EFFECT OF PROCESSING AND MAXIGRAIN® ENZYME SUPPLEMENTATION ON THE UTILIZATION OF RICE OFFAL BY BROILER CHICKENS

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DECLARATION

I hereby declare the work in this thesis entitled "Effect of processing and maxigrain® enzyme supplementation on the utilization of rice offal by broiler chickens" has been performed by me in the Department of Animal Science under the supervision of Dr. F. O. Abeke and Professor A. A. Sekoni. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this thesis was previously presented for another degree or diploma in any university.

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Kehinde, Hannah Wayebo Date

CERTIFICATION

This dissertation entitled "**EFFECT OF PROCESSING AND MAXIGRAIN® ENZYME SUPPLEMENTATION ON THE UTILIZATION OF RICE OFFAL BY BROILER CHICKENS**" by KEHINDE, Hannah Wayebo meets the regulation governing the award of the degree of Masters of Science (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 dissertation is dedicated to the Almighty God the Father, God the Son and God the Holy Spirit for His faithfulness even when I am unfaithful and for bringing this work to pass in my life. I also dedicate this work to my beloved Husband Dr. Adebayo Kehinde for starting this process of my life and my father and mother Mr. & Mrs. Cornelius Esuga and to my dear children Erioluwa Esther Kehinde, Ewaoluwa Flourish Kehinde and Eniara Jedidiah Kehinde and my mother in-law Mama Kehinde for their true love, caring and unflinching support and finally, to all the children of God that believe in me.

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ABSTRACT

Two experiments were carried out to determine the effect of processing of rice offal with or without Maxigrain® enzyme supplementation on its utilization of rice offal by broiler chickens at 10% and 15% level inclusion in starter and finisher diets, respectively. The first experiment determined the effect of differently processed rice offal on growth performance, carcass and blood parameters. The starter lasted 25days while finisher phase lasted 21days. Growth performance, carcass characteristics, haematological and economic indices were evaluated. There were five diet treatments for each phase and treatment were replicated three times with equal number of birds in a completely randomized design. The second experiment was conducted to determine the effect of differently processed rice offal supplemented with Maxigrain® enzyme at 10g/100kg on broiler chickens. In the first experiment a total 225 three-day old broiler chicks were used in the first experiment during the starter phase and 210 five weeks old chickens at the finisher phase. The experimental diets consisted of treatment 1 control (no rice offal), treatment 2 (unprocessed rice offal), treatment 3 (regrind rice offal), treatment 4 (boiled rice offal) and treatment 5 (Fermented rice offal). The results showed that dietary treatments had significant ($P<0.05$) effects on final body weight, weight gain, feed cost/kg gain, total cost and income above feed expenditure. The chicks fed regrind rice offal in their diet gave the highest body weight, weight gain and income above feed expenditure. For the finisher phase, the birds fed boiled rice offal in their diet performed significantly ($P<0.05$) better than the rest in terms of final weight, weight gain, Feed cost/kg gain and income above feed expenditure there were no significant ($P>0.05$) difference in feed conversion ratio and mortality rate. Diet treatments had significant ($P<0.05$) effects on packed cell volume and total protein but the differences were within normal range. The carcass evaluation showed significant ($P<0.05$) differences across treatments for live, slaughtered, defeathered weights and dressed percentage. There were also significant ($P<0.05$) effects on some prime cuts and organs. For experiment 2, there were significant ($P<0.05$) difference in final weight, body weight gain, feed intake, feed conversion ratio, income above feed expenditure of the starters. The birds fed the control diet (without rice offal-supplemented with Maxigrain® enzyme) gave the best results for final weight, weight gain. For the finisher phase, there were significant ($p<0.05$) difference between means for final weights, weight gain, feed conversion ratio feed cost/kg gain and income above feed expenditure. The control and fermented rice offal enzyme – supplemented group gave better results in terms of final weight, weight gain and were at par. Dietary treatments had significant ($p<0.05$) effect on the PCV and Haemoglobin and on breast, drum stick, thigh and wing weights. This study therefore showed that regrinding rice offal at 0.5mm and at 10% inclusion was best at the starter phase, while boiling for 30 minutes was best and at 15% inclusion in the finisher phase. For the processed rice offal- enzyme supplemented experiment, processing rice offal with enzyme supplementation was not necessary in the starter phase whereas, fermented rice offal- enzyme supplemented gave best results in the finisherphase

CHAPTER 1

1.0 INTRODUCTION

1.1 Background to the Study

Global consumption of poultry products, especially poultry meat, has consistently increased over the years, and this trend is expected to continue. Much of the increase in global demand for poultry products will be in developing countries. Such growth in the poultry industry is having a profound effect on the demand for feed and raw materials (FAO, 2007).

Feed is very important in any livestock enterprise. Its availability and cost are a major challenge to any productive and profitable livestock enterprise. Feed constitutes the major cost of poultry meat and egg production, usually estimated to be between 65-70% all over the world (Enteshan and Chowdhury, 2002). Feed insufficiency is due to stiff competition between man for his food and with need for human food and the fast growing monogastric species such as poultry and pigs, and for concentrate mixes for ruminants. The quality of life in a society can be measured in terms of the standards of food of that society. The level of animal protein in the food is a good measure of the living standard (Ogundipe, 1996). Animal protein intake is dismally low in less-developed countries than in developed countries. The FAO recommends a minimum of 70g of protein per caput of which at least 35g (50%) should come from animal protein sources. Nigeria with a population of about 140 million people, the highest in Africa has the highest number of under-five mortality. These deaths occur because of low protein intake which is due to high cost of the product arising mainly from high cost of production input especially feed. (Abanikannda e*t al.,* 2008).

Abeke (1997) reported that solution to high cost of poultry feed is the discovery, processing and harnessing of non- conventional sources of poultry feed stuffs for which there is little or no competition from humans. Dafwang and Damang (1996) reported that the search for cheaper feedstuffs continues to be very central to the research efforts of animal nutritionists in the tropics. There is need to find alternative feed ingredients that can substitute for the more conventional feedstuffs which are expensive and highly needed for human consumption.

Rice offal is one of the agro-industrial by-products that is readily available and cheap and can be used in poultry diets. It is often referred to as rice mill feed (RMF), rice husk, and local rice bran or rice offal. Rice mill feed (RMF) is made up of ground hulls, bran and broken rice (FAO, 2007). The increasing demand for rice in West and Central African (Sub-Saharan-Africa Rice belt) is at the rate of about 6% annually (Africa Rice Center, 2008) which would mean increased production of rice in this region with a corresponding increase in RMF output. The use of agro-industrial by-product such as rice offal in poultry nutrition has been intensified in recent years due to the high cost of conventional feed ingredients such as maize, groundnut cake and soybean cake. Rice offal is cheap but high in crude fibre (mainly lignin) and low in protein. These characteristics have resulted in low utilization in poultry rations or diets. Inspite of the low feeding value of fibre, it is important that poultry rations should have a certain level of such nutrients (Ojewola *et al,* 2000). The ingested dietary fibre adds bulk to the diet, it absorbs water in the intestinal lumen and produces softer faeces that are easy to eliminate. Fibre helps in peristaltic movement in the digestive tract and assists in maintaining muscle tone. The high fibre concentration of rice offal results in poor utilization with consequent poor growth performance when fed to broiler birds without any form of treatment thereby limiting its utilization (Seimiyenkumo *et.al.,* 2008). Ashan (1994) and Tiemoko (1994) reported that the nutrient utilization of rice offal could be improved by processing techniques. High levels of inclusion of fibrous feedstuffs in poultry diets results in negative responses because of reduced nutrient utilization and metabolic function with attendant growth depression when ingested by poultry birds (Onyimonyi, 2005). In order to enhance utilization of these feedstuffs, nutritionists have resorted to using exogenous enzymes for poultry.

Enzymes are organic and inorganic catalyst which hasten the break down and digestion of food substances and thereafter remain unchanged. The breakthrough in feed enzyme products has provided a quantum leap in animal nutrition. Feed enzymes enhance digestibility and availability of dietary nutrients and subsequent animal performance to sustain livestock production. The inclusion of enzymes in poultry feed brings about higher utilization of nutrients trapped in the vegetable feed ingredient. Enzymes enable the nutritionist to lower the cost of production and improve performance of birds (Dadang 2006).

In view of the importance of processing of rice offal to improve its utilization by poultry birds and the benefits of the use of enzymes to increase digestion and utilization of fibrous feedstuff, the need for this study becomes imperative. This study was therefore designed to investigate the effect of processing methods and enzyme supplementation on the performance, carcass and haematological parameters of broiler chickens fed diets containing differently processed rice offal with or without Maxigrain® enzyme supplementation.

1.2 Objectives of the Study

The objectives of the study were

1) To determine the effect of three different processing methods (regrinding, boiling and fermentation) on the proximate composition of rice offal.
2) To determine the effect of diets containing differently processed of rice offal on growth performance, carcass and haematological characteristics of broilers chickens.
3) To determine the effect of diets containing differently processed rice offal supplemented with Maxigrains® enzyme on performance, carcass and haematological parameters of broiler chickens.

CHAPTER 2

2.0. LITERATURE REVIEW

2.1 Rice Milling in Nigeria

Rice (*Oryza sativa* L) was first cultivated some 7000 years ago in East China and India (Lu and Chag 1980). It is the staple food of the two- thirds of the world's population with 90% of world's production of over 425 million tonnes grown in the Asian region (Saunders 1986).

Nigeria's rice production between 2011 and 2012 is estimated at 2.7 million tons, as against the previous 2.6 million tons produced between 2010 and 2011. The Government of Nigeria is aggressively promoting rice cultivation under a Presidential initiative to increase rice production to 6.0 million tons within three years. This initiative involves the promotion of the New Rice for Africa (NERICA) variety. This variety is resistant to the African Rice Gaul Midge disease and is higher yielding than currently used varieties. Government sources indicate that 1.3 billion Naira ($8.5 million) was released by the Government of Nigeria for the dissemination of improved varieties at a 50 percent subsidy (Global Agricultural Information Network, 2011).

Rice milling in Nigeria is a 'cottage industry' with no operational industrial mills yet there is substantial diversity within these relative small-scale operations. Rice mills are diverse according to their milling capacity, ways of operation and range of processing operations performed (WARDA, 2003). Rice mills in Nigeria are generally small and in most cases produce coarse offal because the milling and polishing operations are combined. It is estimated that these small mills produce over 80% of the rice produced in Nigeria (Osuji, 1982).

Dafwang (2006) reported that these small- scale rice milling machines process parboiled rice into two products, the rice seed which is the main product and the waste which is a by-product called rice offal. This rice offal contains hull, bran, polishing and small quantities of broken grains. These fractions can be separated in the large modern mills into rice hull, bran and polishing; they are combined as rice offal in the traditional and semi-modern mills (Palipane and Swarnasiri, 1985 and Dafwang, 2006).

2.2 Description of Rice Mill by-products

Some by-products obtained in the preparation of rice for table use, and for feeding animals include the following:

2.2.1 Rice meal:

A mixture of all the by-products obtained in the milling of rice, it contains approximately 60% hulls; 35% bran and 5% polishing. The offal obtained from one-stage mills is of similar composition and is often erroneously called rice bran. Production of rice mill feed in multi-stage mills is somewhat cheaper than separate production of the ingredients. The suitability of rice mill feed for animals has been well established. In countries where the use of rice hulls as animal feed is legally allowed, up to 75% of the hay can be replaced by rice mill feed with good results. (Animal Feed Resources Information System, 2002).

Rice meal has a varied composition which is due in part to the different methods of treating the grain before the removal of the bran coat. In some countries the rice is parboiled and then dried before dehusking and polishing and it is claimed for this method that the polished rice has greater nutritional value than when bran coat is removed without this pre-treatment. Rice meal consist of bran coat plus the polishing, thus it contains the pericarp (bran coat) the germ, a small percentage of hull and some endosperm.

2.2.2 Rice husk /hull

Rice hulls are generated during the first stage of rice milling, when rough rice or paddy rice is dehusked. This is the outer covering of rice, the hulls, which are the glumes, are harsh, and fibrous. Rice husk contains 16 to 22% ash, which is high in silica. One hundred kilogram of paddy rice will generate approx 20 kg of husk. The bulk density is 100 to 150 kg/m^3 (IRRI, 2003). In the modern rice milling industry, rice husks are increasingly being used as a fuel source for grain drying and parboiling, and for electricity generation. In Bangladesh, rice hulls are the preferred fuel for parboiling, and rice hulls are widely used for grain drying in the larger rice mills in Northern India. Rice hulls, once ground, are also used as ingredient in animal feeds (IRRI, 2003). Rice hulls are used in some countries as poultry litter that can be later fed to ruminants. It can be used in animal feeding in the following ways: as raw rice hull, low quality roughages like ground rice hulls can be included in small amounts (up to 15%) in high concentrate diets for feeding cattle to help furnish bulk, stimulate appetite and decrease incidence of liver abscesses. Ammoniated rice hulls have been used in proportions of up to 40 per cent of the total ration for sheep, without digestive or mastication problems (FAO, 1992) and Farrell (1994) reported that rice hull may be used to reduce the energy content of diets for replacement pullets and particularly broiler breeder males and hens. Recommended maximum inclusion of rice hull is 150g/kg for broiler breeder and 50g/kg diets for growing pullets above 8 weeks of age.

2.2.3 Rice Bran

Rice bran is a powdery fine, downy material that consist seeds or kernels, in addition to particles of pericarp, seed coat, aleurone, germ and fine starchy endosperm. This agricultural by-product is rich in B-vitamins and its nutrient density and profiles of amino acids, including 74% of unsaturated fatty acids, are superior to cereal grains (Ersin *et al.,* 2006).

When the term is used to distinguish “bran” from “white bran”, it refers to the byproducts obtained in the first stages of whitening. In practice, the demand for white bran is usually lower than the actual production and in many countries it is not even marketed. As a result, white bran and bran are used mixed in the proportion in which they are produced, being offered commercially as a single by products under the general term “bran”. (UNIDO, 1985).

Rice bran constitutes about 10 per cent of brown rice and is used in animal feed (Farrell, 1994). One hundred kilogram of paddy rice will generate approx 5 to 10 kg of bran. Rice bran is a mixture of substances, including protein, fat, ash, and crude fibre. In many cases, bran contains tiny fractions of rice hull, which increases the ash content of bran. Bran composition is largely dependent on the milling process. The bran fraction contains 14-18% oil. This oil can be extracted from the bran to avoid the problem of rancidity during storage caused by the presence of a lipolytic enzyme that becomes active when the bran is separated from the rice and rapidly increases the free fatty acid content. The free fatty acid content of bran from parboiled rice is below 3% immediately after millings but increases at the rate of about 1% per hour. Apart from extraction of the oils, the rancidity process can be delayed by heating or drying immediately after milling. Rice bran is the most important rice by-product. It is a good source of B-vitamins and is fairly palatable to farm animals. With attention to the oil content, rice bran is a valuable feed for all classes of livestock. The maximum amount advisable for cattle is about 40% of the total ration. For pigs, rice bran should not exceed 30-40% of the total ration to avoid soft pork in the final weeks of fattening, lower levels must be used. Up to 25% can be included in poultry rations and double that amount has been used successfully in experiments. Rice bran that has not been defatted is a useful binder in mixed feeds. (Animal Feed Resources Information System, 2002).

2.2.4 Rice Polishing

In the processing of whole rice (Figure1.0), the first step is the removal of the husks. Once the husks have been removed, the rice becomes "brown rice". The second step is the removal of bran which yields white rice. White rice is milled from brown rice as very little brown rice is consumed. Milling removes the outer layer of the rice caryopsis producing white rice, which is almost entirely endosperm. White rice is usually further processed or polished and the residue is named as rice polishing (Daghir, 1995). Rice polishing is the outer portions of the rice kernel produced by the process used in producing polished white rice. Rice polishing has a crude protein content of 11.8 percent; crude fat, 13.2 percent; and crude fibre, 3.0 percent (FAO, 2007). Polishing presents the same storage problems as rice bran. Polishing has a wider use than rice bran because of their lower fibre content. They can be used in poultry and pig rations, but only in small amounts for piglets as they may cause scour like rice bran. Polishing should be limited in the diets of pigs during the final week of fattening to avoid oily carcasses. Up to 5 kilogrammes per day have been fed to dairy cows without harmful effects in performance (FAO,1992).

