantothenic acid 6mg; Biotin 0.90mg; Vit B_{12} 0.012mg; Folic acid 0.60mg; chloline chloride 210mg; Manganese 48mg; Iron 24mg; Zinc 36mg; copper 3.60mg; Iodine 1.20mg; cobalt 0.24mg; selenium 0.24mg;; Antioxidant 1.5mg.

Note: Treatment diets for experiment 1 were derived from the three basal rations as follows:

Treatment 1 - 0% rice offal basal + no enzyme=Control
Treatment 2 - 0% rice offal basal + maxigrain
Treatment 3 - 7.5% rice offal basal + no enzyme
Treatment 4 - 7.5% rice offal basal + nutrase xyla
Treatment 5 - 7.5% rice offal basal + maxigrain
Treatment 6 - 15% rice offal basal + no enzyme
Treatment 7 - 15% rice offal basal + nutrase xyla
Treatment 8 - 15% rice offal basal + maxigrain

EXPERIMENT 2

3.4 Determination of the Effects of Enzymes (Nutrase Xyla and Maxigrain) on the Utilization of Maize Offal in Broiler Diets

Starter Phase (0-4weeks)

Three hundred and twenty four day old broiler chicks of mixed sexes and of Aboricae strain purchased from FIDAN farms Ltd. Ibadan were used for this study. The birds were weighed at day old and randomly assigned to six dietary treatments. Each treatment was replicated three times with eighteen chicks per pen. The chicks were brooded conventionally in a deep litter house. Kerosene stoves were used as sources of heat. The birds were kept under constant light throughout the duration of this phase. Two isonitrogenous corn-soybean/groundnut cake broiler starter basal rations of 23.7% crude protein were formulated and two different enzymes added to the rations to make up the six dietary treatments as described below:-

Treatment 1, control diet (no maize offal, no enzyme supplementation).

Treatment 2, control diet plus Nutrase Xyla enzyme supplementation.

Treatment 3, control diet plus Maxigrain enzyme supplementation.

Treatment 4 contained 25% maize offal plus no enzyme supplementation

Treatment 5 contained 25% maize offal plus Nutrase Xyla enzyme supplementation.

Treatment 6 contained 25% maize offal plus Maxigrain enzyme supplementation.

Both enzymes when required were supplemented at the rate of 100g/ton of feed as recommended by the manufacturers. The compositions of the basal rations for the starter phase were as provided in Table 4.

The treatments were arranged in a completely randomized design. Diets and water were supplied ad libitum. The first and the second gumboro and the lasota vaccines were administered on the 10^{th}, 24^{th} and 28^{th} day respectively. Mortality was recorded as it occurred. The birds and feeds were weighed weekly. Live weight, weight gain, average daily gain, feed intake, feed-to-gain ratio and feed cost (₦/per kg gain) were determined at weekly intervals.

Finisher Phase (5-9weeks)

At the end of the broiler starter phase, the birds were pooled, fed on a common diet for one week and then randomly distributed to eighteen experimental pens at the beginning of the fifth week for the broiler finisher phase ensuring that average weight of birds per pen for all the pens were approximately equal.

There were 6 dietary treatments, replicated three times with fourteen broiler chicks per pen.

Table 4: Percentage Composition of the Basal Diets for the Broiler Starter Enzyme Supplemented Maize Offal Study (0-4weeks)

	Percent Maize Offal in Basal Rations	
Ingredients	**0%**	**25%**
Maize	46.55	23.33
Maize Offal	0	25.0
Soyabean Meal (Fulfat)	12.0	12.0
Palm kernel cake (Oily)	2	2
Groundnut cake	31.9	30.1
Fish meal	3.0	3.0
Bone Meal	3.5	3.5
Salt	0.3	0.3
Vitamin TM Premix*	0.3	0.3
L-Lysine	0.26	0.25
D-L-Methionine	0.19	0.22
Total	100.00	100.00
Calculated Analysis		
CP (%)	23.7	23.7
ME (Kcal/kg)	2904	2710
EE (%)	6.23	6.24
CF(%)	3.86	5.86
Ca (%)	1.17	1.18
Available P (%)	0.68	0.70
Lysine (%)	1.29	1.29
Meth +Cys	0.91	0.91
Cost ₦/kg	44.98	42.71

*Bio-mix Premix supplied per kg ration: Vit A 12000 I.U; Vit D_3 2400 I.U: Vit E 27.6mg; Vit K_3 2.4 6mg; Vit B_1 2.14mg: Vit B_2 6mg Vit B_6 3.6mg; Niacin 3.3mg; Pantothenic acid 9mg; Biotin 0.07mg; Vit B_{12} 0.02mg; Folic acid 0.9mg; chloline chloride 360mg; Manganese 48mg; Iron 24mg; Zinc 36mg; copper 3.6mg; Iodine 1.2mg; cobalt 0.23mg; selenium 0.23mg; Antioxidant 1.5mg.

Note: Treatment diets were derived from the two basal rations above as follows:

Treatment 1 - 0% maize offal basal ration + no enzyme (Control)
Treatment 2 - 0% maize offal basal + nutrase xyla
Treatment 3 - 0% maize offal basal + maxigrain
Treatment 4 - 25% maize offal basal + no enzyme
Treatment 5 - 25% maize offal basal + nutrase xyla
Treatment 6 - 25% maize offal basal + maxigrain

The compositions of the two basal rations for the broiler finisher phase were as shown in Table 5. The six experimental diets for the finisher phase were derived from the two basal diets. Feed and water were supplied ad libitum. Mortality was recorded as it occurred. Weekly records of live weight, weight gain, average daily gain, feed intake, feed-to-gain ratio and feed costs (₦ / kg gain) were kept.

