NUTRITIVE VALUE AND ENZYME SUPPLEMENTATION OF SORGHUM BREWER'S WASTE IN BROILER DIETS

BY

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A THESIS SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, ZARIA. IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTERS DEGREE IN ANIMAL SCIENCE

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DECLARATION

I hereby declare that the work reported in this thesis entitled "**Nutritive Value and Enzyme Supplementation of Sorghum Brewer's Waste in Broiler Diets** has been performed by me in the Department of Animal Science under the supervision of Prof. (Mrs) A.A Sekoni and Prof. G.S Bawa.

The information derived from 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 at any University.

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Signature Date

CERTIFICATION

This thesis entitled "**Nutritive Value and Enzyme Supplementation of Sorghum Brewer's Waste in Broiler Diets**" by Modupeola Oluwaseun KEHINDE meets the regulations governing the award of the degree of Master of Science (Animal Science) in Ahmadu Bello University, Zaria, and is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

This thesis is dedicated to the Almighty God who is the fountain of Knowledge.

ABSTRACT

Two experiments were conducted to evaluate the nutritive value and enzyme supplementation of sorghum brewer's waste (SBW) in broiler diets. In Experiment I, 225 one-week old broiler chickens with an average initial live weight of 73g were fed diets containing graded levels of SBW. There were five dietary treatments for both starter and finisher phases. The treatments were replicated three times with fifteen birds per replicate and a total of forty five birds per treatment in a completely randomized design. Treatments 1, 2, 3, 4 and 5 contained 0, 10, 20, 30 and 40% SBW, respectively. Results showed that at the starter phase, there were no significant differences ($P>0.05$) among the treatments up to 40% SBW while the finisher birds performed better in terms of final weight and weight gain up to 30% level of inclusion. Digestibility of crude protein and crude fibre were better up to 20% and were similar to those fed 30% inclusion of SBW. Dietary treatments had significant ($P<0.05$) effect on live weight, dressing percentage, breast, thigh, back, gizzard, liver, intestinal length and intestinal weight. At 40% level of SBW, thigh, back, gizzard, liver, intestinal length and intestinal weight were highest. In Experiment II, 225 one-week old broilers with an average initial live weight of 80g were used to evaluate the effect of Rovabio® enzyme supplementation at 0.01% on the performance, carcass characteristics and digestibility of nutrients by broilers fed diets containing 0, 30, 35, 40 and 45% SBW in Treatments 1, 2, 3, 4 and 5, respectively. Design and management of experimental birds were same as described in Experiment I. Results obtained at the starter phase showed that Rovabio® enzyme supplementation significantly ($P<0.05$) affected feed intake and feed cost per kilogram gain. Average feed intake was highest in birds fed 40% and similar to those fed 45% SBW plus enzyme, respectively while Feed cost per kilogram gain was lowered in birds fed 35 and 45% SBW. At the finisher phase, enzyme supplementation significantly ($P<0.05$) affected feed intake, feed conversion ratio and feed cost per kilogram gain. Average feed intake was highest up to 30% and similar to those fed 35% SBW. Feed conversion ratio was best with birds fed 40 and 45% SBW and significantly ($P<0.05$) lower than birds on the control diet. Dietary treatments had no effect on the final weight, weight gain and mortality rate of the birds. Birds on 35% SBW plus enzyme had highest digestibility in terms of crude protein and crude fibre and similar to those on 40%. Digestibility of ash was highest in birds fed the control diet and similar to those fed up to 40%. Significant ($P<0.05$) differences were observed on the carcass parameters measured except for the live weight, dressing%, drumstick, heart, spleen, intestinal weight and length. The results from these studies suggested that Sorghum Brewer's Waste can be economically fed to broilers up to 33.33% as obtained using a regression analysis with the feed cost/kg gain at the finisher phase as the parameter used without inclusion of exogenous enzymes. However, the use of Rovabio® enzyme enhanced the performance of birds up to 45% inclusion level in terms of feed cost per kilogram gain.

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CHAPTER ONE

1.0 INTRODUCTION

The present trend of inflation worldwide has become the source of concern for livestock owners, as such inflationary trend often imposes adverse effects on livestock feeds and hence, on costs of producing livestock and livestock products (Nyannor *et al*., 2007). Consequently, one of the greatest challenges facing the African continent is the provision of sufficient food to the ever increasing population which is not matched with similar increase in food production (Fasuyi, 2005).

The increasing demand for animal protein has aroused great interest in the production of fast growing animals with short generation intervals (Apantaku *et al*., 1998).Obinne and Okorie(2008) reported that expansion of poultry industry in Nigeria holds the greatest promise for bridging the animal protein requirement gap prevailing in the country within the shortest possible time. Atteh (2004), reported that protein from poultry meat and egg is of good quality and is used as a standard against which other proteins are compared. Broiler chickens are fast growing species of poultry that are commonly raised to provide tender meat for human consumption.The availability of cheap and good quality protein sources remain the single most important limiting factor in poultry production in Nigeria (Bawa *et al*., 2003; Abeke *et al*., 2008).However, the rising cost of poultry feed has continued to be a serious problem. This is because feed alone accounts for about 70% of the total cost of production (Ogundipe *et al*., 2003). Competition for conventional feedstuffs by man, industry and livestock has contributed immensely to the high cost of these feedstuffs in the local markets. This high cost coupled with inadequate knowledge of possible alternative and cheap ingredients have been the most important factors militating against the

increase in commercial poultry production in Nigeria and other developing countries (Olorede and Ajayi, 2005).

Babatunde (1986), suggested a drastic increase in the production of ingredients commonly used in livestock feeds, such as maize, soybeans, millet and others, so as to cater for the needs of both humans and animals. Where this cannot be achieved, he emphasized that attempts should be made to source for alternative feedstuffs for livestock. Therefore, the quest for exploring the use of alternative feed ingredients that are cheaper and locally available in dietary formulations to reduce production cost becomes imperative (Okeke, 2000).A characteristic of such alternative feedstuff should be its non competitive usage with man, brewery by- products fall into this category (Dowling *et al*., 2003).Some non- brewery alternative feedstuffs have been evaluated and found to be good replacements for the expensive conventional feedstuffs which have direct use as human food. These alternative feed sources have been utilized successfully by several animal nutritionists in the formulation of feed which include the use of cassava peel meal in rabbits (Adegbola and Oduozo, 1992), leucaena leaf in broiler diets (Dada *et al.,* 1998), cocoa pod husk meal in cockerel diets (Nworgu *et al*., 2003) etc.

According to Bello (1984), brewer's spent grains and brewer's yeast are the most common by-products of the brewing industry in Nigeria. Brewers' dried grain (BDG), a form of brewers' grain is a dried extracted residue of barley malt alone or in mixture with other cereal grains, resulting from the manufacture of beer (Adebowale and Ademosun, 1981). Babatunde (1986) identified that brewers dried grains have relatively high crude protein (23.62%) compared with maize (10.15%). They are rich sources of essential fatty acids and vitamins especially B- complex

vitamins and unidentified growth factors since they are by-products of fermentation. A lot of work had been carried out on spent barley grains (Almiral *et al.,* 1995; Amin *et al.,* 2011). However, works on sorghum brewers' grains are very few. The production of sorghum brewers' waste (SBW) is derived from sorghum used solely or in combination with other cereal grains like maize (maize-sorghum) in the production of *burukutu* (Dogari, 1985; Ayodeji and Fasuyi, 2005). According to Udedibie and Emanalom (1993) the striking features of the maize- sorghum based brewer's waste are its relatively low fibre (12.42%) and very high crude protein (28.64%) contents, deviating significantly from the crude fibre content of the conventional barley based waste which ranges between 19-22% (Alawa *et al*., 1990; Maertens *et al*., 1990).

Thousand tones of brewer's spent grains are turned out annually from many small and large scale breweries in the country, with only a small fraction being used by animals particularly monogastrics (Kingsell *et al.,* 1999). Udedibie and Emanalom (1993), Ayodeji and Fasuyi (2005) have successfully incorporated 20% maize- sorghum beer residue in poultry diets. Uchegbu *et al.* (2010) also reported the use of 30% maize-sorghum beer residue in poultry diets without any deleterious effect on growth and production performance. The production of beer from 100% sorghum is entirely a new concept following the ban of the importation of barley in 1988 and the need to conserve maize for human consumption. Sorghum brewer's waste is more nutritious than the conventional barley-based by-product and would appear best suited for feeding ruminant animals, taking advantage of its high fibre content and fairly rich source of fermentable products (Maertens *et al*., 1990). Abdulmalik (1997) reported that sorghum beer residue from the industry can be included at a level of 15 and 20% in the diets of breeding and weanling does respectively without adverse effects on performance. In a feeding trial, Tegbe *et al*. (1995) fed graded levels of

0, 10, 20, 30% spent grains to weaned pigs and reported a decrease in weight gain, feed intake, feed to gain and feed cost per kilogram gain as the level of the spent grains increased in the diet. The best result on the utilization of *burukutu* waste was obtained at 10% inclusion level. Tegbe *et al.* (1995) also fed diets of 0, 12.5, 25 and 37.5% *burukutu* waste to adult pigs and found that performance characteristics related to feed intake, weight gain and feed to gain ratio were not affected by the level of inclusion of the waste.

On the other hand, it is expedient to note that poultry cannot fully utilize high fibre diets because they lack the digestive frame work that can elaborately digest large amount of fibre. Many researchers have proved that it is imperative to incorporate exogenous enzymes into their diets in order to enhance the breakdown of the non-starch polysaccharides (NSPs) present in fibre (Isikwenu and Bratte, 1999). Amin *et al.* (2011) reported 15% Brewer's Dried Grain (BDG) on enzyme supplemented diet for finishing broilers. Enzymes are known to increase the digestibility of fibrous feed ingredients by disrupting the plant cell walls and by reducing the viscosity of the gut contents, thereby enhancing nutrient absorption (Isikwenu and Bratte, 1999). Almiral *et al.* (1995) reported that the inclusion of ß- Glucanase enzyme in a diet based on barley increased the final body weight of broilers. The enzyme considered in this study was Rovabio®.