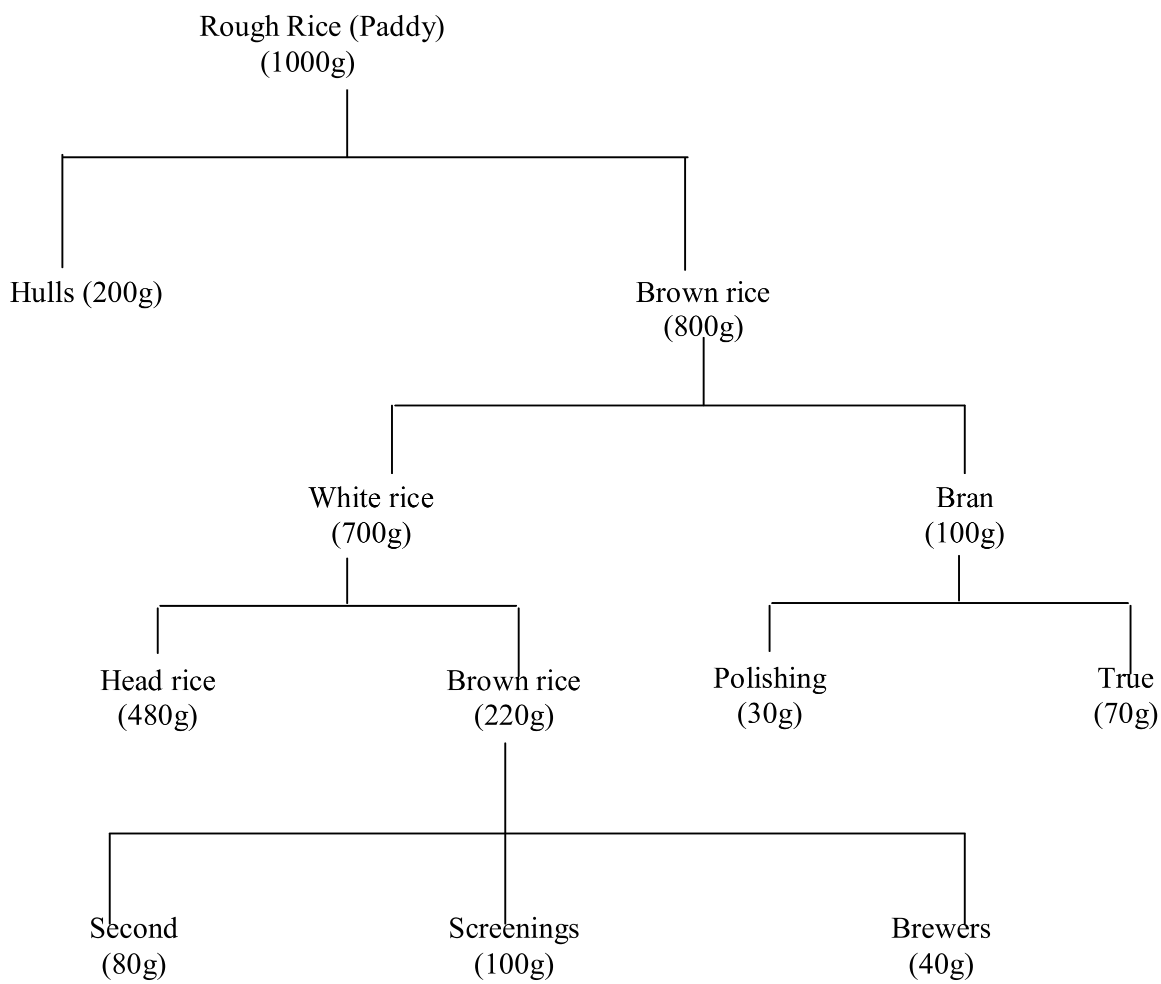

Figure 1: **The different fraction of paddy as a result of milling (After, 1985).**

2.2.5 Rice offal

Rice offal is a mixture of all the by-products obtained in the milling process of rice. It contains approximately 60 per cent hull, 35 per cent bran, and 5 per cent polishing. Rice offal is a potentially useful component of diets for monogastric animals. D'Mello (1987) reported that processing appears to be an essential prerequisite in the feeding of rice offal to poultry. The quality is however, variable depending on the methods of milling. Rice offal is obtained during the milling of either untreated or steam treated paddy seeds is referred to as raw and parboiled rice offal respectively. The offal obtained from one stage milling process is of similar composition and is often erroneously called rice bran. The suitability of rice offal for livestock feed has been well established.

Rice offal is an agro-industrial by-product that could contribute to poultry feeding. It is available in large quantities all year round in many towns in the rice growing areas of Nigeria. These areas have many small scale rice mills that are used to process parboiled rice into grains and offal (Dafwang and Damang, 1996). Dafwang and Shwarmwen (1996) reported that rice offal can be fed at dietary levels of 10 per cent in broiler starter diets without adverse effect on growth. (Dafwang and Damang 1996) also reported that rice offal can successfully be utilized in broiler finisher diets at 15- 22.5 per cent. Tegbe *et al.* (1995) reported that rice offal can be included in swine rations up to 30 per cent level with significant savings on the use of maize, feed cost and also in the production of lean carcasses which is an important quality parameter in pork. Other uses of rice offal include the use in manufacturing of ceiling boards. Isa (2003) reported that rice offal in rice producing areas is used as source of cooking energy and in cold season is used to provide heat by farmers.

The proximate composition of rice offal is presented in table 2.1

Table 2.1: Proximate Chemical Composition and Metabolizable of Rice Offal

Source	Fraction/ Composition in %					
	DM	CP	EE	NFE	CF	ASH
Obeka (1985)	97.38	6.20	5.52	30.54	37.60	20.20
Oyeyiola (1991)	91.00	5.71	5.00	23.38	44.94	20.97
Aduku (1993)	-	6.00	5.00	-	38.00	-
Dafwang and Shwarmwen 1996	93.98	4.88	2.35	2.35	40.06	23.00
Maikano (2005) Kwoi	93.89	5.44	3.54	3.54	31.76	21.54
Maikano(2005) Tamie	93.98	5.09	3.40	-		
Maikano(2005) Zaria	94.42	-	-	-	30.30	

DM= Dry matter, CP = Crude protein, EE = Ether extract, CF = Crude fibre, NFE = Nitrogen free extract.

Other workers had also reported the metabolizable energy content of rice offal or rice waste as follows: (Obeka, 1985) reported 1319.63 MEkcal/kg while (Oyeyiola, 1991) stated a value of 1183MEkcal/kg.

2.3 Mineral contents of rice offal

FAO (1992) reported the calcium and phosphorous contents of rice offal to be 0.09 and 0.39 per cent while, Aduku (1993) reported 0.47 and 0.49 per cent respectively.

2.4 Amino acid content of rice offal

The amino acid content of rice offal reported by (Aduku, 1993) of rice offal as 0.16 per cent lysine, 0.06 per cent methionine, 0.06 per cent cysteine, 0.26 per cent arginine and 0.10 per cent tryptophan.

2.5 Processing of feed ingredients for incorporation in animal diets.

The term "feed process" refers to any treatment to which source materials for livestock feed (whole grain) or the parts of these materials that are to be eaten (bran or germ) are subjected to a series of processes. Thus, there are such combinations "cooked, mechanical extracted, ground dehydrated" etc.

Feed processing methods may be chemical, thermal, mechanical or combination of different methods. Processing may also include microbial fermentation, that is ensiling Processing does one or more of the following: alters physical form of particle size, prevents spoilage, isolate specific parts of a seed or plant, improves palatability, inactivate toxins or anti nutritional factors improve handling. Processing of grain can be divided into wet/dry methods, hot/cold methods (Harris *et al.* 1995).

2.6 Some processing methods

2.6.1 Grinding

Poultry have a short digestive tract and therefore the digestibility must be high. However, they are not too efficient in grinding entire grain in the gizzard. (Nir and Hillel, 1994) found a correlation between particle size and weight of gizzard and duodenum in 3 weeks old broilers (Table 2.2). Also the gizzard pH-value is significantly lower when the feed particles are coarser. Feeding partly entire grains thus is seen as a possibility to prevent intestinal infections in poultry. Finely ground mash increases the time for feed intake and reduces feather picking (Walser, 1997). Particle size structure should be uniform to prevent nutrient imbalances by selective feed intake. An optimal mash structure can be achieved with a combination of expansion and crumbling process. Grinding of feed ingredients is a prerequisite of mixing different ingredients and achieving a low coefficient and variation percentage of nutrients in the feed mash.

Table 2.2: Influence of particle size on intake, growth and gizzard weight of 3weeks old broilers

	Intake	Growth	Gizzard
Particle size (mm)	0.6	1.1	2.3
Weight at 21days (g)	491	568	540
Feed intake 7-21days (g)	591	662	645
FCR (7-21 days)	1.66	1.56	1.61
Gizzard wt. 7day (% of LW)	3.95	4.5	4.87
Gizzard wt. 21day (% of LW)	2.22	2.8	3.13

Source: (Peisker, 2008).

Grinding or particle-size reduction is a major function of feed manufacturing. Many feed mills pass all incoming ingredients through a grinder for several reasons: These include clumps, and large fragments are reduced in size, some moisture is removed due to aeration, and additives such as antioxidants may be blended. All of these improve the ease of handling ingredients and their storability. There are other reasons for grinding and the associated sieving of ingredients in formula feeds before further processing. Extremes in particle sizes are wasteful and often dangerous. On the other hand, dust or "fines" may become colloidal suspensions in water, so dilute that several mouthfuls carry little nutritive value. Grinding may increase the nutritional value of feeds by reducing the particle size of the ingredients and thereby increasing the surface area of the ingested feed and facilitating digestion. In addition, the grinding process adds metals to feeds from the grinding machinery and can prevent a micro mineral deficiency. The metals that are added to feed are Fe, Zn, Cu, Mn, and Na (Walker, 2002).

Particle size measurements can be termed fine, small, medium, large and coarse. The standard method for particle size measures the geometric mean diameter and the standard deviation (Chewning, 2007).

2.6.2 Fermentation

Fermentation is one of the oldest and most important traditional food processing techniques. Food fermentation involves the use of microorganisms and enzymes for the production of foods with distinct quality attributes that are quite different from the original agricultural raw material. Fermentation is the process of souring food used for many centuries by mankind as a means of processing and persevering foods. Most of the fermentation processes used are spontaneous. They occur without any deliberate effort to control or influence the reaction (Maud, 1990). There are two main applications of fermentation in animal feeding. The first is preservation of feeds in the best possible nutritional condition for use when the original fresh material is not available (Barnett, 1954). The second application is enhancement of nutritional value of feeds either by fermenting the feedstuff or by fermenting other materials that may be used as additives to supplement the original feed. The fermentation extends shelf life, inhibit spoilage and pathogenic microorganisms, impart desirable sensory qualities, and improve nutritional value or digestibility (Harris *et al.,* 1995).

2.6.3 Boiling:

Boiling generally inactivates heat sensitive anti- nutritive factors such as trypsin and chemotrypsin inhibitors and volatile compounds (Akande *et al*., 2010). When heat is applied to feed, digestibility is increased and this helps to release nutrients. Cooking has a softening effect on feed that are hard or tough, thus making them easy to digest (Maud, 1990).

2.7 Anti-nutritional factors in rice by-products

Growth retardation in animals fed on rice bran diets was attributed to phytic acid interference with zinc metabolism (Thompson and Weber, 1981). Growth responses in rice bran diets are not due to energy availability (Kratzer and Payne, 1977). This conclusion was based on lack of growth response to the addition of fat and that the ME for untreated rice bran was essentially the same as that autoclaved or parboiled sample and yet the birds fed raw rice bran had a lower weight gain. Similarly, (Zombade *et al.,*1982) reported that the growth depression in broilers fed rice bran based diet cannot be based on the association of the effect of crude fibre and metabolisable energy (ME), since ME consumption of the chicken on rice bran diet at 40% level of inclusion was not less than those of birds on the maize diet. They explained further that another effect of substituting rice bran for maize at 40% level of inclusion was on linoleic acid contents of deoiled rice bran could be the primary cause of the poor growth rate on this type of rice bran. However, the growth depression cannot be based on linoleic acid content of the diet alone since the growth rate of birds receiving parboiled rice bran at 40% level of inclusion, although better than the birds on deoiled and raw rice bran with lower linoleic acid contents, it was however not equal to that of birds on the maize diet. This suggests that apart from the reduced contribution of linoleic acid, other factors are involved in the depression of growth when feeding rice bran.

Trypsin inhibitor of rice bran was inactivated by moist heat but not by chemical treatment. Oyeyiola (1991) could not however find any relationship between trypsin inhibitor activity of rice bran diets and growth rate of birds.
Kratzer and Payne (1977) reported that lipase activity in rice bran was destroyed by autoclaving or parboiling and may be a useful index to predict the adequacy of treatment to improve growth different grades of rice bran were fed to birds. The results showed that weight gain and feed efficiency were influenced by the quality of rice bran (Fetuga, 1977). Thus, the different results obtained by different investigators may be partly due to the quality of rice bran fed.

The growth depressing effects of rice bran has been noted both in diets containing fish meal and soya bean meal as the source of protein (Kratzer *et al.,* 1977). It was also reported that the factor in untreated rice bran that cause retarded growth in chicken did not affect poults or young quail (Kratzer and Earl, 1980). In the case of rice husk it is not suitable in high amount in monogastric diets because of it high silicon and fibre contents which render them harmful to the digestive and respiratory organs.

2.8 Methods of improving the nutritional value of rice by-products

Of all the rice by-products, improvements on the quality have been extensively discussed on rice bran. Many investigators have given recommendations on how to improve the quality of raw rice bran for feeding chickens.

2.8.1 Treatment with ethylene diamine tetra acetate (EDTA)

Rice bran that was allowed to become rancid that was fed to birds at 60% of the diet reduced growth more than fresh rice bran or a stored sample in which rancidity was reduced by the addition of EDTA (Hussein and Kratzer, 1982). The EDTA had no effect on rice bran that was already rancid or in which lipase activity had been destroyed by autoclaving. They reported that addition of 0.5% EDTA caused significant improvement in growth rate whereas growth increase at 0.05% EDTA was not significant. However, there was no significant difference in the taste of thigh and skin samples of fryers fed control diet or the diets in which rice bran was fresh, rancid or stored with EDTA. They further reported that the full fatty acid (FFA) of fresh rice bran before storage was 13.7%; this value increased to 42.8% after 3 months of storage with addition of EDTA. The high oil level in rice bran can be properly stabilized by an anti oxidant (Scott *et al.,* 1976).

2.8.2 Autoclaving

Autoclaving rice bran for 3-20 minutes significantly improved its feeding value as measured by growth rate of broiler chicks (Kratzer and Payne, 1977). It was reported that adding 25% water followed by heating in an oven for 30 minutes at 121°C gave growth results comparable to autoclaving rice bran (Hussein and Kratzer, 1982).

2.8.3 Parboiling

Rice bran from parboiled rice was equivalent to the autoclaved rice bran and was not further improved by autoclaving (Kratzer and Payne, 1977). This is of importance in Nigeria since most of the rice for milling is from parboiled rice. Furthermore, it was reported that the bran of parboiled rice could be stored as long as 10 months with only minor deterioration of oil and bran quality (Shaheen *et al.,* 1975).

Both autoclaving and parboiling have been found to improve its feeding value (Kratzer *et al.,* 1974). Both methods bring about a marked improvement in growth, indicating destruction of the growth – depressing factor in rice bran. The pancreas of birds fed rice bran was significantly enlarged when compared to that of birds on the control diet (Kratzer, *et. al.*, 1974). Rice bran also contains a lipase which is active after the rice is milled. It is this lipase activity that makes rice bran prone to rancidity on storage.

2.9 Particle size in relation to feed intake of broilers

It has also been hypothesized that feeding whole grains or larger particle sizes may improve the health of the bird as well as strongly influence gizzard size and function (Gabriel *et al.,* 2006; Amerah *et al.,* 2007). Many of the diets that are used are based on wheat, sorghum, barley, and oats. However, poultry diets in the United States are primarily based on corn; therefore, by comparison, feeding large particle size corn may produce benefits similar to the effects seen in whole grain feeding (Parsons *et al.*, 2006).