Table 5: Percentage Composition of the Basal Diets Used for the Broiler Finisher Enzyme Supplemented Maize Offal Study (5-9weeks)

	Percent Maize Offal in basal rations	
Ingredients	**0%**	**25%**
Maize	50.8	27.8
Maize Offal	0	25.0
Soyabean Meal (Fulfat)	12.0	12.0
Palm kernel cake (Oily)	2	2
Groundnut cake	25.6	23.6
Fish meal	3.5	3.5
Palm Oil	1.3	1.3
Limestone	0.5	0.6
Bone Meal	3.3	3.15
Salt	0.3	0.3
Vitamin TM Premix*	0.3	0.3
L-Lysine	0.2	0.2
D-L-Methionine	0.2	0.2
Total	100.00	100.00
Calculated Analysis		
CP (%)	21.5	21.5
ME (Kcal/kg)	3009	2818
EE (%)	5.56	7.28
CF(%)	3.57	5.57
Ca (%)	1.32	1.32
Available P (%)	0.66	0.66
Lysine (%)	1.16	1.18
Meth +Cys	0.87	0.84
Cost ₦/kg	45.99	43.5

*Bio-mix Premix supplied per kg ration: Vit A 10800 I.U; Vit D_3 1800 I.U: Vit E 12.0mg; Vit K_3 1.8mg; Vit B_1 1.92mg: Vit B_2 480mg Vit B_6 1.8mg; Niacin 44.40mg; Pantothenic acid 6mg; Biotin 0.90mg; Vit B_{12} 0.012mg; Folic acid 0.60mg; chloline chloride 210mg; Manganese 48mg; Iron 24mg; Zinc 36mg; copper 3.60mg; Iodine 1.20mg; cobalt 0.24mg; selenium 0.24mg;; Antioxidant 1.5mg.

Note: Treatment diets were derived from the two basal rations above as follows:

Treatment 1 - 0% maize offal basal ration + no enzyme (Control)
Treatment 2 - 0% maize offal basal + nutrase xyla
Treatment 3 - 0% maize offal basal + maxigrain
Treatment 4 - 25% maize offal basal + no enzyme
Treatment 5 - 25% maize offal basal + nutrase xyla
Treatment 6 - 25% maize offal basal + maxigrain

3.5 Carcass Characteristics

At the end of nine weeks of the feeding trial, three birds from each pen with approximate body weights equal to the mean weight of the birds in the pen were selected and weighed. The selected birds were slaughtered for carcass analysis by severing the neck with a sharp knife. The birds were allowed to bleed completely. They were then defeathered and eviscerated. The liver, gizzard, head, thigh and breast were weighed and expressed as percentages of the live-weight. The intestinal length was measured in centimeters. The dressed weights were taken and the dressing percentages computed.

3.6 Data Analysis

All data obtained were subjected to the analysis of variance using the model for a completely randomized design. The statistical analysis was performed using the General Linear Model procedure of Statistical Analysis System (SAS) computer software package (1985). Significant differences between means were determined by applying the Duncan's Multiple Range Test (DMRT) (Duncan, 1955).

CHAPTER FOUR

4.0 RESULT AND DISCUSSIONS

4.1 RESULTS

4.1.1 Proximate Composition of Rice Offal and Maize Offal

The proximate composition of the parboiled rice offal used in the experiment is presented in Table 6. The average dry matter content is 96.22 %, crude protein, 5.42 %, crude fibre, 31.47 %, ether extract, 8.22 %, ash, 14.69 % and nitrogen free extract (NFE), 40.10 %.

The proximate composition of the local source maize offal used in the experiment is also shown in Table 6. The average dry matter content is 94.67%, crude protein, 9.75 %, crude fibre, 4.50 %, ether extract 5.83 %, ash 2.37% and nitrogen free extract 77.55 %.

TABLE 6: PROXIMATE CHEMICAL COMPOSITION OF RICE AND MAIZE OFFALS.

	Rice offal		Maize offal	
Parameter (%)	**Parboiled**	**Unparboiled**	**Local source**	**Factory source**
Dry matter	96.22	95.69	94.67	97.21
Crude protein	5.42	6.69	9.75	9.75
Crude Fibre	31.47	27.49	4.50	9.04
Ether Extract	8.22	3.54	5.83	4.76
Ash	14.69	14.69	2.37	6.25
Nitrogen –free-Extract	40.10	47.59	77.55	70.2

Mean values of two determinations

EXPERIMENT 1:

4.1.2 Effects of Enzyme Supplementations on the Performance of Broiler Chicks Fed Rice Offal Diets.

BROILER STARTER PHASE (0-4weeks)

The results of the performance of broiler chicks fed rice offal based diets with or without enzyme supplementations during the broiler starter phase are presented in Table 7. The table shows that dietary treatments had significant effects ($P<0.05$) on final weight, weight gain, average daily gain, feed to gain ratio and on feed cost (₦/kg gain). However, dietary treatments had no significant effect on feed intake and on mortality rate ($p>0.05$).

Effects of Enzyme Supplementations of the Broiler Starter Control Diet on the Performance of Broiler Starter Chicks (0-4 weeks).

The effects of enzyme supplementation of the control diet on the performance of the broilers during the starter phase are illustrated by the results obtained for diets 1 and 2 in Table 7. There was no significant effect of the maxigrain enzyme supplementation in diet 2 on feed Intake, final weight, weight gain, average daily gain, feed to gain ratio, feed cost (₦ / kg gain) and on mortality rate when these results are compared with those obtained with the control diet 1.

Table 7: PERFORMANCE OF BROILER STARTER CHICKS ON RICE OFFAL DIETS WITH OR WITHOUT ENZYME SUPPLEMENTATIONS (0-4 WEEKS)

Treatments	1	2	3	4	5	6	7	8	
Parameters	**Control**	**Control +Max**	**7.5% RO**	**7.5% Ro +Xyla**	**7.5% +Max**	**15% RO**	**15% RO +Xyla**	**15% RO +Max,**	***SEM***
Initial weight(g)	34.67	33.77	34.67	34.87	33.97	33.30	33.30	33.77	0.66
Feed intake (g)	1190.00	1180.00	1230.00	1196.67	1266.67	1240.33	1196.67	1226.67	46.97
Final weight (g)	491.00^{a}	503.00^{a}	385.33^{c}	406.67^{bc}	438.00^{b}	380.33^{c}	409.33^{bc}	439.00^{b}	19.85
Weight gain (g)	456.33^{a}	469.00^{a}	350.67^{c}	371.80^{bc}	404.03^{b}	347.03^{c}	376.03^{bc}	405.23^{b}	19.91
Average daily gain(g)	16.30^{ab}	16.75^{a}	12.52^{c}	13.28^{c}	14.34^{bc}	12.39^{c}	13.43^{bc}	14.38^{bc}	0.72
Feed: Gain ratio	2.62^{a}	2.54^{a}	3.51^{c}	3.23^{c}	3.15^{bc}	3.57^{c}	3.10^{abc}	3.05^{abc}	0.17
Feed cost (₦/kg gain)	115.96^{ab}	109.31^{a}	143.12^{b}	133.28^{ab}	129.80^{ab}	122.99^{ab}	116.10^{ab}	115.14^{ab}	9.50
Mortality %	7.14	4.76	2.38	4.76	2.38	4.76	4.76	7.14	2.90