Sorghum brewer's waste is relatively cheap as large quantity is produced in local gin production (Awika *et al*., 2001). It does not require much of additional processing such as grinding before being incorporated into livestock diets and preserves the ecosystem from further pollution resulting from its disposal.

1.1 Justification

The high cost of conventional feed ingredients such as maize, millet, soybeans, groundnut and others arising from the competition between man and animals has contributed immensely to the current high cost of poultry feeds. Hence, the need to explore the use of underutilized, non-conventional and cheap energy sources like sorghum brewer's waste as an alternative energy source in poultry nutrition.

Poultry farmers will appreciate any ingredient that is cheap and can be harnessed for production sustainability. Consequent of this, brewer's spent grains which have high fibre contents are explored, thus, the need to introduce exogenous enzymes in poultry diets because they lack efficient digestive frame work to breakdown and utilize high fibre diets. Supplementation of sorghum brewer's waste with Rovabio® enzyme in broiler diets will enhance its effective utilization and there could be a remarkable decrease in the cost of poultry feed to the advantage of the poultry farmers in Nigeria.

1.2 Objectives of the study

This study was designed to:

1. Evaluate the effects of using graded levels of Sorghum Brewer's Waste (SBW) on performance and carcass characteristics of broilers
2. Evaluate the nutrient digestibility of the diets of broiler birds fed graded levels of SBW.
3. Evaluate the effect of enzyme supplementation of SBW diets on performance, carcass characteristics and digestibility of nutrients of broilers.
4. Evaluate the cost: benefit of utilizing SBW in the diets of broilers.

Hypothesis.

H_o; sorghum brewer's waste with or without enzyme supplementation has no significant effect on growth performance, carcass characteristics and nutrient digestibility of broiler chickens.

H_a; sorghum brewer's waste with or without enzyme supplementation has a significant effect on growth performance, carcass characteristics and nutrient digestibility of broiler chickens.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Concept of alternative feedstuffs

The interest in unconventional feed sources was borne out of the need to find alternative feeding materials for incorporation into animal diets particularly in developing countries where there has been an acute shortage of animal protein (Fasuyi, 2005). Inadequate protein consumption in most developing countries including Africa has been the major cause of malnutrition. Adequate provision of balanced animal feed at a reasonable cost is one of the greatest constraints to the expansion of the poultry industry. Apart from the high and fluctuating costs, some of the ingredients used in compounding feeds notably cereals grains are in high demand for human consumption and this has exacerbated the livestock feed situation (Olorede and Ajayi, 2005). Olomu (1995) reported that the largest single most expensive dietary need of an animal is energy because of the amount required. The high cost of feed resulting in reduced profit margins, especially in the last few years has kept people away from the business of poultry production (Akinfala, 2002). In order to address this problem, Babatunde (1986), Onuh (2005) stressed the need to find alternative sources of feed ingredients that are cheap, adequate and readily available for feeding livestock. Similarly, Alawa *et al*. (1990) advocated the development of alternative feeding materials that will be relatively cheaper when compared with commercial feeds or conventional feedstuffs. Feed constitutes the single largest expense in livestock production (Ogundipe *et al*., 2003).

Traditionally, feeds for livestock production consist mainly of cereal grains (corn, grain sorghum, oats, barley), forage feeds (grass hay, legume hay), and oilseed meals (groundnut cake, soybean meal, cottonseed meal). Many classes of livestock however, can and have used a wide range of

feedstuffs. Many of these "alternative" feedstuffs that can be of use are by-products and edible waste products from the food processing, food preparation and food service industries, and the bio-fuels industry. Example of these industries include grain milling, brewing and distillation, baking, fruit and vegetable processing, meat, milk and egg processing, seafood processing, prepared food manufacturing, and retail food outlets. Other alternatives include feedstuffs that are not commonly fed, such as wheat which may be a good choice during times of low prices, or during shortages of more traditional feedstuffs (Odunsi *et al*., 2005).

Most classes of livestock can successfully use alternative feedstuffs in their diets. Examples of the more common alternative feedstuffs include distillers' grains, soy hulls, corn gluten feed, brewers' grains, citrus pulp, rice milling waste, molasses, and whole cottonseed (Onuh, 2005). Examples could also include waste candy, culled peanuts, culled/ waste vegetables, bakery waste, cotton gin trash, and table scraps (restaurant food waste). These provide a high quality alternative to conventional feedstuffs often at lower costs. Some of these alternative feedstuffs are available to livestock producers in West African countries, but due to traditional practices or a poor understanding of their values and limitations, usage can be limited (Olorede and Ajayi, 2005).Even though using alternative feedstuffs may be cost effective, cost is not the only factor to be considered. Variations in processing methods, availability, and form (pellet, meal, wet or dry) can impact the value of these feedstuffs (Babatunde *et al*., 1986).

2.2 Poultry industry and alternative feedstuffs.

As laudable as poultry industry is to bridging animal protein gap in Nigeria, the industry faces lots of problems and the most important problem is sub-standard nutrition which needs urgent

attention (Faniyi, 2002). This is because the potentials of the birds depend majorly on the type of feed given. Competition for conventional feedstuffs by man and livestock had contributed immensely to the high costs of ingredients in our local markets (Babatunde *et al*., 1986). This thus creates problems for poultry industry in the area of providing good quality feed at affordable prices. Faniyi (2002) and Ogundipe *et al*. (2003) reported that feed alone accounts for over 70% of the total cost of raising commercial poultry. In fact, the price of various feed ingredients has risen over the past few years such that the cost per unit of feed is now very high making poultry production more expensive (Ladokun and Longe, 2004). This high cost coupled with inadequate knowledge of possible alternatives and cheap ingredients are important factors militating against increased commercial poultry production (Olorede and Ajayi, 2005).

One of the possible options advocated to solving the present high costs of feed stuffs is the substitution of the conventional with the non-conventional feedstuffs in poultry diets (Babatunde *et al*., 1986). Alternative feedstuffs had been severally evaluated at every stage of life of birds with the aim of reducing the cost of feeding. There are many indigenous plants and animal materials in Nigeria which had been evaluated and found to be good replacements for the conventional feedstuffs. The only condition is that enough information regarding their nutritional value and freedom from toxic substances must be known before they can be used as replacements.

2.2.1 Agro- industrial by- products in Poultry Feeds

The use of agro- industrial by- products as substitutes for conventional feedstuffs in poultry diets is well documented. Faniyi and Ologhobo (1999) used bio-graded cowpea and sorghum seed-hulls to replace brewer's dried grain as source of protein and fibre in broiler diets. They concluded that the average body weight gain and average feed intake were at the highest at 50%

level of inclusion. Sobamiwa (1998) used cocoa husk meal in replacement for maize on hen performance and egg quality. It was concluded that laying hens could tolerate and produce eggs economically on diets of 20% cocoa husk meal. Ladokun and Longe (2004) used cocoa bean meal to replace groundnut cake on the performance of broilers and they concluded that its substitution in broiler diets (starter and finisher) can be up to 15%. Bamgbose *et al.* (2004) reported that broilers on 10% pigeon pea processed via fermentation were better off than others. Ogbonna and Oredein (1998) reported that cockerel chicks can be fed cassava leaf meal as source of energy or protein at 30% inclusion.

Uko *et al*. (1990) replaced maize with industrial maize offal at 10, 20, 30, 40 and 50% levels of inclusion in laying hen diets and concluded that there were no significant differences among the birds fed the different diets in terms of egg production and weight gains of the hens. In addition, Igene and Oboh (2004) used rice offal to replace wheat offal at 0, 25, 50 and 75% levels of inclusion. They concluded that at 75% wheat offal replacement with rice offal in the diets of cockerels, their growth performance and hematological values were still within the normal ranges, and that there was no deleterious effect on the birds. It was noted by Oji *et al.* (1990) that the feed intake and feed conversion ratio decreased at 20 and 30% levels of inclusion of molasses in broiler diets. The authors also noted that the body weight of the birds decreased as the level of inclusion of the test material increased. It was concluded that molasses may not be used more than 10% in broiler diets.

2.2.1.1 Benefits in utilizing agro- industrial by products

Agro- industrial by- products reduce environmental pollution when they are utilized as feedstuffs by livestock, thereby, improving environmental sanitation (Dowling *et al*., 2003). They provide good sources of calcium, protein, B- complex vitamins and some essential amino acids.

Reduction of the dependency on imported feed ingredients which constitute a drain in foreign exchange is actualized and it can also be mentioned that the conversion of these by products in the diets of livestock reduces the use of feedstuffs which have competitive usage with man (Babatunde, 1986).

2.3 Alternative feedstuff from the breweries

According to Olomu (1984), an industrial by product can be described as that material which remains after the main product of interest has been removed or extracted in the industry. There are two main by-products that can be produced in association with the production of beer, such as, brewer's grains (wet or dried) and brewer's dried yeast (Kuhl *et al.,* 1998). These materials are considered to be good sources of un-degradable protein and water soluble vitamins. They have been used in feeding both ruminant and monogastric animals. Brewers' grain is the material that remains after grains have been fermented during the beer making process. These materials can be fed in wet form (wet brewer's grains) or dried form (dried brewer's grains) (Kuhl *et al.,* 1998).

The nutritional content of the material will vary from plant to plant and depending on the type of substrate being used (barley, wheat, corn, etc.), proportions being fermented and fermentative process being used. Some plants will dry the brewer's grain and sell it as dried brewer's grain, while others will have it available as wet brewer's grain. Both types have similar feeding characteristics if the wet brewer's grain is fed shortly after it was produced. Although the rumen degradability of the protein in the dried brewer's grain is lower, this is directly related to the amount of heat that was subjected to it during the drying process. Wet brewer's grains need to be used in close proximity to the plant of production since they contain high moisture content (75-80%) and transportation can be expensive (Kuhl *et al.,* 1998). On the other hand the water that it

contains may be at an advantage to livestock producers in areas where water quality and supply are limited. The main grain by-product of interest in the beer and local alcohol brewing industries in Nigeria are the brewers' spent grains or sorghum brewers' waste (Dogari, 1985).