Particles size of the diet seems to have great importance in regulating the intake in broiler chickens that show preference for diets containing larger particles instead of those finely ground (Nir *et al.,* 1999a). Birds have difficulty in eating particles that are bigger or much smaller than the size of the beak (Moran, 1982). Nir *et al.* (1995) suggested that particle digestion within the proximal small intestine is slower when particles are bigger, resulting in more peristaltic movements and may be a better utilization of the nutrients. Thus, the consumption of diets with different characteristics may not be similar and may have a direct effect on the morphological structure of the digestive system of the birds, such that any alteration in the structure of the feed might have a significant effect on performance by restricting or making some nutrients unavailable (Macari *et al.,* 1994). For example, birds that eat fibre and/or coarse feed tend to have a longer gastrointestinal tract (Denbow, 2000). On the other hand, both gizzard atrophy (Nir *et al.,* 1994a; Nir *et al.* 1995; Magro, 1999), and a discrete intestinal hypertrophy (Nir *et al.,* 1994a), have been observed when finely ground feed was fed to the birds. To maximize the possible effects on intestinal health and gizzard size and function that may occur from feeding larger particle sizes, it may be beneficial to expose chicks to diets containing large corn particle sizes as early as possible. If gizzard size and activity level are increased at a younger age, this may help to improve the digestibility of nutrients. Nir *et al*. (1994a) found that when day-old chicks were fed coarse and medium corn particles, gizzard weight increased by 26 to 41% when compared with chicks fed fine particles. Also, because nutrient digestion in chicks is sub-optimal until about 14 days of age (Noy and Skylan, 1999; Batal and Parsons, 2002), improving nutrient digestion during the first few weeks of life may be an important step to improving weight gain potential to market weight. Because the gizzard is a major regulator of intestinal motility and enzymatic secretion, (Nir *et al*., 1995) suggested that larger particles are also better suited to the intestinal tract because they stimulate gizzard size and peristalsis more than smaller particles. Digestion of larger particle sizes is slower within the gizzard and small intestine; thus, feed passage rate is slowed, resulting in more reflux of intestinal contents and increased exposure time of nutrients to digestive enzymes, which in turn may improve energy and nutrient utilization (Nir *et al*., 1995).

2.10 Fibre in Poultry Nutrition

The term “crude fibre” originated from science of feed analysis, more specifically the ‘Wender Analysis’ system of feed analysis founded back in 1864. The term ‘crude fibre’ describes different structural plant materials that are insoluble in dilute acids and lyes and form a diverse group of poultry digestible or indigestible feed constituents (Robert *et al.,* 2008). Crude fibre is defined as that portion of a feedstuff that is insoluble, less-digestible, ash free and remains of a plant materials after rigorous boiling with dilute alkali and dilute acid (Cullison, 1979; Feltwell and Fox, 1998). Crude fibre comprises the roughage in feed raw materials, also referred to as structural carbohydrates. These plant structural carbohydrates are composed of cellulose, hemicelluose (pentosans, hexosans) and indigestible materials, mainly lignin.

Wheat and maize for example have comparatively good crude fibre digestibility in monogastric animals (Pigs, Poultry), while oats are poorly digestible. Ruminants are very efficient at utilizing crude fibre via rumen bacteria. The so-called “caecal digesters” (e.g. horses and rabbits) can also utilize dietary fibre for energy. These animal species need fibre in their daily ration for stable and healthy digestion. By products of cereals processing such as wheat bran, wheat middlings and oat hull bran are particularly high in fibre (Robert *et al.,* 2008). Llyod *et al.* (1978) reported the digestibility figures for fibre from different sources, including poultry, pigs, rabbits, guinea pig, ruminants and man as shown in Table 2.3.

Longe and Adekoya (1988) reported that high dietary fibre depresses apparent digestibility of dry matter and nitrogen, decreases daily body weight and increase feed to gain ratio. The depressing effect on apparent digestibility has been found to be due to greater rate of passage.

Abdelsamie *et al.,* (1983) observed that growth and feed utilization decreased with increase in fibre contents in chickens' diet. There is need for delignification and desilification of rice offal as a means of increasing its nutritive value for monogastric animals (Oyawoye and Nelson, 1999). Abdelsamie *et al.* (1983) observed that feed utilization decreased with increasing dietary fibre content of the diet. Ranjhan (1990) reported that the higher the percentage crude fibre in the material, the lower is digestibility of other nutrients. The influence of the bulk in promoting the elimination of feed residue from the gut is essentially based on the laxative properties of the fibre.

Table 2.3: Digestibility figures for fibre as observed from different animals

Species	Where digested	Percent digested
Poultry	Caeca	20-30
Pig	Caecum colon	2-25
Rabbit	Caecum	16-18
Guinea pig	Caecum	34-40
Ruminants	Rumen colon	50-90
Man	Small and large intestines	25-35

Source: Lloyd *et al.* (1978).

Deaton *et al.* (1979) and Din *et al.* (1979) explained that because of its physical characteristics, inclusion of fibre in the diet can modify gut functions. One of the most important physical properties of dietary fibre is its ability to hold water thereby increasing the bulk of the intestinal content. Consequently, gut dimension increases and this improves nutrients absorption. Apart from these beneficial effects provided by the bulky effect of crude fibre, high dietary levels of fibre are also known to limit feed intake by animals, thereby imposing a physical limitation upon the intake of digestible nutrients. Diets high in fibre are usually low in energy and hence restrict energy intake. In addition high fibre rations are usually associated with relatively high heat increment and therefore contribute to heat stress in warm climate. This has been shown to have adverse effect on performance of broiler chicks in the tropics (Stanley and Ishizaki, 1982).

Stacey *et al.* (2006) reported that addition of three fibre sources (i.e., soy hulls, wheat middling, or Distiller dried grain soluble (DDGS)) to the diets of laying hens caused a decrease in total ammonia emission and emission rate from the manure by up to 50%. This decrease was realized partly through a reduction in the amount of manure uric acid and partly through a lowered manure pH. Egg production and egg mass were not affected by the dietary fibre additions, although feed consumption increased slightly (by 2%). Further research is warranted to determine the inclusion rate of the three fibre sources that minimizes ammonia emission without affecting feed intake.

Incorporation of feeding stuffs high in fibre has been proved to affect physical texture of rations and increase feed intake of birds in an attempt to satisfy energy need (Longe and Adekoya, 1988). In the rearing of laying hens, the dietary fibre content is also of key importance during the pullet or developer phase. Provided the development of the chicks during the starter phase (up to week 8) was successful, a nutrient-reduced ration can and should be fed during the pullet phase in order to enable the pullets to grow slowly into physically and sexually mature laying hens. The nutrient reduction in the developer diet refers to the protein and amino acid content rather than the energy content. If available, raw materials with a lower nutrient density and higher fibre content could be introduced into the ration. In many countries these raw materials are also often more cost effective than cereal and soybean meal and can thus help to reduce feed cost in the pullet phase, the time of highest feed consumption during the rearing phase. A higher fibre content in pullet feed (e.g. above 5.5%) also helps the young birds to get used to eating a larger volume of feed. The inclusion of high fibre components (e.g. cereal by-products) slightly reduces the specific weight of the feed, forcing the pullets to spend more time eating.

Nwokolo *et al.* (1985) had indicated that the deleterious influence of dietary fibre on nutrient availability might be more pronounced in diets containing mainly vegetable feed ingredients than in those high in animal protein feed ingredients. Local feedstuffs are frequently of high fibre content. The effects of dietary fibre in chickens are not well understood but it is known to contribute little to the nutrition. However, fibre influences the utilization of other nutrients in the feed through changes in gut transit time; digestion and absorption and feed intake.

2.10.1 Beneficial effect of fibre in poultry nutrition

There is renewed interest in fibre nutrition for all classes of poultry, in terms of both gut health and impact on microflora. With the advent of high nutrient-dense diets in the late 1970`s, the role of fibre was relegated in importance. The notable exception was the negative effect of non-starch polysaccharides (NSP`s) in small grains and means to overcome adverse effects of associated increase in digesta viscosity through use of exogenous enzymes. In both human and animal nutrition, various fibre components are now being scrutinized for beneficial effects on gut health, and potential to modify emphasis, from negative to positive attributes as it relates to inclusion level. At low inclusion level (perhaps less than 1%) there may be advantages in using NSP`s as a means of beneficially modifying the gut microfora, especially in situations where antibiotic growth promoters are not used. Fermentation of NSP`s to VFA`s such as butyrate may be one mode of action in controlling proliferation of pathogens and improving gut health (Steve, 2008).

Dietary fibre is necessary to regulate digestion in broilers and laying hens. High-starch diets favour fermentation in the small intestine where pathogens can quickly multiply and harm the animal creating a situation when dysbiosis or a microbial imbalance occurs. Including dietary fibre will support peristalsis, thus initiating fermentation process along the large intestine and increasing the growth of beneficial bacteria. These bacteria produce lactic acid and short-chain fatty acids that stimulate the health and integrity of the intestinal lining and improve water absorption leading to drier excreta and fewer wet litter problems. Healthy populations of beneficial bacteria decrease the pathogen load in the bird's intestine and in the environment, improving overall health status. Some benefits are; pullets will increase gut capacity to provide for increased feed consumption to support the period of peak feed intake, positive effect on the gut flora through feeding for gut health, stabilisation of digestion with a positive effect on litter condition and house environment, reduced breast blisters and feet pad lesions thereby reducing condemnations and down grading at the processing plants, reduced percentage of dirty eggs due to sticky droppings, favourable impact on behavioural characteristics such as aggressive pecking and cannibalism and birds are less sensitive to problems derived from pathogens like clostridiosis (Arthur, 2011).

The use of fibre in livestock nutrition is due to a number of reasons. Crude fibre is bulky and therefore is used in the deliberate dilution of feed to reduce excess fat deposition in the body of the animal (Olomu, 1996; Aregheore and Abdulrazak, 2005). They are also sources of minerals, vitamins, probiotics and unidentified growth factors (IFST, 2001). Ojewola, *et al.,* (2001) reported that crude fibre plays an important role in the maintenance of the normal structure and function of the intestinal mucosa. Amodu (1985) reported that poultry can digest fibre to between 10 and 20 percent. He also said fibre aids digestion because its bulk stimulates peristalsis and secretion of enzymes. It also opens up concentrated feed so that digestive juices can come in closer contact with them.

Nutritionally, birds would continue to eat until their energy requirements are met. This invariably means that providing birds with low energy density diet would increase their feed intake and eating time, thus reducing feather pecking and cannibalism (Hartini *et al.,* 2003 and Van Krimpen *et al.,* 2005). Anyachie and Madubuike (2004) and Esonu *et al.* (2003) reported that the enhanced feed intake at higher fibre levels was to compensate for the reduced energy density of such diets. According to Hetland *et al.,* (2004) birds fed high fibre diet spend more time eating and appear quieter than those fed low fibre diets. Van Krimpen *et al.,* (2005) stated that chickens prefer not just fibre; but coarse fibre to satisfy their foraging habits. Hetland *et al.,* (2004) stated that fibre could be used to increase feed intake by feed dilution to lower dietary energy in period of high temperature and heat stress. Hetland and Svihus (2001) reported that birds require coarse fibre in their diets, probably for gizzard activity. Hetland *et al.* (2004) noted that birds fed low or moderate contents of fibre would search for coarse materials.

2.10.2 Problems associated with fibre in nutrition

Fibrous feeds might decrease the digestibility of crude protein and ether extract. There is also the possibility that the presence of fibre may speed up the rate of passage of feed through the simple stomach of monogastric (Abeke *et al.*, 2008). Several workers including Nwokolo *et al.* (1985) and Isikwenu *et al.* (2005) have implicated crude fibre as a factor depressing nutrient digestibility, absorption, availability and utilization. Crude fibre entraps nutrients in insoluble complex which it forms in the cell wall of plants, and this resists digestion by the endogenous enzymes in the gastro intestinal tract of poultry and other non-ruminant animals (Khattak, 2002). Ajala *et al*. (2003) reported that high fibre content of diets decreased nutrient utilization and precipitates metabolic dysfunction associated with weight reduction in monogastric animal. Aduku (1993) also opined that dietary fibre has a laxative effect and therefore it increases the rate of gastric evacuation in the birds. High rates of gastric evacuation are usually compensated for by increased feed intake

2.11 Feed Enzymes

Feed enzymes include phytases, carbohydrases (including ∝-amylase, ∝-galactosidase, NSP-degrading enzymes) proteases and lipases. They are largely effective in enhancing the digestibility of phytate phosphorous, carbohydrates (including starch), oligosaccharides and non-starch polysaccharides, proteins and lipids respectively (Radim, 2006). Enzymes are biological catalyst which brings about biochemical reactions without themselves undergoing any change. Enzymes are protein in nature and composed of amino acids arranged in a sequence. Enzymes activities are dependent on the substrate in a random manner or at a very specific site on the substrate. They accelerate chemical reactions of the living cells for certain nutrients from feed stuffs to become available to the organs and tissues. Enzymes are not living organism but they are product of living organisms such as bacteria, yeast, fungi and plant tissue. Feed enzymes function by enhancing the digestibility of the feed nutrients in situ. Enzymes are involved in all anabolic and catabolic pathways of digestion (Poulvet, 2010). Enzymes are able to eliminate the effects of non-nutritive, non-starch, non-water soluble polysaccharides when added to poultry and pig diet, which results in the increase rates of growth and reduced environmental pollution due to the decrease output of manure and gases such as ammonia (Campbell and Bedford, 1992; Chesson, 1993; Bedford, 1995; Marquardt 1997; Marquardt and Bedford; 1997 and Zhang *et al.*, 1997).

The use of enzymes in feed mixtures of growing poultry particularly for young chicks has been the subject of much research activity in recent decades. The interest in the feed enzymes is a reflection in changing the attitude of the society and the economic climate of the feed industry. It has been seen that approximately two billion tons of cereal grains and 140 million tons of legumes and oil seeds are produced throughout the world each year (FAO, 1993) which yield an estimated 230 million tons of NSP. Non-starch polysaccarides are able to bind large amounts of water and as a result, the viscosity of the feed is increased. The increase in viscosity may cause problems in the smooth digestion of fat, protein and carbohydrates. In addition high viscosity of digest increases the amount of stick dropping. These problems can be overcome by addition of enzymes to feed (Panda *et al.*, *2005*).

In recent years, much attention has been focused on improving nutrient utilization of low quality or inferior feed ingredients with the aim of reducing feed costs (Farrell and Martin, 1998a). Such improvements have been achieved largely by the use of exogenous enzymes supplementation in the diets of poultry (Scott *et al.,* 1998, Farrell *et al.,* 1993, Yi *et al.,* 1996a). Enzyme supplementation of fibrous feedstuffs results in a variety of ways. Gunal and Yasar (2000), Bedford (1997), and Taibipour and Kermanshahi (2004) have reported the beneficial effect of reduced digesta viscosity with enzyme supplementation. Results of many experiments indicated that enzyme supplementation of poultry diets improved the nutritional value of cereal grains and their by products.

2.11.1 Enzymes in poultry nutrition

The role of enzymes as feed additive in poultry diets is well established. Hastings (1946) and Allen *et al.* (1995) observed that enzyme addition to monogastric animal feed reduced viscosity of ingesta in the intestine and showed a marked improvement on the various morphological effects of feeding fibrous materials to non-ruminant animals.

The use of enzymes in animal feed is of great importance. Consistent increase in the price of feed ingredients has been a major constraint in most of the developing countries. As a consequence cheaper and non-conventional feed ingredients have to be used which contain higher percentage of non-starch polysaccharides (soluble and insoluble crude fibre) along with starch. Non starch polysaccharides (Fig. 2) are polymeric carbohydrates which differ in composition and structure from starch (Morgan *et al.;* 1995), and possess chemical cross linking among them therefore, are not well digested by poultry according to (Adams and Pough, 1993) and (Annison, 1993). A part of these NSPs is water-soluble which is notorious for forming a gel like viscous consistency in the intestinal tract thus reducing gut performance (Ward, 1995).