* Row means with different superscripts are significantly different ($p<0.05$)

Effects of Enzyme Supplementations of the 7.5% Rice Offal Broiler Starter Diet

The effects of enzyme supplementations of the 7.5% rice offal broiler starter diets on the performance of broiler chicks can be determined by comparing the results for the control diet 1 with those of enzyme unsupplemented 7.5% rice offal starter diet 3 and the enzyme supplemented 7.5% rice offal starter diets 4 and 5 (see Table 7). The table shows that feed intake per bird was slightly higher for the enzyme unsupplemented 7.5% rice offal diet than for the control diet 1 but the increase in value was not significant ($P>0.05$). The table also shows that 7.5% rice offal diet without enzyme supplementation (diet 3) resulted in significantly depressed ($P<0.05$) final weight, weight gain and average daily gain when compared with the values for the control diet. Feed to gain ratio was significantly poorer than that obtained with the control diet 1 ($P<0.05$).

Feed cost (₦ / kg gain) for diet 3 showed some increase above that of the control diet (₦ 143.12 versus ₦ 115.96) although the difference was not significant ($P>0.05$). Mortality rate was also not significantly affected by dietary treatments during the starter phase of this experiment ($p>0.05$).

Enzyme supplemented 7.5% rice offal diets (xylanase for diet 4 and maxigrain for diet 5) resulted in improved performance ($p<0.05$) of chicks above the values obtained for the unsupplemented 7.5% rice offal diet 3. The

improvements observed for the maxigrain supplemented 7.5% rice offal diet 5 were significant ($P<0.05$) when compared to the values obtained for the unsupplemented 7.5% rice offal diet for final weight and weight gain. Whereas the improvements in those parameters were only in numerical values for the nutrase xyla enzyme supplemented diet 4

Effects of Enzyme Supplementations of the 15% Rice Offal Broiler Starter Diet

The effects of the enzyme supplemented 15% rice offal broiler starter diets (diets 7 and 8) on the performance of the chicks compared with those of the control (diet 1) and also with those of enzyme unsupplemented 15% rice offal diet (diet 6) are shown in Table 7. The table shows that there is no significant difference ($p>0.05$) in the feed intake of the different treatment groups. The results also indicated that the unsupplemented 15% rice offal diet (diet 6) caused significant reductions ($P<0.05$) in final weight, weight gain and in average daily gain when compared with the results for the control diet. Feed to gain ratio also increased ($p<0.05$) above the values obtained with the control diet. Feed cost (₦ / kg gain) increased slightly but the increase above the value for the control diet was not significant ($P>0.05$).

Enzyme supplementation of the 15% rice offal diets (xylanase for diet 7 and maxigrain for diet 8) had no effect on feed intake but improved the performance of broiler chicks for final weight, weight gain, average daily

gain, feed to gain ratio and feed cost (₦ per kg gain) above the values obtained for the unsupplemented 15% rice offal diet (diet 6). The improvements were however only significant ($P<0.05$) for the maxigrain supplemented diet 8 for final weight and weight gain, but the values were significantly lower than those obtained with the control diet 1.

Comparison of the Effects of Xylanase and Maxigrain Enzyme Supplementations of Rice Offal Based Diets on the Performance of Broiler Starter Chicks (0-4weeks)

The effects of xylanase and maxigrain enzymes on the utilization of the rice offal based broiler starter diets are presented in Table 8. The table shows that none of the two enzymes significantly affected the feed intake. It also shows that none of the two enzymes was able to improve the utilization of rice offal based broiler starter diets up to the values obtained with the control diet with regard to final weight, weight gain, average daily gain and feed to gain ratio.

When the effects of the two enzymes were compared, it was observed that maxigrain improved the performance of the broiler chicks significantly above the values obtained for the xylanase supplemented diet for final weight and weight gain. There were no significant difference between the two enzymes with regard to their effect on feed intake, average daily gain, feed to gain ratio, feed cost (₦ / kg gain) and on mortality rate ($P>0.05$).

Table 8: EFFECTS OF TYPES OF ENZYME ON THE UTILIZATION OF RICE OFFAL BASED BROILER STARTER DIETS (0-4 WEEKS)

Parameters	Control	Xyla Diets	Maxigrain Diets	SEM
Initial weight(g)	34.67	34.08	33.92	0.36
Feed intake (g)	1190.00	1171.67	1246.67	36.45
Final weight (g)	491.00 [a]	408.00 [c]	438.50 [b]	9.04
Weight gain (g)	456.33 [a]	373.93 [c]	403.30 [b]	8.93
Average daily gain (g)	16.30 [a]	13.35 [b]	14.36 [b]	0.58
Feed: Gain ratio	2.62 [a]	3.16 [b]	3.09 [b]	0.16
Feed cost (₦/ kg gain)	115.96	129.46	122.47	6.52
Mortality %	7.14	4.76	4.76	3.22

* Row means with different superscripts are significantly different ($p<0.05$).

BROILER FINISHER PHASE (5-9weeks)

The performance of broiler chicks fed rice offal based diets with or without enzyme supplementation during the broiler finisher phase are presented in Table 9.

Effects of Enzyme Supplementation of the Broiler Finisher Control Diet

A comparison of the effects of enzyme supplementation of the control diet during the finisher phase can be observed by comparing the results obtained for treatment 1 with those of treatment 2 in table 9. Feed intake was not significantly affected by enzyme supplementation of the control diet. Maxigrain supplemented control diet (diet 2) resulted in some improvements above the unsupplemented control diet (diet 1) with respect to final weight and weight gain but the improvements were not significant ($p>0.05$). The improvements were significant ($P<0.05$) for average daily gain, feed to gain ratio and for feed cost (₦ / kg gain).

Effects of Enzyme Supplementations of The 7.5% Rice Offal Broiler Finisher Diet

Enzyme unsupplemented 7.5% rice offal diet (diet 3) had significantly higher ($p<0.05$) feed intake when compared to the control diet. Diet 3 however, gave similar results as obtained with the control diet (diet 1) for final weight, weight gain, average daily gain, feed to gain ratio and for feed

cost (₦ / kg gain). Feed intake was significantly higher ($p<0.05$) for all the 7.5% rice offal diets whether or not supplemented with enzyme when compared to the control diet 1.