2.3.1 Common constraints in feeding spent grains from the breweries.

Yunis and Cahaner (1999) reported that the major problem with the use of brewer's grain in monogastric diets is its low energy and high fibre content. Confirmatory reports show that spent grains is best fed to ruminants and utilized because of their ability to handle high fibre and low energy feed stuffs than the monogastrics (Maertens *et al*., 1990). However, the inclusion of brewer's grains in diets has been said to reduce the incidence of parakeratosis in the rumen of animals. Brewer's grains have been reported to contain high levels of selenium in which as much as 0.045ppm may limit performance in feedlot cattle especially if dietary protein is low (Khejezea and Walter 1996). About 19% of the selenium supplied in dried brewers grain to dairy cows appeared in milk as reported by Taylor (1980). This was especially so where the dried grains were the main source of dietary selenium and then affirming the hazards associated with selenium toxicity from milk on human health. Yunis and Cahaner (1999) reported that long term feeding of brewers grains to dairy cows often produce infertility. This could be due to the imbalance of the essential amino acids, especially tryptophan which they observed to be very puny. They recommended the use of about 10kg brewer's grains per day alongside tryptophan- rich- feeds in order to avert the problem.

2.4 Sorghum (*Sorghum bicolor)* production and its distribution.

Sorghum is one of the most important feed and food crops in the arid and semi- arid tropics (Hulse *et al*., 1980). It is widely grown in several parts of the world and in Nigeria. It is mainly

grown in the Northern part. It is the main food grain in Africa (Tukur (2011). In Nigeria, the projected estimated production of sorghum for 2010 was put at 5,977,000 tonnes (Shaib *et al*., 1997). Sorghum can be grown successfully on poorer soils and under drier conditions than maize. Davis *et al*. (2003) reported that the metabolizable energy (ME) content of sorghum is comparable to that of maize and which is up to 13.79MJ/kg and that it contains 12-14% CP. Most recently, Tukur (2011) reported that sorghum contains 3,669kcal/kg of ME, 7.8% crude protein and 10.6% crude fibre. It contains low levels of xanthophylls, linoleic acid, lysine, methionine and tryptophan (Lazaro *et al.,* 2000). It is also low in calcium but high in phosphorus. It is used to substitute maize to a reasonable extent in livestock feeding. Sorghum is also used inhuman food in various forms especially in the Northern part of the country (Shaib *et al*., 1997).The use of sorghum in livestock feeding is limited by its contents of tannin (polyphenols), phytates and cyanogenic glycosides (Awika *et al*., 2003).

Sorghum varieties and hybrids differ in palatability and nutritional value, which may be associated with the level of tannin in the grain (Kim *et al*., 2000). This is probably why the efficiency of utilization of sorghum by poultry appears to be either the same as that of maize or 10 to 15% lower, apparently depending on processing method or the amount of tannin in the pericarp (Vinod *et al*., 2004). Although, low tannin sorghum has been bred to improve its utilization in poultry. Tannins are a group of compounds that bind proteins, thus impairing protein digestion (Adewusi and Matthew 1994). Sorghum is mostly cheaper than maize and abundantly available in most parts of the Northern Nigeria. The projected production targets of maize and sorghum in the country for the year 2012 were put at 13,388,000 and 9,859,110 metric tonnes, respectively (FAO, 2011).

2.5 Nutrient Composition of brewer's grains.

The nutrient composition of brewer's grains from different sources is presented on Table 2.1

Table 2.1 Nutrient composition and energy values of brewer's grains from different sources.

%	BDG[1]	BDG[2]	SBR	MSBG	SORGHUM*	MAIZE*
Dry matter	92.40	96.30	91.00	ND	89.00	87.00
Crude Protein	27.60	25.00	22.00	28.64	11.10	8.10
Crude Fibre	19.60	11.40	8.40	12.42	2.00	8.00
EtherExtract	6.10	1.80	4.60	6.50	3.00	3.00
Ash	2.90	ND	8.61	7.27	1.80	1.60
NFE	43.80	52.60	47.39	45.17	71.10	66.10
Calcium	0.36	ND	0.13	0.31	0.04	0.40
Phosphorus	0.62	ND	0.16	0.56	0.1	0.27
GE(Kcal/kg)	499.60	-	ND	ND	ND	ND
DE(MJ/kg)	1978	2870	ND	ND	ND	ND

BDG[1] –Brewer's dried grain (Babatunde *et al.*, 1975), BDG[2]- Brewer's dried grain (Maertens *et al*., 1990)

SBR- sorghum beer residue (Dogari, 1985), MSBG-maize/ sorghum based brewer's grain (Udedibie and Emenalom, 1993), ND-Not determined, * - staple food. GE- gross energy (kilocalorie per kg), DE- digestible energy (megajoules per kg), NFE-nitrogen free extract.

One of the major procedures in assessing the nutritive value of a feedstuff is by determining its chemical composition with respect to dry matter, energy, protein, fibre, vitamins and minerals. Brewer's dried grain (BDG) is a by- product of the brewing industry which has similar amino acid profiles with feedstuffs like groundnut cake (Aduku, 1993). The major limitations to the use of BDG as a source of plant protein is its high crude fibre content (Onwudike, 1983). It has been

documented that BDG represent about twice the nutrient contents of the original grains except for the starch that would have been converted to alcohol (Mowat, 1980). Jensen *et al.* (1976) noted that as a result of the conversion of the utilization of the starch in the original grains for alcohol, low metabolizable energy values were associated with the use of BDG in monogastric diets. The nutrient composition of BDG varies with place, type and source of grain, method of processing as well as methods of drying (Odunsi, 2008). This makes general statements on the composition of brewer's grains difficult. Reports from literature indicate that the crude protein level of conventional barley based brewer's dried grain (BDG) varies from 18-27% (Babatunde *et al.*, 1975, Maertens *et al.*, 1990). Udedibie and Emanalom (1993) reported that maize/sorghum based dried grains had a crude protein value of 28.6% and was higher than 22% reported by Dogari (1985) while Abdulmalik (1997) reported a crude protein value of 30.16% for sorghum beer residue. BDG has been described by Babatunde *et al.* (1975) and Odunsi *et al. (*2008) as very fibrous and may serve as an energy source. It has been documented that the energy content of BDG ranges from 1800- 2500kcal/ME/kg (Bello *et al*., 1984, Maerten *et al.*, 1990 and Odunsi *et al.*, 2008).

The crude fibre content of BDG ranges from 11.7- 21.5% as reported by Babatunde *et al*. (1975) and Udedibie and Emanalom (1993). They noted that BDG being very fibrous is best suited for ruminant feeding with limited use in monogastric rations. However, Dogari (1985) reported a lower crude fibre value of 8.4% for sorghum beer residue. The maize/sorghum based brewer's grain has been described as less fibrous and more nutritious than the conventional barley based by- products. Babatunde *et al.* (1975) reported that the ash content of BDG ranged from 3.1 to 4.6% but significantly lower than the value reported by Udedibie and Emenalom (1993) which

was 7.27% for maize/ sorghum based BDG and slightly higher than the value (2.51%) reported by Abdulmalik (1997) on sorghum beer residue (SBR).

2.6 Influence of brewer's dried grains in poultry diets.

The use of brewer's grains in poultry diets has been well documented. It has been found that they can be incorporated into poultry starter and grower mash rations at levels up to 10 and 15%, respectively without adverse effects on the performance of the birds (Jensen, 1981 and Ibrahim, 1986). Olomu (1984) had earlier reported that with the addition of suitable fat, broiler starters may be able to tolerate up to 30% BDG and broiler finishers up to 37% BDG without adverse effects on growth performance. Deltoro *et al*. (1982) fed BDG to laying hens at the levels of 0, 4, 8, 12 and 16% of the diet. Feed intake, egg production, feed conversion ratio and body weight were not significantly different among the groups but egg weight, interior egg quality and fat content of liver were significantly greater with 16% BDG than in the control group.

Onwudike (1983) reported that feeding diets containing 30% BDG did not affect weight and carcass yields of broiler chickens given diets with up to 30% BDG from 21 days to 11 weeks old. Chickens given large amounts of BDG showed a significant increase in size of pancreas and a decrease in abdominal fat and size of liver. The most efficient diet in terms of amount of feed to produce 1kg of gain was that with 15% BDG. In another feeding trial conducted by Deltoro and Fernandez (1981) who fed diets containing 0, 15, 30, 45 and 60% BDG to 20 Rhode Island Red laying hens in the seventh month of lay, birds fed diets containing 45% or more BDG had significant ($P<0.05$) difference in digestibility of nitrogen and nitrogen retention. Feed intake, egg production, feed efficiency, egg weight, egg quality and body weight gains were also studied. Diets with 15% or 30% BDG seemed to be adequate, although the losses of body weight and shell

quality suggested that this level should not be used without further research. At 60% dietary level, BDG caused a significant decrease in most of the characteristics studied. The use of 90% BDG caused a reduction in feed intake and large body weight losses were recorded.

2.7 Influence of brewer's dried grains in rabbit diets.

Although, studies have been conducted on the use of brewer's dried grains as a feed supplement for various classes of livestock, information on its utilization by rabbits is still being studied. Alawa *et al*. (1990) described the performance of growing rabbits fed diets based on corn in which various proportions of the corn were replaced with BDG. They reported that the rabbits tended to consume more dry matter as the level of BDG in the diets increased. This was associated with increasing dietary fibre concentrations caused by increasing proportion of BDG in the diet. Least final weight and weight gain were recorded for this group of rabbits which also had the poorest feed conversion ratio. Depression in growth rates and increase in the amount of feed consumed per unit of live weight gain was recorded as BDG in the diet increased. Fonolla *et al*. (1985) also fed BDG containing 28.85% Crude Protein mixed with 50% dried bean pods or supplemented with mineral and vitamin premix at 3% and sugar beet molasses at 30%. Digestibility of nutrients in the grains except for crude protein and ether extract was increased by adding bean pods. Palatability of BDG was improved by both treatments.