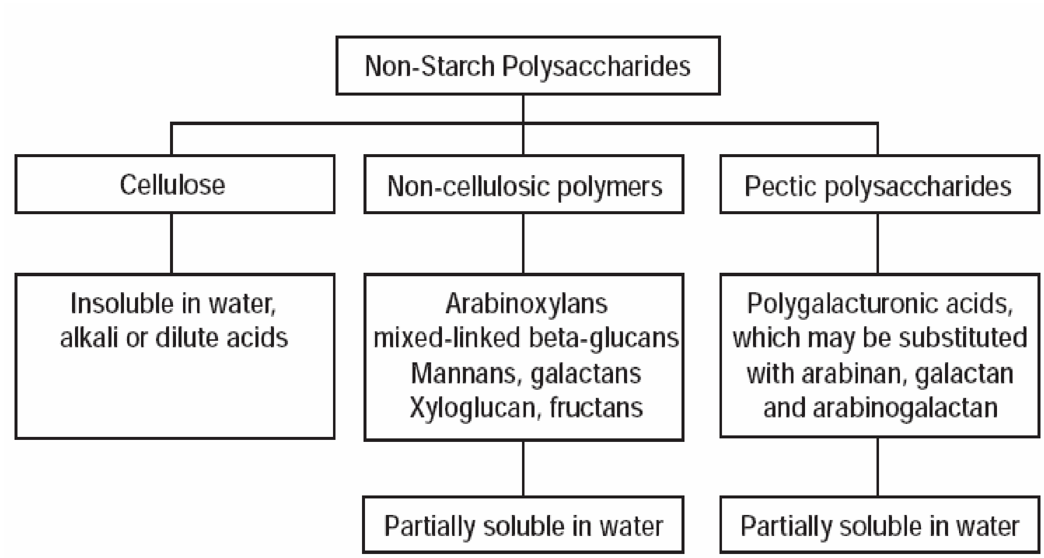

Figure 2.0: Non-starch polysaccharide (Khattak *et al.,* 2006)

Predominantly water soluble and viscous arabinoxylans, which belong to pentosan group, are assumed to be the factor responsible. These pentosans also greatly increase the water intake by the birds, which lead to difficult litter problems caused by wet and sticky droppings. This deteriorates the hygienic conditions and carcass quality of broilers (Dunn, 1996). On the other hand, ß-glucans adversely affect all nutrients, especially protein and starch utilization and are known to give rise to highly viscous conditions in the small intestine of the chicks (Hasselman and Aman, 1986).

Gordon (2000) reported that since 1925, commercial enzyme products have been used to improve live-weight gain and feed conversion of white Leghorn chicks. The product protozyme, produced by Aspergillus orizae, also reduced mortality in young birds. However, little work was done with exogenous enzymes in poultry feeding until 1947 (Acamovic, 2001). Gordon (2000) observed that there has been extensive research work on the benefits of exogenous enzymes in broiler nutrition which is the improvement of nutritive value of feed supplementation with nutrients. Gordon (2000) stated that these studies have provided a nutritional rationale and a technical basis for the progressive deployment of enzymes in commercial broiler feeding operations. An increased use of feed enzymes is expected not only from the aspect of economic gain, but also from the environmental point of view, as enzymes enhance nutrient utilization, thereby reducing manures output.

In Nigeria, there has been efforts directed towards the exploitation and use of non-conventional ingredients in livestock feed formulations. The nutritional values of these feedstuffs have been extensively studied, yet the levels of nutrient digestibility and utilization of these feedstuffs by livestock have not been maximized. To make these cheap fibrous and low energy wastes acceptable to animals, one must either augment the by-product with high energy feedstuffs like palm oil (Jokthan *et al.,* 2006), or breakdown the fibre to release more energy for the livestock. Unfortunately, monogastrics like poultry and swine are not endowed with specific endogenous enzymes necessary for breaking down non-starch polysaccharides (NSP).

Producers of poultry and other animals aim at providing high quality products in as short time as possible, at minimal cost. The rapid growth achieved by monogastric animals generally necessitates that they are fed on high quality diets with readily available nutrients (Acamovic, 2001). He stated that diet and nutrient utilization were influenced by numerous factors, a major one being the wide variety of compounds present in the feed ingredients. Some of these tend to reduce diet quality, efficiency with which the nutrients are utilized and the rates at which the animals grow. The methods used to manufacture these diets can also reduce the efficient utilization of nutrients by poultry. Feedstuffs for diets have been estimated to contribute 60-70 percent of the total cost of rearing poultry. Factors that influence the composition and utilization of the diets will thus have a substantial effect on poultry production (Acamovic, 2001).

Supplementation of diets for monogastric animals with exogenous enzymes has been increasingly investigated and applied during the past decade as a means of enhancing production efficiency and increasing the effectiveness of nutrient utilization. It has been demonstrated many times that the supplementation of poultry diets with enzymes frequently exerts beneficial effects. The extent of the benefit depends on a number of factors, such as the nature of the dietary components, whether or not the diets have been processed and whether the appropriate enzymes have been included for the substances contained in the diets (Acamovic, 2001). Nokes (1999) reported that production of enzymes for use in poultry diets is relatively small in relation to the quantities required for the diets of other animal species and for use in other applications such as in the human food industry, milling and baking, wine making and detergents.

2.11.2 Major types of enzymes used in poultry nutrition

The major classes of enzymes currently used in diets for monogastric, together with their substrates are presented in Table 2.4. The various enzymes added to poultry diets are relatively specific for certain substrates and their associated chemical bonds. However, most of the enzymes prepared for use in animal feeds do not necessarily have activities for these substrates. In fact, it is rare for enzymes that have been produced for commercial use in animal diets to have a single activity. It is often desirable that enzymes are sufficiently impure to possess side activities that can act in synergy (Zyla *et al.,* 1999).

2.11.3 Methods of enzymes supplementation

Enzymes are provided in various forms for supplementation in poultry diets. They can be supplied as powders and added to the diet before mixing and pelleting or they can be added as granules before the diet is mixed and pelleted. Both these procedures allow the enzymes to mix intimately with the dietary ingredients and this allows them, to react effectively with their substrates.

Many enzymes, however tend to be thermo labile and thus processing at high temperatures may reduce their activity (Gibson, 1995 and Silversides and Bedford, 1999). Acamovic (2001) reported that a more recent innovation is to add enzymes as liquid after pelleting. This avoids the problems associated with pelleting at high temperatures, but has the disadvantage of the enzyme being coated with most of the components of the diet. This may reduce the pre-ingestion action of the enzyme compared with application of the enzyme before pellet formation.

Table 2.4: Enzymes used in Poultry nutrition

	Enzymes	Substrates
A	**Carbohydrates**	
	Amylases	Starch
	Pectinase	Pectin
	B-Glucanases	B-glucans
	Arabinoxylanases	Arabionxylans
	Hemicellulases	Hemicellulose
B.	**Proteases**	
	Acid proteases	Protein
	Alkaline proteases	
C.	**Others**	
	Phytases	Phytic acidesters
	Esterases	Fats, esters
	Lipases	Fats, esters

Source: Acamovic (2001)

However, that enzymes applied as liquid to the surface of pellet can frequently exert superior benefits on the nutritional value of the diet and on performance (Hunter *et al.,* 1995; Ziggers, 1998; Best and Gill; 1999 and Acamovic, 2001).

Supplementation of diets with enzymes may reduce nutritional problems as well as variations in performance (Maisonier *et al.,* 2001). It should not be assumed that supplementation with enzymes will solve all the problems associated with dietary anti-nutritional factor according to (Farrell and Martin 1998). The degradation of polymers or arabinose, xylose, and mannose, for example, to oligomers or even monomers, as well as to other products, may cause metabolic problems (Savoy, 1992; Care *et al.;* 1995, Iji, 1999; Naveed, 1999 and Zyla *et al.,* 1999). The adverse effects of the polymetric compounds, their relatively high viscosities in aqueous solutions and their propensity for increasing endogenous losses (Larsen *et al.,* 1999; Ferraz de Oliveria, 1998 and Zyla *et al.,* 1999), could be alleviated by the addition of enzymes. Other adverse effects resulting from absorption and subsequent excretion of monosaccharide and other compounds such as fatty acids could also occur (Savoy, 1992; Carre *et al.,* 1995; Gdala *et al.;* 1997; Zdunczyk *et al.,* 1998 and Kocher *et al.,* 1999).

Similarly, the transfer of un-digestible oligosaccharides to the lower gastrointestinal tract could alter (adversely or beneficially) the microfloral population (Carr'e *et al.,* 1995; Sprin, 1997; Smith *et al.,* 2000; Apajalahti and Bedford, 1998; Reid and Hillman, 1999; Best, 2000; Cowieson *et al.*, 2000 and Gilbert *et al.,* 2000). Such changes may also alter the ability of the bird to absorb and utilize the products of enzymes degradation as reported by (Savoy, 1999 and Carr'e *et al.,* 1995).

2.11.4 Enzymes activity in diets

It is frequently difficult to evaluate the efficacy of an enzyme and its activity in diets other than by comparing the performance of birds that have been fed diets containing enzymes with those that have not (Acamovic, 2001). Many supplementary enzymes are thermolabile, the lack of response in the animal may be attributed to the loss of enzyme activity by thermal degradation, even though the activity may be found by chemical analysis. The content of starches in different grains can be similar, but the extents to which they are digested can vary, depending on their source and nature. One of the major advantages of adding exogenous enzymes to poultry diets is to allow otherwise inexpensive and nutritionally poor, ingredients which may be available locally to be utilized in poultry diets. In effect, the addition of dietary enzyme has the ability to increase the nutritional value of certain ingredients (Acamovic, 2001). Naveed *et al.* (1999) and Bach-Knuden (2000) reported that enzyme supplementation improved apparent metabolizable energy provided the composition of the various ingredients are known, it may be possible to design diets with lower nutrient density than in conventional, which is enhanced to conventional values by the presence of enzyme.

2.12. Responses of poultry birds to enzyme supplemented diets.

2.12.1 Broilers

One of the main reasons for supplementing wheat and barley-based poultry diets with enzymes is to increase the available energy content of the diet and increase energy digestiblity (Patridge and Wyatt, 1995 and Venderkliss *et al.,* 1995). Enzyme supplementation improves carbohydrates digestibility, reduces gut viscosity, and improves fat utilization (Almirall *et al.,* 1995). The improvements from enzyme supplementation are variable because of the variability in the NSP content of wheat. Classen *et al.*, (1995), Schutte *et al.*, (1995) and Venderkliss *et al.* (1995) reported improvements of 5-16%, 3.1-4.5%, and 4.5-12.4%, respectively. A wheat-based diet was formulated with or without enzyme supplementation, a 5% increase in AME was observed in the diets with enzyme supplementation. Without compensating for the result of improved growth and feed efficiency, the cost per kilogram broiler in the enzyme-treated group was 1.3% lower than in the wheat-control group. Compensating for the additional energy further improved production characteristics and also reduce feed cost, giving a reduction in cost per kilogram broiler of 8.8% compared with the control diet which was not supplemented with enzyme. Partridge and Wyatt (1995) cited similar benefits when allowances were made for the improvements in energy and amino acid digestibility. The problem facing the feed formulator is estimating the correct energy allowance for wheat-based diets. Typically, a conservative 5-6% upgrading of the AME of wheat is recommended for commercial situations. This allowance effectively improves the energy value of wheat to about 13800KJ/kg in a least-cost ration, bringing the value of a wheat-enzymes combination closer to that for maize and allowing the use of less supplementary energy. Amino acid adjustments may also be made, as enzyme supplementation also improves protein digestibility (Bedford, 1992; Patridge and Wyatt 1995). Typically, the digestibility of amino acids should be expected to increase by 10% with added enzymes (Bedford*,* 1992 and Ward, 1995). Responses to enzyme supplementation depend on the bird's age, which is apparently related to both the type of gut microflora present and the physiology of the bird. Older birds, because of the enhanced fermentation capacity of the microflora in their intestines, have a greater capacity to deal with negative viscosity effects (Allen *et al.,* 1995; Choct *et al.;* 1995; Vukic and Wenk, 1993).

The dry matter content of the litter of wheat-or barley-fed broilers is improved (reduced sticky droppings) by adding enzymes to their diets according to Wiedmer and Volker (1989) Jansson *et al.* (1990) and Mohammed (1995). The improved litter condition reduces ammonia build up in sheds and reduces the incidence of hock burns and breast blisters. Also birds fed high-barley or high-wheat diets have been shown to have elevated intestinal weight, which negatively affects the carcass yield. This negative effect is reduced after supplementation with the appropriate enzymes (Francesch *et al.*, 1989 and Jeroch and Danicke, 1993).

It has been suggested that supplementation with enzymes could increase the energy available in wheat by 6-8% and would result in growth rates similar to, and feed: gain ratios better than those obtained with a control wheat diet. To investigate this suggestion, a study was conducted using a wheat-based diet formulated without enzymes, based on National Research Council (1994) nutrient requirements. The same diet was re-formulated to upgrade metabolizable energy by 6% and the amino acid content by 10%. This diet was fed with and without enzyme supplementation. The results of this study are shown in Table 2. 5.

Table 2.5: Evaluation of male-broiler performance when nutrient matrix is upgraded in an enzyme-supplemented wheat-based diet.

Time (days)		Upgraded nutrients[a]	
		Control	Enzyme
	Avg. BW		
21days	750[a]	707[b]	745[a]
42days	2256	2184	2252
Avg. feed consumption (g/bird)			
0-21days	1064	1037	1054
0-42days	4303	4237	4265
Feed-gain ratio			
0-21days	1.518[b]	1.574[a]	1.513[b]
0-42days	1.941	1.973	1.922

Source: (Guenter, 1994)

Note: Avg. BW, average body weight.
[a]Nutrient values of wheat were upgraded by 6% for nitrogen-corrected apparent metabolizable energy and by 10% for amino acids. [b]Enzyme used was Avizyme TX @ 0.2kg/t. a,b, Means within a row not followed by the same letters are significantly different ($P<0.05$).

2.12.2 Laying hens

The responses of laying hens to enzyme-supplemented feeds are also well documented. Typically, enzymes added to layer feed appear to have little effect on egg mass but improve feed efficiency (Benabdeljelil and Arbaoui, 1994; Vukic and Wenk, 1993) energy utilization (Wyatt and Goodman, 1993; Vukic and Wenk, 1993), and laying rate

(Poultry International, 1996). Wyatt and Goodman (1993) reported that corn-fed layers exhibited better feed efficiency than those fed enzyme-supplemented barley-based diet. Nevertheless, enzyme supplementation improved the utilization of barley diets. Increased energy utilization in laying hens appears to be due to microbial fermentation of solubilized NSPs (Vukic and Wenk, 1993), and the subsequently higher absorption of volatile fatty acids (Choct *et al.,* 1995). Wet litter arising from the use of barley and newly harvested wheat can result in an increased incidence of dirty egg shells and ammonia build up in poultry pens. Adding enzymes to both wheat and barley-based diets has been shown to reduce the moisture content of faecal matter in layers (Marquardt *et al.,* 1994). Thus, barley can effectively be used if diets are supplemented with the appropriate enzymes.

CHAPTER 3

3.0. MATERIALS AND METHOD

3.1 Location of study area

The study was carried out at the Poultry unit of the National Animal Production Research Institute (NAPRI) Shika Zaria, Kaduna state. Shika is located in the Northern guinea savannah of Nigeria at an altitude of 610m above sea level. It lies between latitude 11^0 12^0 N and longitude 7^0 33^0 E. The average rainfall is 1100m which starts from late April and early May to mid October (www.googleearth .com, 2012).

3.2 Source and preparation of test ingredient for laboratory analysis

Rice offal was purchased from local rice mills in Shika, Zaria, Kaduna State and was subjected to the following processing methods before incorporation into the various diets.

3.2.1 Boiling

About 5 litres of water was brought to boiling point in a 10 litre aluminum cooking pot and about 500 grammes of rice offal was poured into the boiling water and covered. Fire wood was used as source of heat. From the moment the rice offal was poured into the water, the specified time of boiling was taken. The rice offal was boiled for 15, 30, 45 and 60 minutes respectively. This was achieved by removing representative samples of rice offal at the times indicated above. These samples were sun dried for three days.

3.2.2 Fermentation

The second method involved the processing of the rice offal by fermentation. For this, about 500 grammes of rice offal was soaked in about 5 liters of cold water in a 10 litre plastic bucket and left to ferment for 12, 24, 36, 48, 60 and 72 hours respectively.