Enzyme supplemented 7.5% rice offal diets (diets 4 and 5) resulted in numerically higher but not significant values above the control diet for final weight and weight gain. Average daily gain was significantly higher ($p<0.05$) for the enzyme supplemented 7.5% rice offal diet than the result obtained for the control diet. Enzyme supplemented 7.5% rice offal diets also resulted in significantly higher values ($p<0.05$) than the unsupplemented 7.5% rice offal (diet 3) for final weight and for average daily gain. Enzyme supplementation of the 7.5% rice offal diet did not significantly affect feed to gain ratio when compared with the unsupplemented 7.5% rice offal diet ($P>0.05$).

Maxigrain supplemented 7.5% rice offal diet resulted in significantly lower feed cost (₦ per kg gain) ($P<0.05$) compared with the control diet.

Table 9: PERFORMANCE OF BROILER FINISHER CHICKS ON RICE OFFAL DIETS WITH OR WITHOUT ENZYME SUPPLEMENTATIONS (5-9 WEEKS)

Treatments	1	2	3	4	5	6	7	8	
Parameters	**Control**	**Control +Max**	**7.5% RO**	**7.5% RO +Xyla**	**7.5% +Max**	**15% RO**	**15% RO +Xyla**	**15% RO +Max,**	***SEM***
Initial weight(g)	689.00	694.67	669.33	692.33	692.00	689.00	675.33	688.67	9.63
Feed intake (g)	3470.0 ^{c}	3285.0 ^{c}	3710.0 ^{b}	3906.7 ^{a}	3793.3 ^{a}	3723.3 $^{a\ b}$	3863.3 ^{a}	3780.0 ^{a}	80.34
Final weight (g)	1917.67 ^{ab}	1983.67 $^{a\ b}$	1906.00^{b}	2029.67^{a}	2049.33^{a}	1898.33^{b}	1944.33^{ab}	2017.00^{a}	42.73
Weight gain (g)	1228.67 ^{ab}	1289.00 ^{a}	1236.67^{ab}	1327.34^{a}	1357.33^{a}	1209.33^{b}	1269.00^{a}	1328.33^{a}	45.00
Average daily gain(g)	43.88^{b}	46.03 ^{a}	44.17^{b}	47.39^{a}	48.48^{a}	43.19 ^{b}	45.32^{ab}	47.44^{a}	1.64
Feed: Gain ratio	2.82 ^{b}	2.54 ^{a}	2.98^{b}	2.98^{b}	2.79^{ab}	3.08^{b}	3.04^{b}	2.85^{b}	0.09
Feed cost (₦/kg gain)	132.26 ^{c}	119.86 ^{a}	129.88^{bc}	130.30^{c}	122.02^{ab}	122.55^{b}	123.11^{b}	114.54^{a}	3.93
Mortality %	5.55 ^{a}	0.00 ^{b}	8.33 ^{a}	8.33 ^{a}	0.00 ^{b}	5.55 ^{a}	8.33 ^{a}	5.55 ^{a}	2.49

* Row means with different superscripts are significantly different ($p<0.05$).

Effects of Enzyme Supplementations of the 15% Rice Offal Broiler Finisher Diet (5-9 Weeks)

The effects of enzyme supplementation of the 15% rice offal diets on the performance of broiler chicks during the finisher stage can be determined from the results of diets 6, 7 and 8 in Table 9. The enzyme unsupplemented 15% rice offal diets resulted in significantly higher ($p<0.05$) feed intake when compared with the control diet. Similarly it resulted only in slight but non-significant depression ($P>0.05$) in final weight and weight gain when compared with the value obtained with the control diet. Unsupplemented 15% rice offal diet also did not significantly ($P>0.05$) depress average daily gain, feed to gain ratio and mortality rate when compared with the value obtained with the control diet. Feed cost (₦ per kg gain) was significantly reduced when compared to the result obtained with the control diet ($P<0.05$).

Enzyme supplementation of the 15% rice offal diets (diets 7 and 8) showed no significant difference ($p>0.05$) for feed intake when compared to the unsupplemented 15% rice offal diet but the result was significantly higher ($p<0.05$) for feed intake when compared with that of the control diet.

Enzyme supplementation of the 15% rice offal diets (diet 7 and 8) resulted in some improvements in final weight, weight gain and average daily gain of broilers above the results obtained with the enzyme unsupplemented 15% rice offal diet (diet 6). The maxigrain enzyme had greater and sometimes

significant effects in improving the utilization of the 15% rice offal diets above the unsupplemented diet than the xylanase with regards to their effects on final weight, weight gain, average daily gain and in reducing feed cost (₦ per kg gain).

Comparison of the Effects of Xylanase and Maxigrain Enzymes on the Utilization of Rice Offal Based Broiler Finisher Diets (5-9 Weeks)

The effects of xylanase and Maxigrain enzymes on the utilization of the rice offal based broiler finisher diets are compared in Table 10. Even with the presence of both enzymes, feed intake was significantly increased above the value obtained with the control diet. Both enzymes improved the quality of the rice offal based broiler finisher diets when compared with the control diet as shown by higher values for final weight, weight gain and average daily gain. The two enzymes also resulted in some reductions in feed cost (₦/kg gain). Maxigrain generally showed some level of superiority above xylanase in improving the quality of rice offal based broiler finisher diets with regard to final weight, weight gain, average daily gain, feed to gain ratio and in reducing feed cost (₦/kg gain).

Table 10: EFFECTS OF TYPES OF ENZYME ON THE UTILIZATION OF RICE OFFAL BASED BROILER FINISHER DIETS (5-9 WEEKS)

Parameters	Control	Xyla Diets	Maxigrain Diets	SEM
Initial weight(g)	689.00	689.00	690.33	7.22
Feed intake (g)	3470.00 [b]	3885.0 [a]	3786.67 [a]	35.31
Final weight (g)	1917.67 [b]	1987.00 [ab]	2033.17 [a]	42.15
Weight gain (g)	1228.7 [b]	1298.0 [ab]	1342.84 [a]	39.55
Average daily gain (g)	43.88 [b]	46.35 [ab]	47.96 [a]	1.73
Feed: Gain ratio	2.82	3.02	2.82	0.11
Feed cost (₦/ kg gain)	132.26 [b]	126.71 [ab]	118.28 [a]	4.71
Mortality %	5.55	8.33	2.77	2.78

* Row means with different superscripts are significantly different ($p<0.05$)

EXPERIMENT 2

4.1.3 Effects of Enzyme Supplementations on the Performance of Broiler Chicks Fed Maize Offal Diets

BROILER STARTER PHASE (0-4WKS)

The performances of broiler chicks fed maize offal diets with or without enzyme supplementations during the starter phase of experiment 2 are presented in Table 11. Dietary treatments had significant effects on final weight, weight gain, average daily gain, feed intake, feed to gain ratio and on feed cost (₦ / kg gain).