In another study conducted by Alawa and Amadi (1991), it was reported that 35% brewer's dried grains had a greater potential for utilization compared to corn cobs or wheat bran when used to replace maize.

2.8 Influence of brewer's dried grains in swine diets.

The high fibre content (15%) and great variability of brewer's grains limit their values for pigs (Serres, 1992). However, it is widely used in small scale systems of pig production in Nigeria. Tegbe (1985) reported a significant decrease in the daily feed intake and daily gain when weaner pigs received up to 30% BDG levels in their diets in the starter phase. They however, reported at the grower and finisher phases that significant increase occurred in the feed intake, daily weight gain and poorer feed to gain ratio. It was concluded that starter and grower pigs can tolerate 10% BDG in their diets while the finisher pigs can be fed as much as 20% in their diets without any detrimental effect on performance.

Babatunde *et al*. (1975) reported that when 70 weaner pigs were fed graded levels of 5, 10 and 15% BDG, no significant difference in average daily gains and efficiency of feed utilization was observed, but the average daily feed and digestible energy intakes were significantly affected. The authors concluded that inclusion of barley brewers dried grains at 15% of the diet for growing pigs did not depress growth rate, although, nutrient digestibility was lowered. This level of inclusion substantially reduced total feed cost. Madubuike (1988) also fed graded levels of BDG up to 15% level in the diets of early weaned pigs and reported no adverse effect on total gains and average weight gains of the pigs. In addition, average daily feed intake and feed to gain ratio increased with increasing levels of BDG in the diets. The pigs placed on the 15% BDG however consumed more feed per unit gain. It was reported that the 15% BDG had a higher fibre level which may be responsible for the depressed digestion and the pigs may have made up their gain through increased feed intake.

2.9 Sorghum brewer's waste (*burukutu waste*) and its utilization in livestock diets

The locally produced beer using sole sorghum generates spent grains which depend on the system used. This by product can also be referred to as *burukutu waste* or BKT waste (Dogari, 1985). Though it has been fed to livestock, literature is still quite scanty on its utilization. The grain source is usually sorghum or the combination of it with maize and it is used by pig farmers singly or in combination with other feed ingredients (Tegbe *et al*., 1995). Dairo (1990) reported high fibre content (16.9%) for sorghum distillers waste (SDW) with crude protein value of 14.98%. Results showed that there were no significant difference in feed intake, average daily weight gain and feed conversion ratio. Feed intake increased up to 10% but no difference was noticeable between 10 and 15% replacement levels. A generally low rate of growth was observed for pigs on all the treatments. Thus, SDW at 10% replacement level of maize appeared to be the optimum level of inclusion in growing pig rations and this agreed with the reports of Tegbe (1985) who fed brewers dried grains to growing pigs.

According to Dogari (1985), *burukutu* waste can be included at up to 50% of broiler starter diets. His results showed that there was no significant difference in the weight gain of broilers fed sorghum brewer's waste and those fed with maize as the main energy source. He also reported that increasing level of *burukutu* waste in the diets of broiler chickens at up to 50% depressed weight gains, feed efficiency and feed cost per kilogram gain. In a feeding trial, Tegbe *et al*. (1995) fed graded levels of 0, 10, 20, 30% local spent grains to weaner pigs and reported a decrease in weight gain, feed intake, feed to gain and feed cost per kilogram gain as the level of BKT waste increased in the diet. The best result on the utilization of BKT waste was given at 10% inclusion levels in the diets of weaner pigs. Same authors in another trial fed diets of 0, 12.5,

25 and 37.5% BKT waste to adult pigs and found that performance characteristics related to feed intake, weight gain and feed to gain were not affected by the level of the waste.

Abdulmalik (1997) carried out two studies using the weaner and the breeding rabbits. The weaner rations contained 0, 10, 20, 30 and 40% brewer's sorghum residue (BSR) while the rations for the breeding does contained 0, 7.5, 15, 22.5 and 30% of same test ingredient. Results showed that BSR was a rich source of protein having 30.16% and other nutrients for rabbit growth. Inclusion of BSR in weaner rations reduced feed intake and feed cost per kilogram of the feed. Weight gain increased up to 20% inclusion in the diets and thereafter decreased. The 20% diet gave the best result in terms of feed conversion and feed cost per kilogram live weight gain. Inclusion of BSR in the diet reduced dressing percentage, gut length and abdominal fat contents. There was no significant effect on liver weight and edible organ weights. These studies showed that without adjusting for energy, BSR can be included at a level of 15 and 20% in the diets of breeding does and weaner rabbits, respectively without adverse effects on their performance. There was also savings in the cost of feed when BSR was included in their diets.

2.10 Effect of fibrous diets on growth response of broilers

Fibre has been known to have varying effects on the growth performance of broilers. Bate-Smith (1973) reported a decrease in voluntary feed intake of birds fed kolanut husk meal (KHM) due to the presence of tannin which provoked an astringent reaction in the mouth of the birds, thereby reducing voluntary intake of KHM feed. The mechanism of action may be related to the ability of insoluble fibre to hold water, thus influencing gut bulk (physical fill) and potential motility (Aulrich and Flachowsky, 2001). Babatunde and Hamzat (2005) observed an increased feed consumption of cockerel birds when fed KHM and this agreed with the fact that under *ad libitum* feeding conditions, birds consume feed primarily to satisfy their energy requirements first due to

caloric dilution of the diets by KHM as described by Leeson *et al*. (1996), Rabie and Szilagyi (1998), Oluokun and Olalokun (1999).

2.11 Effect of fibrous diets on broiler carcass and organ weights

Broiler growth is dependent on optimal feed intake throughout the growing period. Optimal feed intake is dependent on a number of factors such as environmental temperature, diet nutrient density and physical feed characteristics which are considered to have a very significant impact on broiler growth (Esonu *et al*., 2008). Diets have been known to have varying effects on the carcass characteristics and organ weights of broiler chicks. For example, Ijaiya *et al.* (2011) observed that the dressing percentage obtained in a study conducted on broilers fed rubber seed meal (RSM) based diet was comparable with the range of 74.82 to 77.39% reported by Esonu *et al*. (2008) for broilers fed oil palm leaf meal based diet. However, diets did not have significant effect on heart weights of the birds across the treatments which were explained with the observations of Sankyan *et al*. (1991) in goat, that the heart being a vital organ attained most of its matured weight during development of the foetus. Therefore, varying levels of fibre based diets do not significantly change heart in the latter stages of growth. This was further established by Ijaiya and Fasanya (2004).

The increase in the weight of gizzard as the level of rubber seed meal (RSM) (a highly coarse feed stuff with high crude fiber level) inclusion increased agreed with the earlier findings of Mokaji (1994) and Lamidi *et al.* (2008) that high fiber content in the diets of birds was responsible for the enlargement of the gizzard. Birds fed RSM level up to 50% performed generally better than the control diet because diets contained adequate crude fiber level which tended to activate the intestine and more production of enzyme resulting in better nutrient digestion (Adeniji, 2001; Esonu *et al*., 2008).

2.12 Effect of fibrous diets on digestibility of nutrients in broilers.

Varying effects of fibre diets have been shown on the digestibility of nutrients in broiler diets. Lala *et al*. (2011) observed a decrease in dry matter digestibility as instant noodle waste (INW) inclusion in the diets of broilers increased at the starter phase while it showed no effect at the finisher stage. Digestibility values of nutrients were higher at the finisher phase than in the starter phase due to the trend in age difference with the fact that the digestive tract systems of the broilers were not well developed at the starter phase compared with the well-developed digestive system at the finisher stage.

Babatunde and Hamzat (2005) observed a direct reduction in apparent crude fibre digestibility of cockerels as dietary inclusion of kolanut husk meal (KHM) increased. The authors also observed that the birds on the control diet were able to digest their feed better than birds on KHM. Apparent crude fat digestibility was higher for the control diet than other diets and this decreased as the level of KHM increased in the diets. Yasar and Forbis (2000) have reported reduction in the intestinal digesta in chicks as early as between 2 and 3weeks of age. Palander *et al.* (2005) also reported that there were longer retention times in older birds due to the increase in the volume of the digestive tract which improved digestibility.

2.13 Enzymes in poultry production and their benefits

Enzymes are basically protein catalysts that aid chemical reaction in biological systems. They are composed of long chains of amino acid with highly complex molecular structures (Isikwenu and Bratte, 1999).

They are used in degrading different structural carbohydrates found in cereals, particularly those that are not digested by avian and mammalian enzymes; those that are highly viscous and have

high water binding capacity, thus, enzymes play a key role in digestion (Allen *et al*., 1996). In recent years, enzymes have been used in monogastric diets to reduce anti-nutritional factors consequently increasing the digestibility of existing nutrients, increase the digestibility of non-starch polysaccharides (NSP) thereby increasing body weight gain, supplement the activities of the host endogenous enzymes, lower feed cost per kg live weight gain, reduce the occurrence of sticky droppings and to decrease nutrient waste in the excreta (Classen and Copper, 1998).

The effect however depends on the type of diet and the type of animal. Dry matter digestibility of feed stuffs by animals range from 50-80%, the remainder of the dry matter is lost via the excreta. Therefore, enzymes have been demonstrated to increase the digestibility of poorly digested cereals to a much greater extent than well digested cereals (Allen *et al*., 1996).