Representative samples were then taken at the end of the various hours specified above and sun dried for three days.

3.2.3 Regrinding

The third method involved re-grinding of the rice offal using a 0.1mm and 0.5 mm sieves. A representative sample of the un-processed rice offal, the 0.1mm and 0.5mm re-ground rice offal, the rice offal boiled for 15, 30, 45 and 60 minutes and the fermented rice offal for 12, 24, 36, 48, 60 and 72 hours respectively.

Samples were analyzed for proximate chemical composition: dry matter (DM), nitrogen free extract (NFE), crude fibre (CF) and ash according to A.O.A.C (1990) and the metabolizable energy (ME) was calculated using the mathematical equation MEkcal/kg = 37(%CP) + 81.8 (EE) + 35.5(NFE) ± 100 (Ichaponani, 1980). The processing method that gave the best proximate analysis was used in each case for the preparation of the ingredient for feed formulation. The selection was one based on the reduction on crude fibre and the cost.

3.3 Experiment 1: Investigation of the effect of differently processed rice offal on growth performance, carcass and haematological characteristics of broilers chickens.

The best results obtained from the proximate analysis from each of the various processing methods: boiling for 30minutes fermentation for 36hours and regrinding using 0.5mm sieve were used in formulating diets for the starter and finisher phases. A total of two hundred and twenty five Marshall broiler chicks of mixed sexes, purchased from Zarm hatchery from Offa, Kwara state were used for this experiment. They were reared on deep litter, in an open sided wire mesh screened poultry house. Additional heat sources were provided using electric bulbs, kerosene stoves, and lanterns for brooding. The open sides were covered with polyethylene sheets to conserve heat for the first 2-3 weeks of age. The chicks were fed on a common diet for three days. After three days, the chicks were weighed and divided into five treatments. Each treatment was divided into three replicates (pens) with 15 birds per replicate making a total of 45 birds per treatment in a completely randomized design experiment.

During the starter phase, five isonitrogenous and isocaloric diets were formulated to contain 10 percent rice offal from the best results obtained from the various processing method. (Table 3.1). Treatment 1 which was without rice offal served as the control, treatment 2 (unprocessed rice), treatment 3 (reground rice offal) treatment 4 (cooked rice offal) and treatment 5 (fermented rice offal). The experiment lasted from three days to 4weeks. Water and feed were given *ad – libitum*. The chicks and feed were weighed weekly and feed weighed back recorded. Vaccination schedule as recommended by National Animal Poultry Research Institute (NAPRI) was adopted. Performance parameters calculated were feed intake, weight gain, feed to gain ratio, feed cost per kilogram gain and mortality rate

During the finisher phase Two hundred and ten (210) broilers finisher chicks were used. The chicks earlier used for the starter phase of the experiment were pooled together and fed a common diet for one week after which they were weighed and randomly allocated based on an average initial weight to the five broiler finisher diets (Table 3.2). The feeding trial involved five treatments with 14 birds per pen. The experiment lasted from 5-8 weeks. The birds and feed were weighed weekly and feed left overs were recorded. Performance parameters calculated were feed intake, weight gain, feed to gain ratio, feed cost per kilogram gain and mortality rate. Also carcass and haematological parameters were measured at the finisher phase.

3.4 Experiment 2: Investigation of the effect of differently processed rice offal supplemented with maxigrains® enzyme on growth performance, carcass and haematological characteristics of broilers chickens

This experiment had the same design as in experiment 1. Two hundred and forty broiler chicks were purchased from Zarm hatchery from Offa, Kwara State. They were reared on deep litter, in an open sided wire mesh screened poultry house. Heat was supplied by using kerosene stoves, electric bulbs, and lanterns during brooding. The open sides were covered with polyethylene sheets to conserve heat for the first 2 to 3 weeks of age. The feeding trial involved five treatments replicated three times with sixteen birds per replicate and forty eight birds per treatment in a completely randomized design. The chicks were brooded together for three days before they were weighed and allocated to their various treatments.

In the starter phase, five isonitrogenous and isocaloric diets were formulated to contain 15 percent rice offal from the best results obtained from the various processing methods along with an unprocessed rice offal sample (Table 3.3). Each of these diets constituted a treatment and each treatment was replicated thrice. Treatment one (1) was without rice offal and served as control. Maxigrain® enzyme was added to treatments 2- 5 at 10 grams per 100kg of feed. The experiment lasted from 3days old to 4 weeks. Feed and water were given *ad libitum*. They chicks and feed left overs were weighed and recorded weekly. Vaccination schedule as recommended by National Animal Poultry Research Institute (NAPRI) was adopted. Performance parameters calculated were feed intake, weight gain, feed to gain ratio, feed cost per kilogram gain and mortality rate.

In the finisher phase one hundred and ninety- five (195) broilers finisher chicks were used. They chicks earlier used for the starter phase of the experiment were pooled together and fed a common diet for one week after which they were weighed and randomly allocated to five broiler finisher diets (Table 3.5). The feeding trial involved five treatments with three replicate per treatment and 13 birds per replicate. The experiment lasted from 5- 8 weeks birds and feed were weighed weekly and left over were recorded. Performance parameters calculated were feed intake, weight gain, feed to gain ratio, feed cost per kilogram gain and mortality rate. Also carcass and haematological parameters were measured at the finisher phase.

3.5. Haematological determinations

Haematological studies were carried out in each of experiments 1 and 2 respectively at the finisher phases. One bird per replicate making a total of three birds from each treatment group was bled using a 2ml syringe at the wing vein. About 2ml of the blood was put into a test tube containing ethylene diamine tetra acetate (EDTA) to prevent coagulation. This was immediately taken to the laboratory for analysis to determine the packed cell volume (PCV), red blood total proteins (TP) and haemoglobin (Hb) content using Ganti (1993) procedure.

3.6 Carcass Evaluation

The carcass evaluation was done following the procedure of Jones (1984). At the end of the finisher phase, three birds were randomly selected from each treatment representing the average weight. The birds were fasted for 24 hours but given water before slaughtered. The birds were weighed, slaughtered by severing the neck at the first vertebrae with a sharp knife and bled. They were dipped into hot water (70-80^{o}C) and their feathers manually plucked. Each bird was eviscerated and the weight measured. The following parameters were taken and calculated: live weight, slaughtered weight, defeathered weight, carcass weight and dressing percentage. The weights of the breast, thighs, wings, back, shanks, head, and neck were expressed as percentage of live weight.

Internal organs parameters which included weights of the lungs, heart, spleen and gizzard were taken. Lengths and weights of the empty gastrointestinal tract were taken.

3.7 Data Analysis

All data generated were subjected to the analysis of variance using the general linear models SAS software (SAS, 2001). Significant differences between means were separated using Duncan's Multiple Range Test (Duncan, 1995).

Table 3.1: Percentage composition of Broiler starter diets containing differently processed rice offal

Ingredients (%)	Treatments				
	Control 1	Unprocessed rice offal 2	Reground rice offal 3	Boiled rice offal 4	Fermented rice offal 5
Maize	54.85	42.45	42.45	42.45	42.45
Soya bean	15.00	15.00	15.00	15.00	15.00
Groundnut cake	23.00	21.50	21.50	21.50	21.50
Rice offal	0.00	10.00	10.00	10.00	10.00
Fish meal	2.00	3.00	3.00	3.00	3.00
Bone meal	3.00	3.00	3.00	3.00	3.00
Blood meal	1.20	1.60	1.60	1.60	1.60
Palm Oil	0.00	2.50	2.50	2.50	2.50
Table Salt	0.30	0.30	0.30	0.30	0.30
**Premix	0.25	0.25	0.25	0.25	0.25
Lysine	0.20	0.20	0.20	0.20	0.20
Methionine	0.20	0.20	0.20	0.20	0.20
Total	100.00	100.00	100.00	100.00	100.00
Calculated Analysis					
ME kcal/kg	2890	2854	2858	2849	2842
Crude Protein (%)	23.04	23.05	23.05	23.05	23.05
Crude Fibre (%)	4.43	4.87	4.82	4.82	4.82
Ether extract (%)	6.16	9.33	9.06	9.05	9.06
Calcium (%)	1.01	1.04	1.04	1.04	1.04
Avail. Phosphorus (%)	0.79	0.77	0.77	0.77	0.77
Lysine (%)	1.20	1.24	1.24	1.24	1.24
Methionine(%)	0.56	0.55	0.55	0.55	0.55
Methionine+ Cysteine (%)	0.89	0.87	0.87	0.87	0.87
Cost/kg diet(₦)	78.89	65.68	66.28	71.68	67.78

** Biomix premix supplied per kg of diet: Vit. A. 10,000i.u,Vit. D_3 2000iu, Vit E. 23mg, Vit K_3, 2mg, Vit B_1. 1.8mg, Vit B_2. 5.5mg, Niacin 27.5mg, Pantothenic acid 7.5mg Vit.B_6, 3.0mg, Vit B_{12} 0.015mg, Folic acid 0.75mg, Biotin, 0.06mg, VitB_{12} 0.015, Choline chloride 300mg, Cobalt 0.2mg, Copper 0.03mg, Iodine 1mg, Iron 20mg, Manganese 4.0mg, Selenium 0.2mg, Zinc 30mg, Antioxidant 1.25mg.

Table 3.2 Percentage composition of broiler finisher diets containing differently processed rice offal

Ingredients (%)	Treatments				
	Control 1	Unprocessed rice offal 2	Reground rice offal 3	Boiled rice offal 5	Fermented rice offal 5
Maize	61.95	45.35	45.35	45.35	45.35
Soya bean cake	12.00	12.00	12.00	12.00	12.00
Ground nut cake	12.50	12.50	12.50	12.50	12.50
Rice offal	0.00	15.00	15.00	15.00	15.00
Fish meal	3.20	3.20	3.20	3.20	3.20
Bone meal	3.00	3.00	3.00	3.00	3.00
Blood meal	2.40	3.00	3.00	3.00	3.00
Limestone	1.00	1.00	1.00	1.00	1.00
Palm Oil	3.00	4.00	4.00	4.00	4.00
Table Salt	0.30	0.30	0.30	0.30	0.30
**Premix	0.25	0.25	0.25	0.25	0.25
Lysine	0.20	0.20	0.20	0.20	0.20
Methionine	0.20	0.20	0.20	0.20	0.20
Total	100.00	100.00	100.00	100.00	100.00
Calculated Analysis					
ME kcal/kg	3000	2994	2995	2989	2985
Crude Protein (%)	20.00	20.05	20.05	20.05	20.05
Crude Fibre (%)	4.50	5.29	5.27	5.25	5.25
Ether extract (%)	7.79	11.03	11.03	11.01	11.03
Calcium (%)	1.59	1.58	1.58	1.58	1.58
Avail. Phosphorus (%)	0.84	0.79	0.79	0.79	0.79
Lysine (%)	1.15	1.17	1.17	1.17	1.17
Methionine(%)	0.52	0.52	0.52	0.52	0.52
Methionine+ Cysteine (%)	0.83	0.79	0.79	0.79	0.79
Cost/kg diet(₦)	76.91	72.90	73.35	74.40	73.35

** Bio-mixpremix supplied per kg of diet: Vitamin A 10,000iu, Vit. D_3 2000 i.u, Vit E 23mg, Vit K 2mg, Vit $B_1$1.8mg, Vit B_2,, 5.5mg, VitB_6 6.0mg, Niacin 27.5mg, pantothenate 10.0mg, Biotin 0.06mg, VitB_{12} 0.015mg, Folic acid 0.75mg, choline chloride 300mg, Manganese 40mg, Iron 20mg, Zinc 30mg, Iodine 1mg, Selenium 0.2mg, Cobalt 0.2mg, Antioxidant 1.25mg

Table 3.3: Percentage composition of Broiler starter diets containing differently processed rice offal supplemented with Maxigrains® enzyme

Ingredients (%)	Treatments				
	Control 1	Unprocessed rice offal	Reground rice offal 3	Boiled rice offal 4	Fermented rice offal 5
Maize	53.75	42.65	42.65	42.65	42.65
Soya bean cake	12.00	12.00	12.00	12.00	12.00
Groundnut cake	23.00	21.50	21.50	21.50	21.50
Rice offal	0.00	10.00	10.00	10.00	10.00
Fish meal	2.00	3.20	3.20	3.20	3.20
Bone meal	3.00	3.00	3.00	3.00	3.00
Blood meal	1.20	1.60	1.60	1.60	1.60
Limestone	1.00	1.00	1.00	1.00	1.00
Palm Oil	3.00	4.00	4.00	4.00	4.00
Table Salt	0.30	0.30	0.30	0.30	0.30
**Premix	0.25	0.25	0.25	0.25	0.25
Lysine	0.20	0.20	0.20	0.20	0.20
Methionine	0.20	0.20	0.20	0.20	0.20
Maxigrains	0.10	0.10	0.10	0.10	0.10
Total	100.00	100.00	100.00	100.00	100.00
Calculated Analysis					
ME kcal/kg	2890	2854	2858	2849	2842
Crude Protein (%)	23.00	23.05	23.05	23.05	23.05
Crude Fibre (%)	4.45	4.87	4.82	4.82	4.82
Ether extract (%)	6.16	9.33	9.06	9.05	9.06
Calcium (%)	1.59	1.58	1.58	1.58	1.58
Avail. Phosphorus (%)	0.84	0.79	0.79	0.79	0.79
Lysine (%)	1.15	1.17	1.17	1.17	1.17
Methionine(%)	0.50	0.48	0.47	0.47	0.47
Methionine+ Cysteine (%)	0.83	0.79	0.79	0.79	0.79
Cost/kg diet(₦)	76.91	72.90	73.35	74.40	73.35

** Biomix premix supplied per kg of diet: Vit. A. 10,000i.u,Vit. D_3 2000iu, Vit E. 23mg, Vit K 2mg, Vit B_1 1.8mg, Vit B_2 65.5mg, VitB_6 6.0mg, Niacin 27.5mg, Calcium Pantothenate 7.5mg, Biotin 0.06mg, VitB_{12} 0.015m, Folic acid 0.75mg, Choline chloride 300mg, Manganese 40mg, Iron 20mg, Zinc 30mg, Iodine 1mg,Selenium 0.2mg, Antioxidant 1.25mg

Table 3.4: Percentage composition of broiler finisher diet containing differently processed rice offal supplemented with Maxigrains® enzyme

Ingredients (%)	Treatments				
	Control 1	Unprocessed rice offal 2	Reground rice offal 3	Boiled rice offal 4	Fermented rice offal 5
Maize	61.85	45.25	45.25	45.25	45.25
Soya bean cake	12.00	12.00	12.00	12.00	12.00
Groundnut cake	12.50	12.50	12.50	12.50	12.50
Rice offal	0.00	15.00	15.00	15.00	15.00
Fish meal	3.20	3.20	3.20	3.20	3.20
Blood meal	2.40	3.00	3.00	3.00	3.00
Bone meal	3.00	3.00	3.00	3.00	3.00
Limestone	1.00	1.00	1.00	1.00	1.00
Palm Oil	3.00	4.00	4.00	4.00	4.00
Table Salt	0.30	0.30	0.30	0.30	0.30
**Premix	0.25	0.25	0.25	0.25	0.25
Lysine	0.20	0.20	0.20	0.20	0.20
Methionine	0.20	0.20	0.20	0.20	0.20
Maxigrain®	0.10	0.10	0.10	0.10	0.10
Total	100.00	100.00	100.00	100.00	100.00
Calculated Analysis					
ME kcal/kg	3000	2994	2995	2989	2985
Crude Protein (%)	20.00	20.05	20.05	20.05	20.05
Crude Fibre (%)	4.45	5.59	5.56	5.53	5.41
Calcium (%)	1.59	1.58	1.58	1.58	1.58
Avail. Phosphorus (%)	0.84	0.79	0.79	0.79	0.79
Lysine (%)	1.15	1.17	1.17	1.17	1.17
Methionine(%)	0.54	0.43	0.43	0.43	0.43
Cysteine(%)	0.29	0.27	0.27	0.27	0.27
Methionine+ Cysteine (%)	0.83	0.79	0.79	0.79	0.79
Cost/kg diet(₦)	76.91	72.90	73.35	74.40	73.35

** Bio-mixpremix supplied per kg of diet: Vitamin A 10,000iu, Vit. D_3 2000 i.u, Vit E 23mg, Vit K 2mg, Vit B_1 1.8mg, Vit B_2,,5.5mg, VitB_6 6.0mg, Niacin 27.5mg, Pantothenate 10.0mg, Biotin 0.06mg, VitB_{12} 0.015mg, Folic acid 0.75m, Choline chloride 300mg, Manganese,40mg, Iron 20mg, Zinc 30mg, Iodine 1mg, Selenium 0.2mg, Cobalt 0.2mg, Antioxidant 1.25mg.