Effects of Enzyme Supplementations of the Maize-Based Control Starter Diet on the Performance of Broiler Chicks (0-4weeks)

The effects of enzyme supplementations of the control diet on the performance of broiler chicks can be determined from Table 11 by comparing the effects of control diet 1 with the xylanase or maxigrain supplemented diets 2 or 3 respectively. There were no significant effects ($p>0.05$) of supplementing the two enzymes in the control diet on the performance of broiler chicks as regards final weight, weight gain, average daily gain, feed to gain ratio and on feed cost (₦/kg gain). Feed intake of the maxigrain supplemented control diet was however, significantly less than that of the unsupplemented control diet 1 and the xylanase supplemented control diet 2.

TABLE 11: PERFORMANCE OF BROILER STARTER CHICKS ON MAIZE OFFAL DIETS WITH OR WITHOUT ENZYME SUPPLEMENTATIONS (0-4 WEEKS)

Treatments	**1**	**2**	**3**	**4**	**5**	**6**	
Parameters	**Control**	**Control +Xyla**	**Control + max**	**25% MO**	**25% +Xyla**	**25% +Max**	**SEM**
Initial weight (g)	38.89	38.89	38.89	38.89	38.89	38.89	0
Feed intake (g)	1116.7^{a}	1105.87^{a}	1073.97^{b}	1138.88^{a}	1114.22^{ab}	1120.94^{a}	19.87
Final weight (g)	496.93^{ab}	490.27^{ab}	495.30^{ab}	473.33^{b}	509.53^{a}	506.27^{a}	14.85
Weight gain (g)	458.03^{a}	451.37^{a}	456.40^{a}	434.43^{b}	470.63^{a}	464.03^{a}	14.01
Average daily gain (g)	16.36^{ab}	16.12^{ab}	16.30^{ab}	15.52^{b}	16.71^{a}	16.57^{a}	0.52
Feed: Gain ratio	2.45^{a}	2.45^{a}	2.36^{a}	2.61^{b}	2.37^{a}	2.41^{a}	0.053
Feed cost (₦/kg gain)	109.78^{b}	111.04^{b}	106.89^{ab}	112.14^{b}	101.93^{a}	103.97^{a}	2.34
Mortality %	1.83	1.83	1.83	0.00	1.83	1.83	1.71

* Row means with different superscripts are significantly different ($p<0.05$)

Effects of Enzyme Supplementations of the 25% Maize Offal Diet on the Performance of Broiler Starter Chicks (0-4 Weeks)

There were no significant effects of the unsupplemented 25% maize offal diet (diet 4) on feed intake, feed cost (₦ / kg gain) and on mortality rate ($P>0.05$) when compared with the results obtained with the control diet 1 (Table 11). Enzyme unsupplemented 25% maize offal broiler starter diet (diet 4) however, resulted in slightly but not significantly depressed final weight and average daily gain but significantly depressed weight gain ($P<0.05$) when compared with the results obtained with the control diet 1. Feed to gain ratio was significantly increased ($P<0.05$) for the unsupplemented 25% maize offal diet.

Comparison of the Effects of the Xylanase and Maxigrain Enzyme Supplementations of Maize Offal Diets on the Performance of Broiler Starter Chicks (0-4weeks)

The comparison of the supplementation effects of the two enzymes in maize offal diets on the performance of broiler chicks can be made from Table 11 as follows:-

a. Control diet versus xylanase supplemented maize offal broiler diet (Treatment 1 versus Treatment 5).

b. Control diet versus maxigrain supplemented maize offal broiler starter diet (Treatment 1 versus Treatment 6).

Supplementation of both enzymes in the 25% maize offal diets (diets 5 and 6) had no significant effect on feed intake when compared with the control diet 1 and with the enzyme unsupplemented 25% maize offal diet 4. Diet 5 (with xylanase enzyme) and diet 6 (with maxigrain enzyme) resulted in significantly higher or better values ($p<0.05$) for final weight, weight gain, average daily gain and feed to gain ratio than the values obtained with the enzyme unsupplemented maize offal broiler starter diet 4. Feed cost (₦ / kg gain) was also significantly reduced when compared with the result for the enzyme unsupplemented maize offal diet 4.

The two enzyme supplemented diets 5 and 6 improved the performances of the birds to the same levels and sometimes with numerically better values than those obtained by the control diets for all the parameters measured. Similarly, there was no significant difference between the two enzymes (diets 5 and 6) for their effects on any of the parameters considered ($p>0.05$).

BROILER FINISHER PHASE (5-9weeks)

The performance of broiler chicks fed maize offal diets with or without enzyme supplementation during the broiler finisher phase (5-9weeks) are presented in Table 12. There was no significant effect of diets on the mortality rate ($P>0.05$).

Effects of Enzyme Supplementations of the Maize-Based Control Diet on the Performance of Broiler Finishers (5-9 Weeks)

The effects of enzyme supplementations of the control diet on the performance of broiler finishers (5-9 weeks) can be determined by comparing the effects of diet 1 with those of diets 2 and 3 respectively (Table 12). The table shows that enzyme supplementations of the control diet (diets 2 and 3) did not have any significant effect on most of the parameters studied ($p>0.05$). The only significant effect observed was the xylanase supplemented diet 2 which resulted in significantly lower feed intake when compared with the control diet 1($P<0.05$).

Effect of Enzyme Supplementations of the 25% Maize Offal Diets on the Performance of Broiler Finishers (5-9 weeks)

Diet 4 containing 25% level of maize offal without enzyme supplementation caused significant depression of final weight, weight gain and average daily gain ($p<0.05$) when these results were compared with those obtained with the control diet 1. Feed to gain ratio also significantly increased ($p<0.05$) above the value for the control diet. Feed intake and feed cost (₦/kg gain) were similar for both the unsupplemented maize offal diet and the control diet.