There is also a dramatic reduction in the moisture content of poultry faeces when Xylanase, protease, phytase, polysaccharidase, glucanase, amylase, cellulase, pectinase, arabinase, lipase and hemicellulase, which are various categories of enzyme preparation with varying degrees of substrate specificity, are included in the diets (Allen *et al.*, 1996, Choct, 1997, Aboosadi 1998; Oluyemi and Robert 2000; Atteh, 2004).

Exogenous enzymes have been explored and found to degrade different structural carbohydrates found in cereals, particularly those that are not capable of being digested by avian and mammalian enzymes. Most offals of food crops like rice, wheat and maize, dried and spent grains from the breweries can be improved through the use of enzymes (Classen and Copper, 1998). Though, some specific activities are necessary to breakdown some other heavier compounds in feed that surpasses the strength of intrinsic enzymes, therefore exogenous enzymes are added to the diet to

break down these compounds. Phytases are routinely utilized particularly in environmentally sensitive areas of the world due to their ability to increase the phosphorus availability from vegetable ingredients (Jongbloed *et al*., 1997; Kemme *et al*., 1999). Bedford (2003) also reported that the use of enzymes enables the feed manufacturer to minimize feed costs through reduced usage of expensive ingredients like maize, soybean, and groundnut cake, so as to substitute for some alternatives, but cheap feed ingredients which may pose readily to an extent difficulty in digestibility due to their fibrous nature. He further reported that phytase releases phytate phosphorus which when accounted for, replaces inorganic phosphate sources and at the same time reduces formulation costs.

The response to the use of enzymes is greatest on the poorest quality raw materials (Scott *et al*., 1998; Bedford *et al*., 2003) and as a result, variations in subsequent bird performance are reduced allowing for more uniform flock and also less variation in productivity from flock to flock. Some commercial enzymes such as Maxigrain and Allzyme contain a spectrum of different enzymes including xylanases and β-glucanases and therefore can be used effectively with most of the cereals. The inclusion of enzymes in non-ruminant diets has been reviewed by Campbell and Bedford (1992). They reported that the enzymes must not be inactivated by processing or by low pH or by the digestive enzymes in the gastrointestinal tract (GIT) in order for it to be very effective. It also should be noted that different cereals contain different amounts of sensitive anti-nutritional factors therefore; the response to enzyme treatment may vary within a given cereal. Results after the administration of enzymes are affected by class and age of poultry and the responses in swine are usually less pronounced than those of poultry.

2.14 Rovabio® multi-enzyme.

Rovabio is a complex enzyme that improves digestibility of feed. In feed, the enzymes in the complex work synagically to breakdown the different substrates. Thus, more nutrients are evolved and made readily available to the animal and thereby improving growth and economic efficiency. Rovabio Excel is available as a concentration powder that can be incorporated into premix formulations or as a 10 to 20% dilution for direct use by feed-mills. The enzyme activities in Rovabio are listed below.

Enzyme group	Enzyme name
Xylanases	Endo-1,4-ß-xylanase, ß-xylosidase
ß-Glucanase	Endo-1,3(4)-ß-glucanase, Laminarinase
Cellulases	Endo-1,4-ß-glucanase, cellobiohydrolase
Pectinases	pectinase, polygalacturonase
Proteases	Aspartic protease, metallo protease

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2.15 Effect of enzyme supplemented diets on broiler performance.

In a study conducted on broilers fed brewers' dried grain (BDG) based diets supplemented with maxigrain, birds performed significantly better than those on similar diets without enzyme supplementation (Bawa *et al*., 2010). Consequently, there was a reduction in cost per kilogram gain in weight. The significant difference in the final weight of birds across the dietary treatments showed the advantage of incorporating enzymes in the diet of broiler chickens. This could also be an indication of the superiority of BDG over maize offal. Enzyme supplementation in broiler diets as reported by Tuluen *et al.* (1991) and Agbede *et al.* (2002) enhanced feed intake. These authors reported that the use of exogenous enzymes complement the digestive enzymes of poultry

to enhance the digestion and utilization of non- starch polysaccharides (NSP) in cereals with overall increase in growth. Atteh (2002) and Adene (2004) also reported that there were improvements on the utilization of fibrous feed materials when broiler diets were supplemented with enzymes.

Generally, BDG based diets whether supplemented with enzymes or not promote faster weight gain than the maize offal based diets (Bawa *et al.*, 2010). Babatunde *et al.* (1975) had earlier noted that BDG being a fermentation product is rich in both the B-complex vitamin as well as in digestive energy and crude protein. There were higher rate of nutrient utilization when fibrous based diets were supplemented with exogenous enzymes (Atteh 2002, Agbede *et al.*, 2002 and Bawa *et al.*, 2010) thereby having better values for feed conversion ratio. Birds fed BDG supplemented with maxigrain had the least cost per kg weight gain. Ayaehie and Irole (2008) reported a significant increase in feed intake on birds fed enzyme supplemented brewers dried grains and the least feed intake was recorded on birds fed the control diet which had no enzyme supplementation and no significant difference was observed on weight gain, feed conversion ratio and dry matter digestibility. Atteh (2002) reported substantial savings in cost of raising starter broilers fed with maize offal supplemented with enzymes and there was no significant effect of treatment on mortality rate.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Location of the study.

The study was conducted at the Poultry Research Programme, National Animal Production Research Institute (NAPRI), Shika-Zaria. Shika is geographically located between latitude 11^0 and 12^0 and longitude 7^0 and 33^0E, at an altitude of 640m above the sea level (Google Earth, 2011). Shika is located about 20km along the Zaria -Sokoto road in the Northern Savannah zone of Nigeria.

3.2 Source and processing of sorghum brewer's waste.

Sorghum Brewer's Waste (SBW) was sourced from a local gin producer in Zaria, Kaduna state. It was further sun dried by spreading on a cement floor for 7days with regular turning to prevent moldiness. Thereafter samples were milled and taken for proximate analysis.

3.3 EXPERIMENT 1: The Effects of diets containing graded levels of Sorghum Brewer's Waste on the Performance, Carcass Characteristics and Nutrient Digestibility of Broiler Chickens.

3.3.1 Design, management of experimental birds and data collection.

A total of two hundred and twenty five one- week old broiler chicks (cross of Hubbard and Anak strains) from the National Animal Production Research Institute Zaria were used for the study which was divided into starter (1 -4 weeks) and finisher (5-8 weeks) phases. The mean weights for all the pens were approximately equal and recorded accordingly at the beginning of the experiment. Birds were thereafter fed diets containing the test ingredient (SBW) and were randomly allocated to five dietary treatments of 45 birds per treatment in a completely

randomized design. Each treatment was further sub divided into 3 replicates of 15 birds per pen. Birds were reared in a deep litter system with feed and water given *ad libitum*. Heat and light were provided throughout the brooding period, using kerosene stoves and electric bulbs. Birds were pooled together and fed the control diet for a week at the end of the starter phase before being randomly allocated to their various treatments for the finisher phase. At the finisher phase, same number of treatments and replications from the starter phase were used.

Drugs and routine vaccines against Newcastle and Gomboro diseases were given as follows, 1st dose of Gumboro vaccine at day 14, 1stdose of Lasota vaccine at day 21, 2nd dose of Gomboro at day 28 and the last dose of Lasota at day 35. Anti-stress in form of vitamin supplements was given to the birds subsequently and majorly after each vaccination. Growth performance parameters like the feed intake and weight gain were measured while feed conversion ratio was calculated. Mortalities were recorded as they occurred and percent mortality was calculated.

3.3.2 Experimental diets

Diets were formulated to meet standard requirements (NRC, 1994). Five experimental diets were formulated and the inclusion levels of sorghum brewer's waste (SBW) were 0, 10, 20, 30 and 40%, respectively. Tables 3.1 and 3.2 show the gross ingredient compositions of the starter and finisher diets, respectively and their corresponding determined analysis.

Table 3.1: Composition of broiler starter diets containing graded levels of sorghum brewer's waste (1-4 weeks).

	Graded levels of sorghum brewer's waste (%)				
Ingredients	**0**	**10**	**20**	**30**	**40**
Maize	55.70	51.60	47.55	43.35	38.25
Sorghum brewer's waste	0.00	10.00	20.00	30.00	40.00
Groundnut cake (46%)	20.00	17.00	14.00	11.00	9.00
Soybean meal (44%)	20.00	17.00	14.00	11.00	9.00
Bone meal	3.00	3.00	3.00	3.00	3.00
Limestone	0.50	0.50	0.50	0.50	0.50
Methionine	0.20	0.20	0.20	0.20	0.25
Lysine	0.10	0.20	0.25	0.40	0.50
Vitamin mineral Premix*	0.25	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25	0.25
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated Analysis (%)					
Crude Protein	23.29	23.29	23.28	23.28	23.27
Métabolisable Energy (kcal/kg)	2999	2981	2965	2949	2943
Ether Extract	3.67	3.66	3.66	3.67	3.69
Crude Fibre	3.39	3.45	3.51	3.55	4.06
Calcium	1.37	1.36	1.35	1.33	1.32
Available Phosphorus	0.84	0.79	0.75	0.70	0.66
Lysine	1.36	1.33	1.25	1.27	1.28
Methionine	1.30	1.30	1.30	1.30	1.30
Ca:P	1.63	1.72	1.80	1.90	2.00
Cost/kg(₦)	80.38	75.12	69.53	64.55	61.19
Determined analysis(%)					
Crude protein	23.20	23.27	23.29	23.38	23.39
Crude fibre	4.03	4.11	4.17	4.27	4.41
Ash	5.17	5.22	5.36	5.41	5.49
Ether Extract	3.21	3.29	3.38	3.39	3.45
Nitrogen Free Extract	59.37	59.01	58.80	58.60	58.21

**Bio-Mix broiler starter premix by Bio- organics (Nig.) Ltd supplied the following per kg of diet: Vit. A, 10,000 IU; Vit D_3, 2,000I.U; Vit E, 23,000mg; Vit K, 2,000mg; Calcium pantothenate, 7,500mg; Niacin, 27,500; Vit B_1(thiamine),1,800mg; Vit B_2(riboflavin),5,500mg; Vit B_6(pyridoxine),3,000mg; Vit B_{12},15mg; folic acid,750mg; Biotin, 60; choline chloride, 300,000mg; Manganese,20,000mg; Iron,1,000mg; Zinc,200mg; Copper,3.0mg; Iodine,3,000mg; Cobalt,200mg; Selenium,40,000mg; antioxidant,1,250mg. Ca:P, calcium phosphorus ratio.*

Table3.2: Composition of broiler finisher diets containing graded levels of sorghum brewer's waste (5-8 weeks).