CHAPTER 4

4.0 RESULTS

4.1 Effect of processing methods on the proximate composition of rice offal.

The results of the effect of different processing methods on the proximate composition of rice offal are presented in Table 4.1. Raw rice offal had a dry matter (DM) of 94 64% ash content of 17.37%, ether extract (EE) of 4.23%, crude fibre (CF) of 12.54%, crude protein of 6.09% and Nitrogen free extract (NFE) of 59.80%.

The result of the boiling duration showed that from 15 minutes to 60 minutes boiling there was a decrease in %DM from 96.20% to 95.09%. Ash content reduced from 17.14% for 15 minutes to 17.03% for 60 minutes. The %EE reduced from 4.15 for 15 minutes to 4.09% for 60 minutes. Percent CF and %CP also reduced as the boiling duration increased.

As the duration of fermentation increased from 12 hours to 60 hours there was a decrease in %DM from 94.35 to 94.10, % ash reduced from 17.33 for 12 hours to 17.02% for 60 hours and % CF decreased from 12.35% to 12.03%. There was an initial reduction and then an increase observed for %EE, %CP and %NFE respectively as the fermentation process increased from 12 to 60 hours.

Regrinding rice offal at 0.1 mm and 0.5 mm showed a decrease in %DM, ash and NFE While there was an increase in percent EE, CF, and CP contents of rice offal.

Table 4.1 Proximate composition of differently processed rice offal (dried matter basis)

Boiling	% DM	%ASH	%EE	%CF	%CP	%NFE
Raw	94.64	17.37	4.23	12.51	6.09	59.80
15min	96.20	17.17	4.29	12.45	6.06	60.05
30min	95.15	17.11	4.12	12.11	5.88	60.08
45min	95.11	17.06	4.11	12.09	5.44	61.30
60min	95.09	17.03	4.09	12.00	5.18	61.71
Fermentation						
Raw	94.64	17.37	4.23	12.51	6.09	59.80
12hours	94.35	17.33	4.28	12.38	6.11	59.90
24hours	94.20	17.10	4.29	12.11	6.13	60.37
36hours	94.15	17.09	4.29	12.08	6.14	60.40
48hours	94.15	17.04	4.30	12.04	6.18	60.40
60hours	94.10	17.02	4.30	12.03	6.18	60.50
Regrinding						
Raw	94.64	17.37	4.23	12.51	6.09	59.80
0.1mm	96.47	17.73	4.21	12.04	6.02	60.00
0.5mm	95.50	17.57	4.28	12.35	6.10	59.70

Each value is a product of three determinations.

4.2 Experiment 1: Effect of processing methods on the utilization of rice offal by broiler chickens.

4.2.1 Performance of Broiler Starter chicks (0 – 4 weeks).

The performances of broilers fed with diets containing differently processed rice offal for starter and finisher phases are presented in Tables 4.2 and 4.3 while the haematological profiles and carcass characteristics of the birds are presented in Tables 4.4 and 4.5 respectively.

The result obtained in this study shows that broiler chicks fed with diets containing differently processed rice offal showed significant ($P<0.05$) differences among the treatment means for final weight, weight gain and daily weight gain. Treatment 3, which had diet containing reground rice offal, had the best final weight, weight gain and daily weight gain results. However, it was not significantly ($P>0.05$) higher than birds on control diet and birds fed diet containing unprocessed rice offal. They were however, significantly ($P<0.05$) higher than results obtained for T_4 (boiled rice offal) and T_5 (fermented rice offal).

Results for feed intake and daily feed intake showed that birds fed on the control diet performed best. This was not significantly ($P>0.05$) higher than birds fed diets containing reground rice offal (T_3). However, these result were significantly ($P<0.05$) different from T_4 (boiled rice offal). Results of T_2 and T_5 were observed to be significantly ($P<0.05$) lower from the rest.

Feed conversion was best for T_2 (unprocessed rice offal), but it was not significantly ($P>0.05$) better than control, T_3 (reground rice offal) and T_5 (fermented rice offal). It was however, significantly ($P<0.05$) higher from treatment 4 which contained boiled rice offal.

Feed cost result showed that T_2 (unprocessed rice offal) had the least cost. It was significantly ($P>0.05$) different from the T_5 (fermented rice offal), T_4 (boiled rice offal) and T_3 (reground rice offal) which all differ ($P>0.05$) significantly from each other. Feed cost for T_1 (control) was the highest and significantly differ from the rest treatments Results for feed cost per kilogram gain shows that T_2 had the best result, although, it was not significantly ($P>0.05$) different from birds on fermented rice offal diet. They were however significantly ($P<0.05$) cheaper than T_3 and T_4 with control been the highest.
Total cost was cheapest for T_2. However, it was not significantly ($P>0.05$) different than control and T_5 but was significantly ($P<0.05$) cheaper than birds on T_3 (regrind rice offal) and T_4 (boiled rice offal)

Mortality rate showed no significant (P>0.05) difference across treatment means.

Income above feed expenditure (IAFE) was highest for unprocessed rice offal (T_2), but it was not significantly (P>0.05) different from results for control and T_3 (reground rice offal). However, these were significantly (P<0.05) higher than for T_4 (boiled rice offal) and T_5 (fermented rice offal).

Table 4.2 Performance response of broilers starter to diets containing differently processed rice offal (3days – 4weeks)

	Treatments					
Parameter	1Control	2 URO	3 RRO	4 BRO	5 FRO	SEM
Initial weight (g/bird)	80.02	80.04	80.01	80.03	80.05	0.03
Final weight (g/bird)	629.40^a	641.74^a	643.41^a	563.22^c	603.55^b	6.17*
Weight gain (g/bird)	549.37^a	561.71^a	563.40^a	476.19^c	523.51^b	6.17*
Daily weight gain	22.20^a	22.47^a	24.20^a	19.47^c	20.94^b	0.42*
Feed intake (g)	1270.23^a	1183.24^c	1256.91^a	1210.00^b	1183.33^c	8.87*
Daily Feed intake (g)	50.81^a	47.33^c	50.28^a	48.40^b	47.33^c	0.35*
Feed conversion ratio	2.32^a	2.12^a	2.23^a	2.54^b	2.26^a	0.03*
Feed cost/bird (N)	100.10^e	77.71^a	83.31^c	86.73^d	80.21^b	0.61*
Feed cost / kg gain	175.58^c	138.96^a	147.83^b	182.45^d	145.12^a	3.22*
Total cost (N/bird)	372.53^a	372.23^a	378.04^b	375.41^b	372.59^a	0.65*
Mortality (%)	2.22	0.00	2.22	2.22	0.00	0.77^{NS}
IAFE (N)	352.31^a	361.80^a	357.22^a	298.82^c	334.78^b	8.95*

^{abc}Means within the same row with different superscripts differ significantly (p<0.05)
SEM = Standard error of means, URO = U nprocessed rice offal, RRO = Reground rice offal, BRO =Boiled rice offal, FRO = Fermented rice offal, IAFE = Income above feed expenses at N700.00/kg live weight, NS= Not significant, * significant difference. g/b = Gram per bird.

4.2.2 Broiler Finisher Phase (5- 8 weeks).

The responses of broiler finisher to utilization of differently processed rice offal based diets are presented in Table 4.3. Results obtained for final weight, weight gain and daily body weight gain showed that birds on T_4 (boiled rice offal) were significantly (P<0.05) higher than control, T_2, T_3 and T_5. Feed intake and daily feed intake were highest for birds fed fermented rice offal diets (T_5). This result was significantly ($P<0.05$) higher than birds fed T_4 (boiled rice offal), control, T_2 and T_3. Feed conversion ratio was best for birds on T_4 (boiled rice offal). However, there was a non-significant ($P>0.05$) difference across treatment means for control, T_2, T_3 and T_5 respectively.

Result for feed cost showed that unprocessed rice offal (T_2) was the best. T_2 was not significantly ($P>0.05$) different from T_3 (reground rice offal) but was significantly ($P<0.05$) different from other treatments. Feed cost per kilogram gain result showed that they were no significant ($P>0.05$) differences across treatment means. Result obtained for total cost was best for birds fed unprocessed rice diet (T_2). However, it did not perform significantly ($P>0.05$) better than birds fed regrind rice offal diets (T_3) but were significantly ($P<0.05$) different from control and T_5 (fermented rice offal).

Mortality rate showed no significant ($P>0.05$) differences across treatment means. Income above feed expenditure was best for boiled rice offal (T_4) which was significantly ($P>0.05$) different from control, unprocessed rice offal (T_2) and reground rice offal (T_3). However, T_1 and T_3 were similar but significantly ($P>0.05$) different from T_2 and T_5 which was similar.

4.3 Performance response of broilers finishers to diets containing differently processed rice offal (5 – 8 weeks)

	Treatments					
Parameters	Control 1	URO 2	RRO 3	BRO 4	FRO 5	SEM
Initial weight (g/bird)	892.87	892.86	892.87	892.87	892.86	0.01^{NS}
Final weight (g/bird)	2771.0^{b}	2697.6^{b}	2735.7^{b}	2858.5^{a}	2725.5^{b}	37.04*
Weight gain (g/bird)	1878.1^{b}	1804.8^{b}	1842.9^{b}	1965.7^{a}	1832.6^{b}	37.04*
Daily weight gain (g/bird)	87.43^{b}	85.94^{b}	87.83^{b}	93.61^{a}	87.27^{b}	1.63*
Feed intake (g/bird)	3950.6^{c}	3901.2^{c}	3949.8^{c}	4150.0^{b}	4409.0^{a}	64.59*
Daily Feed intake (g/bird)	188.1^{c}	185.0^{c}	188.0^{c}	197.6^{b}	210.0^{a}	3.08*
Feed conversion ratio	2.11	2.16	2.22	2.08	2.26	0.05^{NS}
Feed cost (N/bird)	303.84^{b}	284.39^{a}	289.76^{a}	309.43^{c}	298.95^{b}	3.57*
Feed cost / kg gain (N)	162.20	158.19	157.17	157.10	165.42	3.93^{NS}
Total cost (N/bird)	518.13^{b}	498.68^{a}	503.85^{a}	528.14^{c}	513.24^{b}	3.57*
Mortality (%)	2.38	0.00	2.38	2.38	2.38	0.95^{NS}
IAFE (N)	1635.84^{b}	1603.92^{c}	1627.29^{b}	1686.20^{a}	1609.07^{c}	26.67*

^{abc}Means within the same row with different superscripts differ significantly (p<0.05) NS = Not significant (p<0.05), * Significant difference, SEM = Standard error of means, URO = Unprocessed rice offal, RRO = Reground rice offal, BRO = Cooked rice offal, FRO = Fermented rice offal, IAFE = Income above feed expenses N700/kg live weight.

4.2.3 Haematological Parameters

The results of the haematological profile are presented in Table 4.4. Results obtained showed significant differences (P<0.05) among treatment means for packed cell volume (PCV). Birds fed reground rice offal (T_3) had the highest PVC which was significantly (P<0.05) higher other treatments. Haemoglobin results showed no significant (P>0.05) difference across treatment means. Total protein was highest for birds on unprocessed rice offal diet. This was however, significantly (P<0.05) higher than the other treatments.

Table 4.4 Effect of differently processed rice offal diets on some blood factors of broiler finisher. (5 – 8 weeks).

	Treatments					
Parameters	Control 1	URO 2	RRO 3	BRO 4	FRO 5	SEM
Packed cell volume (%)	29.67^{b}	28.67^{c}	31.00^{a}	28.67^{c}	29.33^{b}	0.22*
Haemoglobin count (g/dl)	9.87	9.53	10.40	9.53	9.77	0.69^{NS}
Total protein (gm/dl)	4.40^{c}	5.50^{a}	4.73^{b}	3.20^{e}	3.67^{d}	0.43*

SEM = Standard error means, URO = Unprocessed rice offal, RRO = Reground rice offal, FRO = Fermented rice offal BRO = Boiled rice offal, $^{abcd=}$Means on the same row with different superscripts differ significantly (P<0.05) NS = Not significant, * Significant difference

4.2.4 Carcass Study

Results obtained from the carcass evaluation are presented in Table 4.5. The birds fed the control diets had the best results in terms of live, slaughtered, defeathered, head, spleen weights as well as intestinal weight. Although these results were similar to results obtained for some other dietary treatments, they were significantly different (P<0.05) from others in parameters such as slaughtered weight, defeathered weight and weight of the spleen.

Other important parameters such as dressed weight and weight of thigh showed treatment 3 having the best result. However prime cuts such as breast and drum sticks showed that birds fed the fermented rice offal diet (T_5) and unprocessed rice offal diet (T_2) gave the best results, respectively.

Table 4.5 Effect of differently processed rice offal diets on carcass characteristics of Broiler finishers. (5 – 8 weeks)

	Treatments					
Parameters	Control 1	URO 2	RRO 3	BRO 4	FRO 5	SEM
Live wt. (g)	2616.7^{a}	2500.0^{a}	2616.7^{a}	2400.0^{b}	2566.7^{a}	45.39*
Slaught. Wt.(%LW)	98.08^{a}	95.29^{b}	96.24^{b}	95.0^{b}	94.80^{b}	0.58*
Defeathered wt.(%LW)	93.01^{a}	90.65^{b}	91.64^{b}	90.84^{b}	88.18^{c}	0.82*
Dressed %	74.26^{b}	72.03^{b}	80.04^{a}	74.23^{b}	72.66^{b}	1.71*
Prime cuts and organ weights expressed as % live weight						
Breast	16.54^{b}	19.31^{a}	16.20^{b}	18.07^{a}	20.18^{a}	0.69*
Drum stick	9.91^{b}	12.50^{a}	10.05^{b}	10.12^{b}	9.00^{b}	0.47*
Thigh	12.53^{b}	11.02^{c}	12.97^{a}	11.70^{bc}	11.28^{c}	0.21*
Wing	8.64	8.30	8.31	8.61	8.50	0.16*
Back	14.74^{b}	15.60^{b}	15.23^{b}	16.56^{ab}	17.79^{a}	0.22*
Neck	5.60^{b}	5.70^{b}	5.47^{b}	5.91^{a}	5.15^{b}	0.09*
Shank	3.65	3.51	3.46	3.35	3.21	0.19^{NS}
Head	2.09^{a}	2.31^{a}	2.09^{b}	2.15^{b}	2.05^{b}	0.06*
Liver	2.24	2.18	1.99	2.20	1.99	0.05^{NS}
Gizzard	2.19^{c}	2.32^{b}	2.58^{a}	2.34^{b}	2.39^{b}	0.04*
Spleen	1.17^{a}	0.09^{b}	0.10^{b}	0.11^{b}	0.12^{b}	0.11*
Heart	0.49	0.60	0.50	0.50	0.49	0.02^{NS}
Intestinal length(cm)	245^{a}	224^{b}	238^{a}	198^{c}	214^{b}	6.23*
Intestinal weight	76^{a}	67^{b}	75^{a}	57^{c}	66^{b}	1.05*

URO = Unprocessed rice offal, RRO= Reground rice offal, BRO = Cooked rice offal, Fermented rice offal. SEM = Standard error means. LW = Live weight, ^{abc} = Means on the same row with different superscripts differ significantly ($P<0.05$) * Significant difference, NS = Not significant

4.3 Experiment 2: Effect of processing and enzyme supplementation of rice offal diets on response of broiler chicks.

4.3.1 Broiler Starter Phase (3days- 4 weeks).

The response of broilers to processing and enzyme supplementation of rice offal diets for starter and finisher birds are presented in Tables 4.6 and 4.7, while the haematological profile and carcass characteristics of the birds are presented in Tables 4.8 and 4.9

respectively .The results obtained showed that birds fed on control diet (without rice offal), had the best final live weight, weight gain, daily weight gain, feed intake and daily feed intake across treatment means. These results were significantly ($P<0.05$) higher than for birds fed T_2 (unprocessed rice offal), T_3 (reground rice offal), T_4 (boiled rice offal) and T_5 (fermented rice offal) diets. Feed conversion ratio was best for birds fed boiled rice offal (T_4). This result was significantly ($P<0.05$) better than birds on control, T_2, T_3 and T_5. The results obtained for feed cost per bird showed a non-significant ($P>0.05$) difference across treatment means.