Feed intake increased slightly for the xylanase supplemented diet 5 and significantly increased ($p<0.05$) for the maxigrain supplemented 25% maize

offal diet (diet 6) when compared with the unsupplemented control diet 1 and the unsupplemented 25% maize offal diet. Enzyme supplementations of the 25% maize offal diet resulted in some or significant improvements ($p<0.05$) for final weight, weight gain, average daily gain, feed to gain ratio and feed cost (₦ per kg gain) when compared with the results for the unsupplemented 25% maize offal diet.

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Comparison of the Effect of Xylanase and Maxigrain Enzyme Supplementations of Maize Offal Based Diets on the Performance of Broiler Finisher Chicks (5-9 Weeks)

The effects of xylanase and that of maxigrain enzyme supplementations of maize offal diets on the performance of broiler finisher chicks can be determined by examining the results obtained for diets 1 and 4 and comparing them with those of diets 5 and 6 (Table 12). Diet 5 (with xylanase) and Diet 6 (with maxigrain) both resulted in significantly higher ($p<0.05$) final weight and weight gain when compared with the values obtained by the unsupplemented 25% maize offal diet (diet 4). Feed to gain ratio and feed cost (₦/kg gain) were significantly reduced ($p<0.05$). The improvement on the average daily gain was significant ($p<0.05$) for the maxigrain supplemented diet 6 while the improvement by the xylanase enzyme was only in numerical value.

TABLE 12: PERFORMANCE OF BROILER FINISHER CHICKS ON MAIZE OFFAL DIETS WITH OR WITHOUT ENZYME SUPPLEMENTATION (5-9 WEEKS)

Treatments	**1**	**2**	**3**	**4**	**5**	**6**	
Parameters	**Control**	**Control + Xyla**	**Control + max**	**25% MO**	**25%MO +xyla**	**25%MO +Max**	**SEM**
Initial weight (g)	819.04	816.66	816.66	819.04	816.66	819.04	2.26
Feed intake (g)	4352.33^{b}	4246.33^{c}	4316.67^{bc}	4333.00^{b}	4402.33^{ab}	4456.00^{a}	35.78
Final weight (g)	2669.33^{a}	2615.67^{a}	2648.00^{a}	2485.67^{b}	2619.33^{a}	2700.00^{a}	52.71
Weight gain (g)	1849.96^{a}	1798.34^{a}	1831.01^{a}	1666.63^{b}	1802.34^{a}	1881.29^{a}	52.34
Average daily gain (g)	66.07^{a}	64.23^{ab}	65.39^{a}	59.52^{b}	64.37^{ab}	67.19^{a}	1.87
Feed: gain ratio	2.36^{a}	2.36^{a}	2.36^{a}	2.61^{b}	2.45^{a}	2.37^{a}	0.09
Feed cost (₦/kg gain)	108.52^{ab}	109.36^{ab}	109.20^{ab}	113.64^{b}	107.25^{a}	103.84^{a}	3.89
Mortality %	0.00	2.38	2.38	2.38	0.00	4.76	1.95

* Row means with different superscripts are significantly different ($p<0.05$).

4.1.4 Effects of Enzyme Supplementations on Carcass Characteristics of Broiler Chickens at 9 Weeks of Age

The results for the carcass analysis performed after the 9 weeks of the maize offal feeding trial in experiment 2 are as presented in Table 13. The table shows that enzyme supplementations of maize offal broiler finisher diets had no significant effects on dressing %, gizzard % and on the intestinal length.

Percent thigh was significantly improved when either of the enzymes were supplemented in the control diet (diets 2 and 3). Breast % was slightly increased by the enzyme supplemented diets 2, 3, 5 and 6 when compared with the values for the unsupplemented diets 1 and 4. Similarly, there were little reductions in liver % when diets were supplemented with enzymes (diets 2, 3, 5 and 6) compared with the unsupplemented diets 1 and 4. Greater reductions in liver % was observed with the maxigrain enzyme supplemented 25% maize offal diet 6 when compared with all other diets ($p<0.05$).

TABLE 13: EFFECT OF ENZYME SUPPLEMENTATION AND TYPES OF ENZYME ON CARCASS CHARACTERISTICS OF BROILERS

Treatments	1	2	3	4	5	6	
Parameters	**Control**	**Control + Xyla**	Control + Max	**25% MO**	**25%MO + Xyla**	**25%MO +Max**	**SEM**
Live Weight (g)	2763.30[a]	2740.00[a]	2740.00[a]	2556.70[b]	2650.00[a b]	2730.00[a]	45.35
Dressed Weight (g)	2083.30[a]	2086.70[a]	2063.30[a]	1916.70[b]	2003.30[a b]	2116.70[a]	42.65
Dressing %	75.40	76.20	75.30	75.00	75.60	77.50	1.89
Thigh %	21.67[b]	23.15[a]	22.50[a]	21.09[b]	21.17[b]	21.58[b]	0.42
Breast %	18.31[b]	20.48[a]	20.27[a b]	19.55[b]	20.18[a b]	21.17[a]	0.61
Gizzard %	3.02	3.24	3.35	3.70	3.37	3.25	0.26
Head %	1.81[b]	1.83[b]	1.83[b]	1.96[a]	1.89[a b]	1.83[b]	0.03
Liver %	1.91[a]	1.81[a]	1.77[a]	1.93[a]	1.76[a]	1.69[b]	0.07
Intestinal Length (cm)	273.44	261.89	262.53	273.11	274.11	268.91	6.98

* Rows with different superscripts are significantly different ($p<0.05$).

4.2 DISCUSSIONS

4.2.1 Proximate Composition of Rice and Maize Offals

From the result of the proximate composition of rice offal (Table 6) it was observed that parboiled rice offal is high in crude fibre (31.47%) and therefore this material may not be easy to digest by broiler chicks. Maikano (2005) also reported crude fibre values of 31.76% for Kwoi sample, 31.47% for Taime sample and 30.39% for Zaria city sample, all of which agreed with the result obtained in this study. However, higher values of 40.06%CF and 44.94%CF were reported by Dafwang and Shwarmen (1996) and Oyeyiola (1991) respectively. The value of 5.42% for crude protein obtained for rice offal agreed with the value of 5.44%CP (Taime sample) reported by Maikano (2005). It was however, slightly lower than 5.71%CP and 6.01%CP reported by Oyeyiola (1991) and Dafwang and Shwarmen (1996) respectively.