	Graded levels of sorghum brewer's waste (%)				
Ingredients	**0**	**10**	**20**	**30**	**40**
Maize	56.55	51.45	45.35	42.25	40.25
Sorghum brewer's waste	0.00	10.00	20.00	30.00	40.00
Maize offal	9.00	9.00	11.00	10.00	7.00
Groundnut cake (46%)	16.00	13.00	10.00	7.00	4.00
Soybean meal (44%)	14.00	12.00	9.00	6.00	4.00
Bone meal	3.00	3.00	3.00	3.00	3.00
Limestone	0.40	0.40	0.40	0.40	0.40
Methionine	0.25	0.25	0.25	0.25	0.25
Lysine	0.20	0.30	0.40	0.50	0.50
Vitamin mineral Premix*	0.30	0.30	0.30	0.30	0.30
Salt	0.30	0.30	0.30	0.30	0.30
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated Analysis (%)					
Crude Protein	20.00	20.01	20.01	20.02	20.02
Metabolisable Energy (kcal/kg)	3097	3097	3096	3094	3094
Ether Extract	4.46	4.44	4.30	4.30	4.30
Crude Fibre	4.60	4.66	4.68	4.72	4.75
Calcium	2.58	2.52	2.53	2.52	2.51
Available Phosphorus	0.78	0.68	0.63	0.64	0.61
Lysine	1.22	1.22	1.21	1.22	1.22
Methionine	0.83	0.83	0.82	0.81	0.80
Ca:P	3.33	3.70	3.99	3.92	4.14
Cost/ kg(₦)	76.79	71.97	66.30	61.24	59.89
Determined analysis (%)					
Crude protein	20.06	20.08	20.10	20.10	20.13
Crude fibre	4.38	4.45	4.49	4.54	4.55
Ash	5.14	5.22	5.29	5.32	5.43
Ether Extract	6.27	6.48	6.50	6.53	7.01
Nitrogen Free Extract	59.10	58.72	58.57	58.46	57.88

**Bio-Mix broiler finisher premix by Bio- organics (Nig.) Ltd supplied the following per kg of diet: Vit. A, 8,500,000 IU; Vit D_3, 1,500,000I.U; Vit E, 10,000mg; Vit K, 1,500mg; Calcium pantothenate, 5,000mg; Vit B_1(thiamine),1,600mg; Vit B_2(riboflavin),4,000mg; Niacin, 20,000mg; Vit B_6(pyridoxine),1,500mg; Vit B_{12},10mg; folic acid,500mg; Biotin H_2, 750mg; choline chloride, 175,000mg; Manganese,40,000mg; Iron,20,000mg; Zinc,30,000mg; Copper,3,000mg; Iodine,1,000mg; Cobalt,200mg; Selenium,200mg; antioxidant,1,250mg. Ca:P, calcium phosphorus ratio.*

3.3.3 Digestibility Studies

A digestibility trial was carried out for 7 days at the end of the finisher trial. Three birds per treatment making a total of 15 birds in all were selected on the basis of their average live weights and kept in individual metabolic cages for faecal collection. The first 3days were used as the adjustment period for the selected birds. The birds were fed the control diet throughout the adjustment period. After this, birds were fasted for 24hours and then introduced to the experimental diets. Known weights of feed were supplied to the birds daily and water given *ad libitum*. Faecal droppings per bird were collected in the receptacle below the cages, kept in polythene bags and labeled on daily basis as adopted by Ayanwale and Aya (2006).

Droppings of each bird were weighed, sun dried at subsequent collections and bulked at the end of the collection. They were further oven dried at 70^{o}C till constant weight and milled. Faecal samples were analyzed for proximate composition according to the procedure described by AOAC (1995). Digestibility of nutrients on the experimental diets was determined using the formula:

Apparent digestibility of nutrient (%)

$$= \frac{\text{nutrient intake (g)} - \text{nutrient in faeces (g)}}{\text{Nutrient intake}} \times 100$$

Where: Nutrient intake (g) = feed consumed (g) × % Nutrient in feed

Nutrient in faeces (g) = faecal sample (g) × % Nutrient in faeces

3.3.4 Carcass Evaluation

Carcass evaluation was done at the end of the finisher phase (8weeks). Three (3) birds from each treatment were selected based on the average group body weights. The birds were deprived of

feed overnight, but given water *ad libitum*, thereafter, weighed using a 5kg scale with a precision of 0.005. They were then sacrificed by a ventral neck cut with a sharp knife.

Birds were thoroughly bled and weighed. Thereafter, they were manually de-feathered by scalding in hot water. De- feathered birds were weighed, labeled and eviscerated with the head, neck, shank and viscera removed to obtain the dressed weight. The weights of primal cuts such as thigh, breast, wing, back and drumstick, weights of organs such as heart, gizzard, spleen, intestines and liver were taken and expressed as percentages of the dressed weight.

3.4 EXPERIMENT 2: The Effects of the optimum level of Sorghum Brewer's Waste with enzyme supplementation on the Performance, Carcass Characteristics and Nutrient Digestibility of Broiler Chickens.

3.4.1 Design, management of experimental birds and data collection.

The design, management of experimental birds and data collection were as described in Experiment 1.

3.4.2 Experimental diets

Five experimental diets were formulated. The optimum level of SBW calculated in experiment 1 was predicted to be 33.33% using a regression analysis, with the feed cost per kg gain of birds at its finisher phase as the parameter used, with this equation:

$Y = -b/2c$

Where Y= The optimum value of SBW (dependent variable)

b = regression coefficient c = constant

Thus, diets in this phase of the study using Rovabio® multi –enzyme at 0.01% were as follows.

Treatment1 (control diet; 0%SBWwith enzyme at 0.01%),

Treatment2 (30%SBW with enzyme at 0.01%)

Treatment3 (35% SBW with enzyme at 0.01%)

Treatment4 (40% SBW with enzyme at 0.01%)

Treatment5 (45% SBW with enzyme at 0.01%)

Tables 3.3 and 3.4 show the compositions of the starter and finisher diets, respectively with their corresponding determined analysis.

3.4.3 Digestibility Studies

The procedures adopted for the digestibility studies in this study were similar to the procedures described in Experiment 1.

3.4.4 Carcass Evaluation

The procedures adopted for the carcass evaluation in this study were similar to the procedures described in Experiment 1.

3.4.5 Chemical Analysis

The procedures adopted for the chemical analysis in this study were similar to the procedures described in Experiment 1.

3.4.6 Laboratory Analysis.

Representative samples of dried sorghum brewer's waste (SBW), experimental diets and feaces were collected, properly labeled and taken to the Central Laboratory Service Unit of the National Animal Production Research Institute, Ahmadu Bello University, Zaria. The proximate composition for Dry matter (%DM), Crude protein (%CP), crude fibre (%CF), Ether extract (%EE), Ash (%Ash) and Nitrogen free extract (%NFE) were determined according to A.O.A.C (1995) methods. The analysis was done in triplicate.

Twenty grams of the samples were put into an oven at 100^{o}C for 24hours. The %DM was then determined based on weight loss. Macro Kjeldahl method of A.O.A.C. (1995) was used to determine the nitrogen (N) content as stated below;

$$N = \frac{0.02 \times 14.01 \times T}{\text{Sample weight}}$$

Where,

Crude protein = N × 6.25

0.02 = Normality of acid

14.01 = Constant value for ammonia

T = Titre value

The ash content was determined as the residue remaining after incinerating the samples at 600^{o}C for 3 hours in a muffle furnace. The nitrogen free extract on dry matter basis was calculated using the formula: NFE= 100- (%CP + %CF + %Ash + %EE)

The energy value of LSBW was determined using the formula as described by Pauzenga (1985).

ME = 37 ×%CP + 81.8 ×%EE +35× %NFE

Table 3.3: Composition of broiler starter diets containing different levels of sorghum brewer's waste supplemented with Rovabio® enzyme.