Results for feed cost per kilogram gain was significantly different ($P<0.05$) and was best for birds fed on boiled rice offal (T_4). The result was significantly ($P<0.05$) better than control, T_2, T_3 and T_5. Total cost result was not significant ($P>0.05$) across treatment means. Mortality rate showed that treatment T_2 (unprocessed rice offal) and T_3 (reground rice offal) had the lowest mortality rates. It was significantly ($P<0.05$) lower than results for T_4 and T_5. These result was however, significantly ($P<0.05$) lowest for control treatment. Results of income above feed expenditure showed that the control had the best result. This result was significantly ($P<0.05$) higher than the rest treatments.

Table 4.6 Performance response of broilers starter to diets containing differently processedrice offal supplemented with maxigrains® enzyme (3days- weeks)

	Treatments					
Parameter	**Control 1**	**2 URO**	**3 RRO**	**3 BRO**	**4 FRO**	**SEM**
Initial wt (g/bird)	66.87	66.87	66.87	66.86	66.86	0.00^{NS}
Final wt (g/bird)	602.78^{a}	545.71^{b}	545.71^{b}	556.11^{b}	527.79^{b}	10.65*
Weight gain (g/bird)	523.91^{a}	478.98^{b}	478.97^{b}	489.24^{b}	460.93^{b}	10.63*
Daily weight gain (g/bird)	21.40^{a}	19.00^{b}	18.96^{b}	19.57^{b}	18.44^{b}	0.43*
Feed intake (g/bird)	1147.0^{a}	1019.70^{b}	1019^{b}	950^{b}	984.7^{b}	33.14*
Daily feed intake (g/bird)	45.90^{a}	39.00^{b}	39.80^{b}	38.00^{b}	39.40^{b}	1.35*
Feed conversion ratio	2.13^{b}	2.12^{b}	2.12^{b}	1.93^{a}	2.04^{b}	0.04*
Feed cost/ bird (N)	88.00	71.10	74.80	70.70	72.22	2.43^{NS}
Feed cost/ kg gain	164.60^{c}	149.80^{b}	155.50^{b}	143.90^{a}	156.30^{b}	3.03*
Total cost(₦)	335.38	333.19	331.56	327.53	329.23	2.37^{NS}
Mortality (%)	6.83^{c}	2.38^{a}	2.38^{a}	4.45^{b}	4.60^{b}	0.93
IAFE (N)	421.95^{a}	389.28^{b}	382.09^{b}	382.09^{b}	369.46^{b}	7.43

[abc] Means within the same row with different superscripts differ significantly (p<0.05) NS = Not significant (p<0.05), * Significant difference, SEM = Standard error of means URO = Unprocessed rice offal, RRO = Reground rice offal, BRO =Boiled rice offal, FRO = Fermented rice offal, IAFE = Income above feed expenses at N700.00/kg live weight

4.3.2 Broiler Finisher Phase (5-8 weeks).

The response of broiler finisher birds to utilization of processed rice offal supplemented with maxigrain® enzyme are presented in Table 4.7. The results obtained for final weight, weight gain and daily weight gain showed that the control was the best, it was significantly (P<0.05) higher than results for other treatments. Results of feed intake and daily feed intake showed no significant (P>0.05) difference across treatment means Feed conversion ratio results showed that T_1 (Control) was the best. It was significantly (P < 0.05) better than T_2, T_3, T_4 and T_5 respectively which was all significantly (P<0.05) different from each other. Results of feed cost per bird was not significantly (P>0.05) different across treatment means. Feed cost per kilogram gain was significantly different

(P<0.05) and was best for fermented rice offal, (T_5) but was not significantly (P>0.05) different from the control. However these results were significantly (P< 0.05) better than unprocessed rice offal, (T_2), reground rice offal (T_3) and boiled rice offal (T_4). Result of total cost showed a non-significant (P>0.05) difference across treatment means. Income above feed expenditure was best for fermented rice offal diet (T_5) although it was not significantly different from control. These results was significantly (P<0.05) different from T_2, T_3, and T_4.

Table 4.7: Response of broiler finishers to diets containing differently processed of rice offal supplemented with Maxigrains® enzyme (5- 8 weeks).

	Treatments					
Parameters	Control 1	URO 2	RRO 3	BRO 4	FRO 5	SEM
Initial weight (g/b)	846.84	846.8 4	846.85	846.84	846.84	0.00*
Final w eight (g/bird)	1878.21^a	1839.10^b	1813 .68^c	1804.09^c	1867.09^a	11.48*
Weight gain (g/bird)	1031.36^a	992.26^b	966.83^b	957.69^b	1020.25^a	11.47*
Daily weight gain (g)	49.11^a	47.25^b	46.04^b	45.60^b	48.58^a	0.55*
Feed intake (g/bird)	2547.44	2671.69	2633.33	2582.11	2582.11	26.98^{NS}
Daily feed intake	121.31	127.22	125.40	126.11	122.96	1.28^{NS}
Feed conversion ratio	2.47^a	2.71^c	2.73^d	2.77^d	2.56^b	0.04*
Feed cost/bird(N)	195.92	194.77	193.15	197.04	189.40	1.98^{NS}
Feed cost / kg gain (₦)	190.30^a	197.33^b	200.07^b	205.68^b	185.72^a	3.30*
Total cost (N/bird)	469.00	467.85	466.03	470.12	462.48	1.95^{NS}
Mortality (%)	0.00	2.56	2.56	2.56	2.56	1.03^{NS}
IAFE (N)	1118.82^a	1090.56^b	1073.63^b	1066.10^b	1117.56^a	8.72*

^{abc}=Means within the same row with different superscripts differ significantly (p<0.05) NS = Not significant (p<0.05), * Significant difference, SEM = Standard error of means URO = Unprocessed rice offal, RRO = Reground rice offal, BRO =Cooked rice offal, FRO = Fermented rice offal, IAFE = Income above feed expenses at N700.00/kg live weight,

4.3.3 Haematological Studies

Results of haematological profile of some blood parameters are presented in Table 4.8 Packed cell volume showed that birds fed on fermented rice offal diet (T_5) had the highest value. However, it was not significantly (P >0.05) higher than results for T_3 and T_4. But these results were significantly (p<0.05) different from control and unprocessed rice offal treatments. Haemoglobin results was significantly (P<0.05) different for unprocessed rice offal treatment (T_4) when compared to the rest treatments. Total protein was not significant (P >0.05) across treatment means.

Table 4.8 Effect of variously processed rice offal diets supplemented with Maxigrains® enzyme on some blood parameters of broiler finisher (5-8 weeks)

	Treatments					
Parameters	Contorl 1	URO 2	RRO 3	BRO 4	FRO 5	SEM
Packed cell volume	27.67^a	25.33^b	28.00^a	27.67^a	28.33^a	0.67*
Haemoglobin (g/dl)	9.20^a	8.40^b	9.33^a	9.20^a	9.40^a	0.22*
Total protein (gm/dl)	3.00	3.33	2.87	3.03	3.03	0.10^{NS}

SEM = Standard error, URO = Unprocessed rice offal, RRO = Reground rice offal, BRO = Boiled rice offal, FRO =Fermented rice offal ^{ab} = Means on the same row with different superscripts differ significantly (P<0.05), * Significant difference

4.3.4 Carcass Study

Results obtained for carcass evaluation are presented in Table 4.9. The results showed that birds fed the processed rice offal-enzyme supplemented diets had significantly (P<0.05) higher slaughtered weight, defeathered weight and dressing percentage. Prime cuts such as breast weight, drum stick weight and wing weight also had the best results in the rice offal processed treatments when compared with control. The results of unprocessed rice offal showed a significant (P<0.05) difference in the shank and head weights compared with the other treatments. Organ weights like liver were significantly (P<0.05) enlarged for unprocessed rice offal T_2, reground rice offal T_3 and fermented rice offal T_5 except treatment 4 (boiled rice). While the heart weight and intestinal length showed a significant (P<0.05) difference on birds fed the unprocessed rice offal diet (T_2) compared with the other treatments.

Table 4.9: Effect of differently processed rice offal diets supplementation with maxigrains® enzyme on carcass characteristics of broilers finishers (5 – 8weeks)

	Treatments					
Parameters	Control 1	URO 2	RRO 3	BRO 4	FRO 5	SEM
Live wt. (g)	1970	1730	1780	1870	1930	0.04*
Slaught. Wt.(%LW)	89.82^{b}	90.45^{b}	94.79^{a}	96.06^{a}	95.55^{a}	0.43^{NS}
Defeathered wt. (%LW)	83.03^{b}	80.84^{b}	89.91^{a}	90.16^{a}	90.19^{a}	1.04*
Dressed %	67.76^{e}	71.88^{d}	79.10^{a}	72.73^{c}	75.00^{b}	0.66*
Prime cuts and Organ weights expressed as % live weight						
Breast	14.11^{b}	16.14^{a}	16.75^{a}	17.49^{a}	16.03^{a}	0.45*
Drum stick	9.67^{b}	10.09^{b}	9.40^{b}	9.93^{b}	10.71^{a}	0.13*
Thigh	11.21^{a}	11.42^{a}	11.60^{a}	10.62^{b}	9.81^{c}	0.24*
Wing	7.95^{b}	8.20^{b}	8.55^{b}	9.13^{a}	8.31^{b}	0.19*
Back	16.07	16.31	16.76	17.69	16.70	0.50^{NS}
Neck	5.29	5.09	5.43	5.82	5.43	0.20^{NS}
Shank	3.99^{a}	4.00^{a}	3.64^{b}	3.16^{c}	3.93^{a}	0.13*
Head	2.51^{b}	3.01^{a}	2.69^{b}	2.68^{b}	2.71^{b}	0.12*
Liver	1.51^{c}	1.94^{a}	1.95^{a}	1.75^{b}	1.90^{a}	0.08*
Empty gizzard	2.46	2.79	2.20	2.51	1.97	0.17^{NS}
Spleen	0.15	0.17	0.16	0.17	0.13	0.00^{NS}
Heart	0.54^{b}	3.63^{a}	0.53^{b}	0.45^{b}	0.56^{b}	0.61*
Intestinal length (cm)	175.67^{a}	177.33^{a}	170.67^{b}	176.33^{a}	174.67^{a}	3.05*
Intestinal weight	44.67	42.00	48.33	46.67	47.33	1.59^{NS}

URO = Unprocessed rice offal, RRO = Reground rice offal, BRO = Boiled rice offal, FRO = Fermented rice offal. SEM = Standard error means. LW = Live weight, ^{abcde} = Means on the same row with different superscripts differ significantly (P<0.05) NS = Not significant, * Significant difference.

CHAPTER 5

5.0 DISCUSSION

5.1 Laboratory studies: Effect of processing methods on the proximate composition of rice offal.

There was a direct relationship between the different methods of processing rice offal and their proximate composition. It was observed that there was either a decrease or an increase in almost all the nutrients of rice offal with the different processing methods used.

There was a decrease in ash, ether extract and crude protein contents in the proximate composition as the boiling duration increased from 15 minutes to 60 minutes. The probable reason may be due to the effect of leaching of the soluble inorganic salts into the boiling water. The effects of cooking duration have been reported by (Bawa *et al.* 2003 Abeke; 2005 and Akintunde, 2010). These authors all attribute nutrient loss to leaching into boiling water.

The reduction in crude fibre as the boiling time increased can be explained as being due to the possible breakdown of fibre constituents as a result of the effect of heat. Abeke (2005) reported that cellulose and hemicelluloses, which constitute over 90 percent of fibre are rendered less fibrous by heat.

It was observed that as the fermentation hours increased there was a decrease in dry matter content, ash content and crude fibre content. Fermentation results in a lower proportion of dry matter in the foods. It however, increases the concentrations of vitamins, minerals and protein when measured on a dry weight basis (Adams, 1990). This agrees with the present result in which there was an observed increase in the crude protein as the hours of fermentation increased. The reason for this could be because of increased microbial activity as the fermentation duration increased.

5.2.1 Experiment 1: Effect of diets containing differently processed rice offal on performance of broiler chicks

There have been wide variations in broiler responses to use of rice offal in poultry diets. These were attributed to differences in quality, variety of rice, storage periods, climatic conditions to mention but a few. However, there are various literature reports on the inclusion levels of this unconventional, agro by-product in broiler diets without adverse effect by animal nutritionists in Nigeria (Oyeyiola, 1991, Dafwang and Damang, 1996; Oyawoye and Nelson, 1999; Maikano, 2005 and Duru, 2010).

In the present study (Table 4.2) treatment 3 (reground rice offal) had the highest final weight, weight gain and daily weight gain results, though not significantly ($P>0.05$) different from the control and birds fed unprocessed rice offal diets. However, they were significantly ($P<0.05$) higher for birds fed diets containing cooked rice offal (T_4) and fermented rice offal (T_5). The reason for this could be due to the reduction in particle size of the rice offal because of regrinding. Reduction in particle size increases the surface area for enzyme action on feed ingredient. In the case of other diets groups the birds were young and their gastro intestinal tract was not fully developed yet to handle coarse materials like the cooked and fermented rice offal thus the lower live weight and body weight gain. According to Amerah *et al.* (2007), finer grinding increases substrate availability for enzymatic digestion. Also Goodband *et al*. (2002) reported that continued reduction in particle size increases both the number of particles and the surface area per unit volume allowing greater access to digestive enzymes. Koch (1996) reported that there are practical limits to the degree of particle size reduction, as younger birds may encounter difficulties in consuming very coarse, or very fine particles. The extent of particle size reduction is known to influence a number of aspects including bird performance and digestive tract development. This indicates that rice offal should be reground to 0.5mm before inclusion in broiler starter diets.

The feed intake of birds on the control diet was significantly ($P<0.05$) higher than birds fed diets containing unprocessed rice offal (T_2), cooked rice offal, (T_4) and fermented rice offal (T_5) except diet containing reground rice offal (T_3) as shown in Table 4.1. The reason for this could be that inclusion of rice offal in the diet of chicks' depressed feed intake. This is probably due to the bulkiness of diets containing rice offal and small size of the crop of chicks.

According to the report of Funmilayo (1990), young chicks below four weeks of age were not able to effectively handle high levels of rice offal in their diets. This result however, contradicts the reports of Dafwang and Sharwarmen (1996), Maikano (2005), and Duru (2010), who reported that broiler chicks can tolerate up to 10% and 15% dietary levels of rice offal for the starter phase (0-4 weeks) with no adverse effect on growth performance. Result of T_3 (reground rice offal) was not significantly ($P>0.05$) different from the control. This may be because of the increased surface area as a result of reduction in the particle size of rice offal (0.5mm) which opens up rice offal for better enzyme action. This result agrees with report of Mc Donald *et al.* (2002), who reported that dietary fibre has a laxative effect and might therefore increase the rate of gastric evacuation, which may be compensated by increase feed intake.

The feed conversion result showed a non-significant ($P>0.05$) difference between unprocessed rice offal, reground rice offal and fermented rice offal when compared with the control. The result could be attributed to the level of inclusion. Birds were able to efficiently utilize the feed in spite of the fibre content. The effect of processing on breaking down of the fibre content of rice offal enhanced faster conversion of feed by the birds. However, the low efficiency observed for cooked rice offal treatment is an indication that the birds could not effectively handle this form of processing at this phase (starter phase).

There were significantly ($P<0.05$) better values for feed cost (₦/bird), feed cost/kg gain and total cost for T_2 (unprocessed rice offal) and T_5 (fermented rice offal). This is an indication that lower cost can be achieved when agro by product such as rice offal is used for feed formulation. The value for T_3 (reground) and T_4 (cooked rice offal) were ($P<0.05$) higher than the rest probably because of cost of processing. Onyimonyi and Ugwu (2007), reported that to counter the increase in the price of conventional feedstuff, the use of agro-industrial by-products in poultry feeds should be exploited.