Maize offal was observed to have crude fibre value of 4.50% which is much lower than 10.5%CF reported by Aduku (2004).The crude protein value of 9.75% obtained for maize offal was slightly lower than 11.9% crude protein reported by Aduku (2004).

Waller (2002) reported that by-products by the nature of their origin are often subject to variations in composition. Some of the factors that may affect such variations include growing conditions (climate, soil and fertilizer

applications), harvest conditions (such as variety grown and stage of maturity at harvest), post harvest processing, storage and handling.

Effects of Enzyme Supplementation on the Performance of Broiler Chicks Fed Rice Offal Diets.

There was no significant effect of the maxigrain enzyme supplementation of the control diet (diet 2) on feed intake, final weight and weight gain at both the starter (Table 7) and finisher (Table 9) phases. These results are in agreement with the reports of Classen et al (1995) and Bedford (2000) which stated that the response of birds to enzyme supplementation is more apparent with poorly digested compared with highly digestible diets. This suggests that the enzyme supplementation of a rich corn diet such as diet 2 has no economic benefit to the poultry farmer since it resulted in non-significant improvements in the growth performance of the birds. Enzyme supplementation of the control diet also had no significant effect on average daily gain and on feed cost (₦/kg gain) at the starter phase whereas these parameters were significantly better when compared with the unsupplemented control diet 1 at the finisher phase.

Significant depressions ($p<0.05$) obtained at the starter phase on final weight, weight gain and feed to gain ratio with the enzyme unsupplemented 7.5% and 15% rice offal diets when compared with the control diet (Table 7) is an indication that young broiler chicks at the starter phase were not able to handle

high fibre diets effectively. This result is in agreement with the report of Funmilayo (1990) which stated that young chicks below four weeks of age were not able to effectively handle high levels of rice offal in their diets. The result however, contradicts the reports of Dafwang and Shwarmen (1996) and Maikano (2005) that broiler chicks can tolerate up to 10% and 15% rice offal dietary levels respectively at the starter phase (0-4weeks) with no adverse effect on growth performance. The better performance obtained by Maikano (2005) could have been as a result of the high level of palm oil (3.5 to 5% palm oil) he used in the diets which raised the energy content of the experimental rice offal diet fed. However, similar weight gains and average daily gains obtained at the finisher phase (Table 9) when the unsupplemented 7.5% and 15% rice offal diets were compared with the control diet agreed with the reports of Dafwang and Damang (1995) and Maikano (2005). The two reports recommended that between 15% and 20% dietary inclusion levels of rice offal for broiler finisher diets would be satisfactory.

Significant improvements observed with enzyme supplementations of both 7.5% and 15% rice offal diets when compared with the unsupplemented rice offal diets for both starter and finisher phases are in agreement with the report of Atteh (2004) that enzyme supplementation played significant roles through improvement in the performance of broilers, especially on weight gain. The improvements observed with enzyme supplementation of 7.5% and 15% rice

offal diets when compared with the control diet 1 at the finisher phase are also in agreement with Brufau et al. (1991) who obtained a better response to enzyme supplementation at the finisher period (19 to 45 days) than at the growing period (0 to 19 days). Petterson et al. (1991) and Salih et al (1991) reported that the age of birds can influence their response to growth and nutrient digestibility when fed a barley based diet supplemented with enzyme. They concluded that the young undeveloped gastrointestinal tract was more affected by β-glucan than the mature gastrointestinal tract.

Higher feed intakes observed with 7.5% and 15% rice offal diets whether supplemented with enzymes or not at both starter and finisher phases are in agreement with Onimisi (2005) who reported that with increased bulkiness of feed, birds tend to consume more of the feed in order to obtain similar levels of nutrients needed to satisfy their requirements. Fadugba (1989) also observed that bulky feeds which are high in fibre are rather low in nutrient concentration per unit volume.

A comparison of xylanase and maxigrain enzymes when supplemented in the 7.5% and 15% rice offal based diets showed that both enzymes improved the performance of broiler chicks at both starter (Tables 7 and 8) and finisher (Tables 9 and 10) phases when compared with the unsupplemented rice offal diets and the control diets. This was reflected by the higher values observed for final weight, weight gain and average daily gain for the enzyme supplemented

diets. It must however, be noted that higher effectiveness was shown by maxigrain enzyme than xylanase in improving the performance of broiler chicks fed rice offal based diets (Tables 8 and 10). This could be attributed to the multienzyme composition of maxigrain whereas xylanase consist of a single enzyme. Campbell and Bedford (1992) reported that the enzyme supplement must contain the proper spectrum of enzymes so that antinutritional effects of target substrate will be neutralized.

Effects of Enzyme Supplementation on the Performance of Broiler Chicks Fed Maize Offal Diets

Enzyme supplemented control diets 2 and 3 gave similar results as the unsupplemented control diet 1 for final weight, weight gain, average daily gain, feed to gain ratio and for feed cost (₦/kg gain) at both starter (Table 11) and finisher (Table 12) phases. This observation is supported by the reports of Classen et al. (1995) and Bedford (2000) who stated that the response to enzyme supplementation is more apparent with poorly digested compared with highly digestible diets. The slight decrease in feed intake by broiler chicks fed enzyme supplemented control diets 2 and 3 when compared with the feed intake of the control diet 1 could be as a result of an elevated metabolizable energy levels of the diets due to enzyme supplementation. Marquardt et al.(1994) reported an improvement in apparent metabolizable energy (AMEn) of diets with enzyme supplementation.

There were some depressions in final weight, weight gain, average daily gain and feed to gain ratio for the unsupplemented 25% maize offal diet when compared with the control diet at the starter phase (Table 11). Significant depressions of final weight, weight gain and average daily gain and feed to gain ratio were also observed with the unsupplemented 25% maize offal diet when compared with the control diet at the finisher phase (Table 12). These observations are indications that the birds could not effectively handle this level of fibrous material in their diets without enzyme supplementations. These results also agreed with the findings of Kandra et al. (1974) who reported that body weights in meat type birds decreased when birds were fed higher levels of fibre in the diet. The results however disagreed with that of Vantsawa (1998) who reported that up to 50% of maize can be replaced with maize offal without detrimental effects. Differences in the observations made by Vantsawa and those made in this study could be as a result of variations in the sources and nutrient compositions of the maize offal used in the various studies. It has been found that maize offal derived from local mills are generally higher in energy value than the factory derived maize offal (Ogundipe, 2006).