	Levels of sorghum brewer's waste (%)				
Ingredients	**0**	**30**	**35**	**40**	**45**
Maize	55.70	43.40	41.00	38.25	36.20
Sorghum brewer's waste	0.00	30.00	35.00	40.00	45.00
Soybean meal (44%)	20.00	11.00	9.35	9.00	8.00
Groundnut cake (46%)	20.00	11.00	10.00	8.00	6.00
Bone meal	3.00	3.00	3.00	3.00	3.00
Limestone	0.50	0.50	0.50	0.50	0.50
Methionine	0.20	0.20	0.25	0.25	0.30
Lysine	0.10	0.40	0.40	0.50	0.50
Vitamin mineral Premix*	0.25	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25	0.25
Enzyme	0.01	0.01	0.01	0.01	0.01
Total	**100**	**100**	**100**	**100**	**100**
Calculated Analysis (%)					
Crude protein	23.29	23.29	23.29	23.29	23.28
Metabolisable Energy (Kcal/kg)	2996	2996	2994	2999	2991
Crude Fibre	5.39	5.42	5.48	5.56	5.62
Ether Extract	3.48	3.59	3.59	3.64	3.69
Available Phosphorus	0.64	0.64	0.63	0.63	0.63
Calcium	1.21	1.22	1.22	1.22	1.23
Methionine	0.90	0.90	0.90	0.91	0.91
Lysine	1.30	1.30	1.30	1.30	1.30
Ca:P	1.90	1.91	1.94	1.94	1.95
Cost/kg (₦)	81.03	65.24	62.91	61.04	58.86
Determined analysis					
Crude Protein	23.30	23.30	23.31	23.31	23.30
Crude fibre	4.35	4.38	4.45	4.49	4.58
Ash	5.33	5.28	5.27	5.27	5.16
Ether Extract	3.26	3.51	4.03	4.19	4.29
Nitrogen Free Extract	58.76	53.53	57.94	57.74	57.67

**Bio-Mix broiler starter premix by Bio- organics (Nig.) Ltd supplied the following per kg of diet: Vit. A, 10,000 IU; Vit D_3, 2,000I.U; Vit E, 23,000mg; Vit K, 2,000mg; Calcium pantothenate, 7,500mg; Niacin, 27,500; Vit B_1(thiamine),1,800mg; Vit B_2(riboflavin),5,500mg; Vit B_6(pyridoxine),3,000mg; Vit B_{12},15mg; folic acid,750mg; Biotin, 60; choline chloride, 300,000mg; Manganese,20,000mg; Iron,1,000mg; Zinc,200mg; Copper,3.0mg; Iodine,3,000mg; Cobalt,200mg; Selenium,40,000mg; antioxidant,1,250mg.. Ca:P, calcium phosphorus ratio.*

Table 3.4: Composition of broiler finisher diets containing different levels of sorghum brewer's waste supplemented with Rovabio® enzyme.

	Levels of sorghum brewer's waste (%)				
Ingredients	**0**	**30**	**35**	**40**	**45**
Maize	56.55	42.25	41.25	40.25	37.20
Sorghum brewer's waste	0.00	30.00	35.00	40.00	45.00
Soybean meal (44%)	14.00	6.00	5.00	4.00	2.00
Groundnut cake (46%)	16.00	7.00	6.00	4.00	3.00
Maize offal	9.00	10.00	8.00	7.00	8.00
Bone meal	3.00	3.00	3.00	3.00	3.00
Limestone	0.40	0.40	0.40	0.40	0.40
Methionine	0.25	0.25	0.25	0.25	0.25
Lysine	0.20	0.50	0.50	0.50	0.55
Vitamin mineral Premix*	0.30	0.30	0.30	0.30	0.30
Salt	0.30	0.30	0.30	0.30	0.30
Enzyme	0.01	0.01	0.01	0.01	0.01
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated Analysis (%)					
Crude protein	20.00	20.00	20.03	20.03	20.02
Metabolisable Energy (Kcal/kg)	3089	3089	3088	3087	3080
Crude Fibre	4.58	5.62	5.65	6.71	6.84
Ether Extract	5.46	5.31	4.98	4.87	4.85
Available Phosphorus	0.66	0.65	0.66	0.67	0.68
Calcium	1.28	1.29	1.28	1.27	1.29
Methionine	0.83	0.83	0.83	0.82	0.83
Lysine	1.22	1.22	1.22	1.22	1.21
Ca:P	1.94	1.98	1.94	1.89	1.90
Cost/kg (₦)	77.44	61.89	59.64	57.04	54.06
Determined analysis					
Crude Protein	20.03	20.04	20.03	20.02	20.02
Crude fibre	5.02	5.23	6.37	6.48	6.67
Ash	5.19	5.22	5.43	5.44	5.58
Ether Extract	6.03	6.15	6.21	7.07	7.24
Nitrogen Free Extract	58.63	58.36	56.96	56.99	55.49

**Bio-Mix broiler finisher premix by Bio- organics (Nig.) Ltd supplied the following per kg of diet: Vit. A, 8,500,000 IU; Vit D_3, 1,500,000I.U; Vit E, 10,000mg; Vit K, 1,500mg; Calcium pantothenate, 5,000mg; Vit B_1(thiamine),1,600mg; Vit B_2(riboflavin),4,000mg; Niacin, 20,000mg; Vit B_6(pyridoxine),1,500mg; Vit B_{12},10mg; folic acid,500mg; Biotin H_2, 750mg; choline chloride, 175,000mg; Manganese,40,000mg; Iron,20,000mg; Zinc,30,000mg; Copper,3,000mg; Iodine,1,000mg; Cobalt,200mg; Selenium,200mg; antioxidant,1,250mg. Ca:P, calcium phosphorus ratio.*

3.4.7 Statistical Analysis

All data generated on growth performance, nutrient digestibility and carcass characteristics were subjected to analysis of variance using a General Linear Model procedure for statistical analysis SAS (2001), while Duncan's Multiple Range Test (Duncan, 1955) was used to separate significant means. Regression analysis was used to determine the optimal level of inclusion of sorghum brewers' waste in broiler diets. The statistical model used was:

$Y_{ij} = \mu + G_i + e_{ij}$

Where:

Y_{ij}= the j^{th} observation of the i^{th} LSBW level

μ= the overall estimate of the population mean

G_i = the effect of the i^{th} LSBW level

e_{ij} = the random error

CHAPTER FOUR

4.0 RESULTS

4.1 Nutrient composition of sorghum brewer's waste.

The result of the chemical analysis of sorghum brewer's waste (SBW) is presented in Table 4.1. The dry matter content was 95.28%, crude protein 31.28%, crude fibre 15.81%, Ash content 6.88%, ether extract and Nitrogen free extract contents were 13.78% and 27.53%, respectively. The Metabolisable energy was calculated as 3,213.31kcal/kg.

4.2 The Effects of Sorghum Brewer's Waste (SBW) diets on the Performance, Carcass Characteristics and Nutrient Digestibility of Broiler Chickens.

4.2.1 Experiment 1: The Starter Phase (1-4weeks)

The performance characteristics of broiler starter chicks fed diets containing graded levels of SBW are presented in Table 4.2. Final weight, average feed intake, average weight gain, feed conversion ratio, feed cost per kg gain and mortality rate were not significantly ($P>0.05$) affected by the dietary treatments. The final weight, average gain and feed conversion were numerically better on birds fed the control diet though no significant difference was recorded. Feed cost per kilogram gain was cheaper on birds fed 40% SBW compared with those on the control diet. The control diet was more expensive than the other diets as earlier indicated on the feed composition table (Table 3.1) and here. The % change in feed cost/kg gain for birds on the test ingredient was significantly ($P<0.05$) better than the control. The 40% SBW was the best having the highest % change.

Table 4.1: Proximate Composition of Sorghum Brewer's Waste.

Parameters (%)	%Composition
Crude Protein	31.28
Crude fibre	15.81
Ash	6.88
Ether Extract	13.78
Nitrogen Free Extract	27.53

Table 4.2: Performance of broiler starter (1-4weeks) chicks fed graded levels of sorghum brewer's waste based diets.

	Graded levels of sorghum brewer's waste (%)						
Parameters	**0**	**10**	**20**	**30**	**40**	**SEM**	**LOS**
Initial weight (g)	73.00	73.00	73.00	73.00	73.00	0.00	NS
Final weight (g)	426.76	411.76	410.35	404.61	398.2	25.94	NS
Av. daily feed intake (g)	36.96	38.08	39.50	39.88	40.08	9.35	NS
Av. daily gain (g)	23.58	22.58	22.49	22.11	21.68	12.44	NS
Feed conversion ratio	1.57	1.69	1.76	1.80	1.85	0.58	NS
Feed cost/kg gain(₦)	126.20	126.95	122.37	116.19	113.20	19.49	NS
% change in feed cost/kg feed	0^{c}	6.54^{b}	13.50^{ab}	19.70^{a}	23.43^{a}	2.98	*
Mortality (%)	4.28	4.37	4.49	4.83	5.33	1.13	NS

SEM: Standard error of the means.
LOS: Level of significant.
NS: Not significant
Av: average
Cost on feed was calculated base on the price of ingredients as at February 2013

4.2.2. The Finisher Phase (5-8 weeks).

The results on the growth performance of birds fed diets containing graded levels of SBW are presented in Table 4.3. Final weight, average daily gain, feed conversion ratio and % change in feed cost/kg gain were significantly ($P<0.05$) affected by dietary treatments. Final weight was significantly higher ($P<0.05$) in the group fed 0% SBW (1750g) and similar to treatments with 10, 20 and 30% SBW, while birds fed 40% SBW had the least final weight (1572.22g). Average daily gain generally decreased as the levels of sorghum brewers' waste increased in the diets and the control was significantly ($P<0.05$) better compared to the 40% SBW diet. Birds on the control diet had the best feed conversion ratio (2.08) which was similar (2.18) to the value obtained on birds fed 40% SBW. Similar to results obtained during the starter phase, the % change in feed cost/kg gain for sorghum brewer waste were significantly ($p<0.05$) better than the control. The 40% SBW was best and similar to the 30% level. The feed cost/kg feed for birds fed the control diet was more expensive than those on other treatments as earlier indicated on the finisher feed composition table (table 3.2). Dietary treatments however had no significant ($P>0.05$) effect on the average daily feed intake, feed cost per kilogram gain and mortality of the birds.

4.2.3 Apparent nutrient digestibility of broiler chickens fed diets containing graded levels of Sorghum Brewer's Waste.

The nutrient digestibility of broilers fed graded levels of sorghum brewers' waste is presented on Table 4.4. The crude protein, crude fibre and nitrogen free extract digestibility were significantly ($P<0.05$) affected by the dietary treatments. Crude protein and crude fibre apparent digestibility were similar for Treatments 1-4 but significantly lower for Treatment 5. The nitrogen free extract digestibility was similar for control to 20% SBW level but significantly different from those fed 30 and 40% SBW. Ether extract and ash retentions were not affected by the dietary treatments.

Table 4.3: Performance of broiler finishers (5-8weeks) fed graded levels of sorghum brewer's waste based diets.