5.2.2 Effect of diets containing differently processed rice offal on the performance of broiler finishers (5-8 weeks).

There was a significantly ($P<0.05$) higher final weight, weight gain and daily weight gain (Table 4.3) observed for birds fed boiled rice offal diets (T_4). However, no significant ($P>0.05$) difference was observed between control, unprocessed rice offal (T_2), reground rice offal (T_3) and fermented rice offal (T_5). The performance observed for boiled rice offal (T_4) could mean that boiled rice offal is best at this stage for the birds (finishers). Diets were isocaloric and isonitrogenous which gave equal opportunity for performance when compared to the control. But boiled rice offal gave a better result. Mujahid *et al,* (2004), reported that boiling rice bran gave a significantly ($P<0.05$) better result in comparison with other processing methods. The performance of the birds at this stage can be attributed to their age. They are older and are able to handle this level of rice offal inclusion (15%) better without adverse effect on performance. According to Maikano (2005), broiler finishers are able to utilize up to 20% dietary inclusion levels of rice offal. The higher feed consumption observed with birds fed fermented and cooked rice offal diets could probably be due to palatability offered by fermentation and cooking. The high feed consumption could be as a result of the laxative effect of fibrous ingredients on the gastro intestinal tract. This agrees with the report of Aduku (1993) who reported that fibre has a laxative effect and therefore it increases the rate of gastric evacuation in the birds. High gastric evacuation is usually compensated for by increased feed intake. Babatunde and Hamzat (2005), and Jokthan *et al*. (2006) showed that inclusion of fibre materials in feeding trial had an energy dilution effect on feed and consequently increased feed intake. Feed conversion ratio was not significant (P>0.05) across treatment means. However, boiled rice offal (T_4) recorded the best result numerically. This is an indication that processing of rice offal enhances efficient utilization of feed by broiler finishers. Decrease in feed cost, and total cost of rice offal treatment were observed when compared with control. This is the major thrust of nutritionist that is to lower feed cost while not compromising on feed quality. Utilization of rice offal in poultry feed has been known to lower feed cost because they are cheaper and are of less value for humans. According to Nsa *et al*. (2010), poultry production may not be lucrative, if costly conventional feedstuffs are not replaced with cheaper and available feed stuffs in order to cut down on feed cost which constitutes 65-75% total cost of production.

The significantly (P<0.05) high income above feed expenditure would encourage cooking of rice offal before inclusion especially for broiler finisher diets. When compared to control it gave the best income above feed expenditure. Feeding rice offal diets did not affect percent mortality in broiler finisher. This is an indication that rice offal is safe for incorporation in broiler diets.

5.2.3 Effects of differently processed rice offal on some blood parameters of broiler finishers.

There was a significantly ($p<0.05$) higher packed cell volume across treatment means obtained for birds fed reground rice offal (T_3) as shown in table 4.4. This is an indication that there was a better nutrient availability and utilization by birds. Total protein was significantly ($p<0.05$) higher for unprocessed rice offal treatment than the rest. This could imply that birds on unprocessed rice offal based diet effectively harnessed the available protein in their diets compared to the rest treatments. The results obtained in this experiment for haematological parameters are however, similar to that obtained by (Abeke *et al*. 2008). Oladele (2000) reported that PCV, TP and Hb content of the blood of chickens are a factor of their health status and nutrient intake. The author stated that adequately fed birds in good health are likely to have higher levels of blood proteins and packed cell volume as opposed to inadequately fed or under-nourished birds.

5.2.4 Effect of diets containing differently processed rice offal on carcass characteristics of broiler finishers (5-8 weeks).

There was an observed increase live and slaughtered weights in control when compared to values of other rice offal treatments (Table 4.5). This is an indication that the control diet gave better weights. Dressing percentage for treatment T_3 (reground rice offal) was best with 80.40% when compared with control and the rest treatments. It implies that regrinding of rice offal had a good effect on utilization of feed by birds which culminated to meat. The non-significant liver weights across treatments could mean that rice offal had no toxic effect therefore had no adverse effect on the liver function. Rice offal treatments, though not significant recorded even lower weights than the control.

There was a significant ($p<0.05$) increase observed in the breast weight of rice offal treatments (T_2, T_4 and T_5) except for reground rice offal (T_3) when compared to the control. This is an indication that birds can produced more meat when fed rice offal diets. Gizzard weight for T_3 (regrind rice offal) was highest (2.5%) while the least was control with no rice offal (2.19%). The higher value observed for gizzard weight could possibly be due to higher physiological activities by this organ. This significant difference observed between rice offal treatments when compared with control is because of the fibrous nature of the diet. This observation agrees with report of Maikano (2005) that increased weight of gizzard could be due to higher dietary fibre which probably stimulated the activity of the gizzard, resulting in it increase musculature.

The intestinal weight and length also showed similar pattern of result to the gizzard weight. The observed increase agrees with an earlier report that fibre in monogastric diet specifically has a mechanical effect on intestinal wall and cause the gastro-intestinal tract to increase and thicken (Ahamed and Olorede, 2003). Fibrous diets increase the weight of the viscera due to activity of the intestine especially ceca in handling bulky feeds. This finding agrees with earlier reports of (Lopez and Carmmona 1981; Brenes *et al.* 1993) also reported similar observation with rice bran. These authors reported that in addition to affecting performance of broiler chickens, rice bran substantially increase the size of the gastro intestinal tract.

5.3.1 Experiment 2: Effect of differently processed rice offal diets supplemented with maxigrain® enzyme on performance of broiler chicks

The results for final weight, weight gain and feed intake were significantly ($p<0.05$) higher in the control than all the other treatments (i.e. unprocessed, regrind, cooked and fermented rice offal treatments). There was non- significant ($p>0.05$) difference across all rice offal treatments irrespective of the processing methods used (Table 4.6). The reason could probably be as a result of the effect enzyme supplementation had on rice offal. This is believed to be so because irrespective of the processing methods used there was an insignificant effect on performance. It therefore, implies that both processing and enzyme supplementation would not be necessary. Rice offal can be included at 15% in starter diets without enzyme supplementation. The present data is in agreement with Omojola and Adesehinwa (2007) who indicated that the inclusion of exogenous enzymes did not significantly (P>0.05) improve body weight of broiler chicks. According to Maisonier *et al,* (2001) supplementation of diets with enzymes may reduce dietary problems. Variations in bird performance are reduced when enzymes are added to the feed.

Feed intake was significantly (p<0.05) lower for all the rice offal – enzyme supplemented treatments than the control. This could be as a result of the breakdown of fibre in rice offal diets and the subsequent nutrient availability aided by the use of enzyme. Therefore, birds could consume less feed yet their energy requirement is met. This result is in agreement with the findings of Ani *et al* (2008) who reported that reduction of feed intake was due to enhancement of feed, digestibility and nutrient availability. Birds are able to meet their energy requirement faster than when diets are not supplemented with enzymes. There was a superior feed conversion ratio (FCR) for boiled rice offal treatment when compared with the control and the rest treatments. Boiled rice offal gave FCR of 1.93 and was closely followed by fermented rice offal (T_5) of 2.04. This is an indication that supplementation of boiled rice offal with enzyme (T_4) gave a better working action among the rest processing method and even the control. This is because a good FCR value by birds implies that the diet was better utilized. Similar results were reported by Peterson and Aman (1998) and, Iyayi and Yahaya (1999), who observed significantly

($p<0.05$) better FCR in enzyme – supplemented cassava meal in broiler diets. Also Ani *et al.* (2010) reported that enzyme supplemented fibre diets tend to indicate that the nutrients were more available, efficiently digested and utilized by birds.

There was an insignificant ($p>0.05$) difference across treatment means for feed cost/bird and total cost/bird even though the control, was numerically higher than the rest treatments. It can be inferred that with enzyme supplementation of diets, especially high fibre agro-product like rice offal cost can be reduced. This agrees with Bedford (2003) who reported that the use of enzyme enables the feed compounder to minimize feed cost through reduced usage of expensive ingredients. Also, Torres *et al,* (2008) reported that enzyme supplementation of diets reduced feed cost. The significantly ($p<0.05$) better feed cost per kilogram gain observed for birds on cooked rice offal diet is because of their low fed intake yet better feed cost per kilogram gain when compared with control.

5.3.2. Effect of diets containing differently processed rice offal supplemented with maxigrain® enzyme on the performance of broiler finishers.

At the finisher phase, enzyme supplementation showed a significant ($p<0.05$) effect on final weight and weight gain. Higher final weight and weight gains were obtained for control and fermented rice offal treatment (Table 4.7). This significant response of birds to control and fermented rice offal diets could mean that enzyme supplementation at this stage had the best effect on fermentation as a processing method. This is because the result obtained was comparable to that of the control. This agrees with report of Biwas *et al.* (1999) and Swain and Johri (1999) who reported better growth rates due to enzyme supplementation. It can be advised that farmers can ferment their rice offal at the finisher phase before inclusion in the feed.

There was non-significant ($p>0.05$) effect on feed intake by birds across treatment means. This could be because of the enzyme action which aided availability and efficient utilization of nutrients. This finding is in line with Nduka (2006) who reported that higher feed intake were observed with 7.5% and 15% rice offal diets whether supplemented with or without enzyme at both starter and finisher phases. This was also observed earlier by Onimisi (2005) who reported that with increased bulkiness of feed, birds tends to consume more of the feed in order to obtain similar levels of nutrients needed to satisfy their requirement. Reported effects of enzyme supplementation on feed intake range from no effect by (Adrizal and Ohtani, 2002; Ritcher *et al.,* 1994) to a decrease reported by Kadam *et al.* (1991), while these disagree with (Augelovicova and Michalik 1997) who found increased feed intake due to nutrient digestibility.

There was a poor feed conversion ratio observed for the rice offal enzyme – supplemented treatment except fermented rice offal which was slightly better ($p<0.05$) than the rest processed treatments. Results of higher FCR obtained in this study is in line with Eruvbetine *et al.* (2002) who obtained increased FCR in hens fed enzyme supplemented diets. On the contrary, Iyayi and Davies (2005) found that FCR did not significantly ($p>0.05$) change with enzyme supplementation for broilers at the starter but at the finisher phase FCR was significantly ($p<0.05$) poor. The result of feed cost per kilogram gain was best for fermented rice offal treatment (T_4). This shows that birds on T_4 were able to produce 1kg of meat at a reduced cost when compared to the control. This reduced cost per kg agrees with the findings of Hosamani *et al,* (2001) who reported that profit increased due to low feed cost and faster growth rate of broilers by enzyme supplementation.

5.3.3 Effects of differently processed rice offal supplemented with maxigrain® on some blood parameters of broiler finishers

The high packed cell volume concentration for fermented rice offal compared with the rest treatments could that the birds made better use of the protein content of that diet because of the fermentation process. However, the values obtained across treatments in this study was within the normal range for broiler chickens reported by Patra *et al.* (2010), an indication that the diets did not affect the status of this parameters. An increase haemoglobin concentration of birds fed fermented rice offal could have facilitated increase in oxygen and carbon dioxide transport of the diet. Haemoglobin acts as a buffer (Ganong, 2005). The values obtained for haemoglobin in this study were similar to values reported by (Tuleun *et al*. 2009).

5.3.4 Effect of diets containing differently processed rice offal supplemented with maxigrain® enzyme on carcass characteristics of broiler finishers

The effect of processing and enzyme supplementation of rice offal diets on carcass characteristics of broiler chickens shown in Table 4.9. There was an insignificant ($p>0.05$) effect with enzyme supplementation on live weight, slaughtered weight, defeathered weight and dressing percentage across treatments. However, it is worthy to note that rice offal treatments gave a numerically better dressing percentage compared with control. Reground treatment (T_3) gave the best dressing percentage of (79.10%). This result agrees with report of (Lesson *et al,* 1996) who reported that increased dressing yield for addition of enzyme was due to fat deposition in the carcass. Also Mohammed *et al.* (2009) reported that although enzyme supplementation had non-significant effect on different meat yield characteristics but there was a trend of increased ($P>0.05$) dressed yield, breast, drum-steak and thigh meat yield reported for enzyme supplementation. In contrast, Biswas *et al.* (1999) observed that carcass yield did not differ among different enzymatic dietary groups.

According to Nduka (2006), more meat is produced in broiler chickens when diets were supplemented with enzymes. Significant differences ($p<0.05$) were observed for the liver weights across treatment with the control being the least. It is an indication that there could be slight increase in the weight of the liver when dietary rice offal content is increased. The result is similar with Mujahid *et al.,* (2004), who observed increased liver and heart weights when raw and pelleted rice bran were increased above 200g/kg. Heart weight was significantly ($p<0.05$) higher with birds on unprocessed treatment (T_2). This could be because the rice offal used for this treatment did not undergo any form of processing. As a result, though enzyme supplemented, there was an observed strain on the heart function which could be partly responsible for the enlargement observed. Increased intestinal length observed among rice offal treatments when compared with the control is not unexpected. This is because of the fibrous nature of rice offal and the inclusion rate of 15%. Abdelsamie *et al.* (1983) reported that at similar feed intake, fibre diet increased the weight and length of the gastrointestinal tract of broiler chickens.

CHAPTER 6

6.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 SUMMARY

Fresh samples of rice offal were bought from a local rice mill in Shika, Zaria. Representative samples of rice offal were processed differently by regrinding, boiling and fermentation. Rice offal was reground to 0.1 mm and 0.5 mm, boiled for durations of 15, 30, 45 and 60mins and fermented for 12, 24, 36 ,40 and 60 hours. Representative samples of the differently processed rice offal were taken for chemical analyses. Based on the results obtained the best processing methods in regrinding, boiling and fermentation. Thus 0.5mm was picked for regrinding, 30 minutes for boiling and 36 hours for fermentation.

Two broiler feeding experiments were carried out. Experiment 1, was to determine the effect of diets containing differently processed rice offal on broiler chickens. Processed rice offal was included at 10% in both the starter and finisher phases. There were five dietary treatments, control with no rice offal, treatment 2 (unprocessed rice offal), treatment 3 (reground rice offal), treatment 4 (cooked rice offal) and treatment 5 (fermented rice offal). It was observed at the starter phase that chicks effectively utilized reground rice offal (treatment 3) and it recorded the best performance in terms of weight gain, feed conversion ratio and feed cost per bird. For the finisher phase, boiled rice offal (T_4) was effectively utilized by the birds with a significantly higher final weight, weight gain and feed cost per bird.

Experiment 2, was the effect of diets containing differently processed rice offal with maxigrain® enzyme supplementation on broiler chickens. There were five dietary treatments supplemented with Maxigrain® enzyme at 10g/100kg and rice offal at 15% inclusion levels across treatments. The diertary treatments were treatment 1, control (with no rice offal), treatment 2 (unprocessed rice offal), treatment 3 (reground rice offal), treatment 4 (cooked rice offal) and treatment 5 (fermented rice offal). At the starter phase, control had the best results in terms of final weight and weight gain. Boiled rice offal treatment (T_4) gave the best feed conversion ratio and feed cost per kilogram gain. It was observed that at the finisher phase that fermented rice offal (T_5) gave a comparable result with the control in terms of final weight, weight gain and feed cost per kilogram gain.

6.2 CONCLUSION

The following conclusion were made from these studies

1. The use of rice offal in broiler starter and finisher chicken diets had no adverse effect on their performance at both 10% and 15% inclusion level with or without maxigrain® enzyme supplementation.
2. There were economic advantages in enzyme supplementation of rice offal based diets especially because of reduced cost of feed. Also, processed rice offal treatments supplemented with maxigrain® enzyme had bigger breast, drum stick and wing weight cuts.
3. Farmer should regrind rice offal to 0.5mm at 10% inclusion level in broiler starter feed for effective utilization by chicks.
4. Farmer need not supplement processed rice offal with maxigrain® enzyme when included at 10% level for starter but should supplement fermented rice offal at 15% inclusion for finisher broiler chickens.

6.3 RECOMMENDATIONS

1. Further investigation is recommended to confirm if an increase from 10g/100kg of maxigrain® enzyme, as well as the same rice offal inclusion levels would illicit better performance by the birds using the same processing methods.
2. Other methods of improving rice offal other than the present methods can be tested.

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