The significantly poorer feed to gain ratio in the unsupplemented 25% maize offal diet at both starter and finisher phases when compared with the result of the control diet agreed with Onimisi (2005) and Maikano (2005). Both reported poorer feed to gain ratios with increasing levels of fibre in the diets of

broiler chicks. This implies that the efficiency at which birds convert feed into meat diminishes with increasing bulkiness of diets. The increasing bulkiness of feed with increasing level of fibre reduces the quality of the feed. This observation is common to most agro-industrial by-products when used in livestock feeds (Fadugba., 1999).

Significantly higher or better final weights, weight gains and feed to gain ratios obtained with enzyme supplemented 25% maize offal diets (diets 5 and 6) at the starter (Table 11) and finisher (Table 12) phases when compared with the values for the unsupplemented 25% maize offal diets agreed with Scott et al. (1998a,b). These researchers reported that enzymes increased the digestibility of poorly digested cereals to a much greater extent than for the well digested cereals. This reports were further supported by the fact that enzyme supplementations of the 25% maize offal broiler diets also improved the utilization of the diets up to the values obtained with the control diet for all the growth parameters measured.

A comparison of the effects of both enzymes (xylanase and maxigrain) showed that both enzymes were similar in their efficacy for improving the performance of broiler chicks fed maize offal diets at both starter and finisher phases. The two enzymes improved final weights, weight gains, average daily gains and feed to gain ratios. They also reduced feed cost (₦/kg gain) to about the same level.

Effects of Enzyme Supplementation of Diets on Carcass Characteristics of Broiler Chicken

The observed increase in % breast by the enzyme supplemented diets 2, 3, 5 and 6 when compared with the values for the unsupplemented diets 1 and 4 implies that more meat is produced in the broiler chicken when enzymes are supplemented in their diets. Reductions in liver percentage by enzyme supplemented diets 2, 3, 5 and 6 also agrees with Brenes et al (1993), who reported that enzyme supplementation affects the relative size of some organs with relative reductions in the weights of such organs. Atteh (2004) also reported reduced liver weights with enzyme supplementation. Liver functions in the process of detoxification. Lower liver weight may be as a result of the action of the enzyme in the process of detoxification which could have helped in reducing this burden on the liver (less work means reduced size).

Enzyme supplementations had no significant effect on the intestinal length. This observation disagreed with the report of Marquardt et al (1996). They reported that enzyme supplementation reduced the length and sizes of various sections of the gastrointestinal tract.

Both enzymes had similar effects on most of the carcass characteristics measured except on % liver in which the maxigrain supplemented 25% maize offal diet 6 significantly reduced % liver of the broilers to a greater degree than the effect of xylanase enzyme.

CHAPTER FIVE

5.0 SUMMARY AND CONCLUSION

The need to improve the performance of broiler chicks while at the same time reducing the cost of feeding through the use of cheaper feed ingredients cannot be over emphasized. This study was designed to determine the effects of enzyme supplementations on the utilization of rice offal and maize offal in broiler diets. It was also designed to evaluate the economics of raising broiler chicks on enzyme supplemented diets containing rice offal or maize offal.

Fresh samples of rice offal and maize offal were collected from the local mills in Zaria for chemical analysis. Chemical analyses were carried out on the samples to determine their nutrient compositions before they were used in formulating rations for the broiler feeding trials.

Two broiler feeding experiments were conducted. The starter phases lasted from zero to four weeks. At the end of four weeks, the chicks were fed on a common ration for one week after which they were randomized and reassigned to different treatments for the finisher phases. The finisher phases lasted from five to nine weeks.

Three isonitrogenous basal rations were formulated for the starter (24% CP) and for the finisher (21% CP) phases of experiment 1 containing 0%, 7.5% and 15% rice offal levels respectively. The control diet which contained 0%

rice offal was divided into two parts. One part was supplemented with maxigrain at 100g/ton of complete feed and the other part had no enzyme supplemented. The 7.5% rice offal basal ration was divided into three parts. Two parts were supplemented with either maxigrain or nutrase xyla enzymes respectively while one part had no enzyme supplementation. The 15% rice offal basal ration was also divided into three parts. Two parts were supplemented with either maxigrain or nutrase xyla enzymes respectively while one part had no enzyme supplementation. These altogether constituted the eight dietary treatments for experiment 1. For experiment 2, two isonitrogenous basal rations were formulated containing 0% and 25% maize offal levels for the starter (23.7%CP diet) and finisher (21.5% CP diet) phases of the experiment. The 0% maize offal basal ration (control) was divided into three parts. The first two parts were supplemented with either maxigrain or nutrase xyla enzymes at 100g/ton of complete feed while the third part had no enzyme. The 25% maize offal basal ration was also divided into three parts. The first two parts were supplemented with either maxigrain or nutrase xyla while the third part had no enzyme supplementation. These altogether formed the six dietary treatments for experiment 2. The following observations were made from the two feeding trials:

1. For the starter phase, broiler chicks could not effectively utilize rice offal at both 7.5% and 15% in their diets even when supplemented with either xylanase or with maxigrain enzyme.
2. For the broiler finisher phase, enzyme supplementations effectively improved the utilization of rice offal broiler finisher diets up to 15% dietary levels with significant reductions in feed cost (₦/kg gain).
3. At both starter and finisher phases, enzyme supplementations significantly improved the utilization of maize offal in broiler diets up to 25% dietary level.
4. Enzyme supplementation led to a better usage of rice offal and maize offal with significant reductions in the quantities of maize used in the rations.
5. Maxigrain and nutrase xyla enzymes were equally effective in improving the utilization of maize offal based diets. Maxigrain however, performed slightly better than nutrase xyla for rice offal based diets.
6. There is no economic advantage in enzyme supplementation of an all maize-based diet with low fibre content.
7. Enzyme supplementation increased thigh % and breast % and maxigrain significantly reduced the size of the liver.

RECOMMENDATIONS:

The following recommendations were made from these studies:

1. That farmers may supplement high fibre broiler diets containing maize offal or rice offal with either maxigrain or xylanase enzymes. Such enzyme supplementations will result in improved feed utilization; growth performance and with substantial reductions in feed cost.
2. That rice offal should not be used in broiler starter diets whether the diet is supplemented or not supplemented with enzymes. The improvements observed due to enzyme supplementation could not bring the quality of the rice offal diet to the level obtained with the control diet.
3. There is no economic benefit for supplementing low fibre, high energy diets with dietary enzymes to improve growth performance.

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