	Graded levels of sorghum brewer's waste (%)						
Parameters	**0**	**10**	**20**	**30**	**40**	**SEM**	**LOS**
Initial weight(g)	666.7	666.7	666.7	666.7	666.7	0.00	NS
Final weight(g)	1750^{a}	1643.33^{ab}	1625^{ab}	1641.67^{ab}	1572.22^{b}	7.86	*
Av. Daily feed intake (g)	150.00	150.03	150.78	150.98	151.39	23.35	NS
Av. Daily gain(g)	72.22^{a}	65.11^{ab}	63.89^{ab}	65.00^{ab}	60.37^{b}	8.63	*
Feed conversion ratio	2.08^{a}	2.30^{b}	2.36^{b}	2.32^{b}	2.18^{ab}	0.98	*
Feed cost/kg gain(~~₦~~)	159.72	165.53	156.47	142.08	130.56	33.60	NS
% change in cost/kg feed	0^{d}	6.28^{c}	13.66^{b}	20.25^{ab}	22.01^{a}	0.39	*
Mortality (%)	0.00	0.00	0.00	0.00	0.00	0.00	NS

^{abc}: Means on the same row with different superscripts differ significantly ($p<0.05$)
NS: Not significant ($p>0.05$)
SEM: Standard error of means
LOS: Level of significance
*= $p<0.05$
Av: average

Table 4.4: Apparent nutrient digestibility of broiler chickens fed diets containing graded levels of Sorghum Brewer's Waste (SBW).

	Graded levels of SBW (%)						
Parameters	**0**	**10**	**20**	**30**	**40**	**SEM**	**LOS**
Crude Protein	82.79[a]	82.15[a]	82.63[a]	80.58[ab]	76.71[b]	0.11	*
Crude Fibre	58.94[a]	58.90[a]	58.88[a]	55.24[ab]	47.01[b]	0.25	*
Ether Extract	80.20	80.15	79.67	79.68	79.22	0.75	NS
Ash	64.44	64.52	63.91	63.87	63.81	0.39	NS
Nitrogen free Extract	86.96[a]	86.79[a]	84.39[ab]	81.66[b]	72.11[c]	0.32	*

[abc]: Means on the same row with different superscripts differ significantly ($p<0.05$)
NS: Not significant ($p>0.05$)
SEM: Standard error of means
LOS: Level of significance
*= $p<0.05$

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4.2.4 Effects of graded levels of Sorghum Brewer's Waste (SBW) diets on Carcass Characteristics of Broiler chickens

The results of the carcass study of broiler finisher chickens fed graded levels of SBW are shown in Table 4.5. Live weight, dressed weight, dressing percentage, breast, thigh, back, gizzard, liver, intestinal weight and length were significantly ($P<0.05$) affected by the dietary treatments. Birds fed dietary levels of 30 and 40% SBW gave the highest values of breast, thigh, back, gizzard, liver, intestinal weight and intestinal length. The percent wing, drumstick, heart and spleen of the birds were not significantly ($P>0.05$) affected by the dietary treatments.

4.3. Effects of SBW diets with Rovabio® enzyme supplementation on the performance, carcass characteristics and nutrient digestibility on broiler chickens

4.3.1 The Starter Phase (1-4weeks).

The result on the growth performance of broiler starter chicks fed diets containing different levels of SBW supplemented with Rovabio® enzyme is presented in Table 4.6. The average daily feed intake, feed cost per kilogram gain and % change in feed cost/kg gain were significantly ($P<0.05$) affected by enzyme supplementation. Birds fed 40% SBW based diet consumed more feed and was similar to those fed the highest inclusion level (45%) of SBW**.** Birds fed the 35 and 45% level of SBW were cheaper to feed than those on the other treatments. The control feed was consistently more costly than the other feed as earlier indicated on Table 3.3.. The % change in cost/kg feed for birds fed 45% SBW was significantly ($P<0.05$) higher than those fed other treatments. Final weight, average gain, feed conversion ratio and mortality rate were not significantly ($P>0.05$) affected by enzyme supplementation.

Table 4.5: Effects of graded levels of Sorghum Brewer's Waste diets on Carcass Characteristics of Broiler chickens.

	Graded levels of SBW (%)						
Parameters	**0**	**10**	**20**	**30**	**40**	**SEM**	**LOS**
Live weight (g)	1720[a]	1642[b]	1615[bc]	1630[bc]	1560[c]	3.27	*
Dressed weight(g)	1303.76[a]	1225.58[b]	1198.17[b]	1116.39[c]	1071.41[c]	64.10	*
Dressing (%)	75.80[a]	74.64[b]	74.19[b]	68.49[c]	68.68[c]	7.68	*
Primal cuts expressed as percentage dressed weight							
Breast	22.00[d]	22.57[d]	24.36[c]	28.49[a]	25.90[b]	3.14	*
Wings	11.41	11.04	12.39	11.45	11.51	0.43	NS
Thigh	12.41[c]	13.85[b]	14.15[b]	15.45[ab]	15.61[a]	0.55	*
Drumsticks	12.73	12.33	12.37	12.79	12.42	0.43	NS
Back	21.09[b]	22.37[ab]	22.84[ab]	24.35[a]	24.15[a]	1.27	*
Organs expressed as percentage dressed weight							
Heart	0.71	0.67	0.82	0.78	0.84	0.22	NS
Spleen	0.17	0.13	0.16	0.17	0.12	0.08	NS
Gizzard	2.69[c]	3.08[b]	3.33[ab]	4.13[a]	4.08[a]	0.23	*
Liver	2.49[bc]	2.67 [b]	2.85[b]	3.12[a]	3.09[a]	0.22	*
Intestinal weight	4.21[c]	4.39[c]	4.46[b]	4.80[a]	5.34[a]	0.26	*
Intestinal length(cm)	2.10[c]	2.69[c]	3.17[b]	3.57[ab]	3.80[a]	0.25	*

[abc]: Means on the same row with different superscripts differ significantly ($p<0.05$)
SEM: Standard error of means
SBW: sorghum brewers waste
LOS : level of significance

Table 4.6: Performance of broiler starter chicks (1-4weeks) fed different levels of Sorghum Brewer's Waste with Rovabio® enzyme supplementation.

	Levels of SBW (%)						
PARAMETERS	**0**	**30**	**35**	**40**	**45**	**SEM**	**LOS**
Initial weight (g)	80.00	80.00	80.00	80.00	80.00	0	NS
Final weight (g)	430.66	432.73	441.18	439.26	434.78	89.11	NS
Av daily feed intake (g)	40.89^{b}	41.25^{b}	41.76^{b}	45.83^{a}	43.75^{ab}	5.24	*
Av daily gain(g)	16.70	16.80	17.20	17.11	16.90	35.12	NS
Feed conversion ratio	2.45	2.46	2.43	2.68	2.59	0.32	NS
Feed cost/kg gain (₦)	141.00^{c}	114.17^{b}	108.83^{a}	116.58^{b}	108.89^{a}	5.43	*
% change in cost/kg feed	0^{d}	19.49^{c}	22.36^{b}	24.67^{b}	27.36^{a}	0.21	*
Mortality(%)	4.20	4.44	5.11	5.07	5.63	2.99	NS

^{abc}: Means on the same row with different superscripts differ significantly ($p<0.05$)
NS: Not significant ($p>0.05$)
SEM: Standard error of means
LOS: Level of significance
*= $p<0.05$
Av: average
Cost on feed was calculated base on the price of ingredients as at February 2013

4.3.2 The Finisher Phase (5-8 weeks).

The result of the growth performance of finishing birds fed diets containing different levels of SBW supplemented with enzyme is presented in Table 4.7. The average daily feed intake, feed conversion ratio, feed cost per kilogram gain and % change in cost/kg gain were significantly ($P<0.05$) affected by enzyme inclusion in the dietary treatments. Average feed intake was highest on birds fed 0% (139.90g) and 30% (139.28g) and was similar to those fed 35% SBW (134.17g). The feed conversion ratio was best with birds fed 40% SBW (3.00) and similar to those fed 45% SBW (3.12). Birds fed 40 and 45% SBW recorded the least feed cost per kilogram gain while those fed the control diet were the most costly to produce. The control diet was the most costly as earlier shown on Table 3.4. The % savings in feed cost/kg feed of birds on 45% against the control was significantly ($P<0.05$) higher than those on the other treatments.

4.3.3 Apparent nutrient digestibility of broiler chickens fed Sorghum Brewer's Waste based diets with Rovabio® enzyme supplementation.

The nutrient retention of broilers fed different levels of sorghum brewers' waste at 0, 30, 35, 40 and 45% supplemented with Rovabio® multi-enzyme is presented in Table 4.8.The crude protein, crude fibre, ash and nitrogen free extract retention were significantly ($P<0.05$) affected by enzyme supplementation. Crude protein retention was significantly ($P<0.05$) higher in birds fed 0, 30 and 35% SBW+ enzyme, respectively. Crude fibre retention increased in birds fed diets up to 35% and was similar to those fed 40% SBW. The digestibility of ash was highest on birds fed the control diet and was similar to those fed between 30 and 40% SBW. Nitrogen free extract digestibility significantly ($P<0.05$) declined as the level of SBW increased in the diets. Dietary treatments however, had no significant ($P>0.05$) effect on the ether extract digestibility.

Table 4.7: Performance characteristics of finishing broilers (5-8weeks) fed different levels of Sorghum Brewer's Waste with Rovabio® enzyme supplementation.

	Levels of SBW (%)						
Parameters	**0**	**30**	**35**	**40**	**45**	**SEM**	**LOS**
Initial weight (g)	784.60	784.60	784.60	784.60	784.60	0	NS
Final weight (g)	1538.46	1583.90	1493.46	1629.87	1606.54	189.98	NS
Av daily feed intake (g)	139.90^{a}	139.28^{a}	134.17^{ab}	120.90^{b}	122.14^{b}	4.28	*
Av daily gain (g)	35.90	36.06	33.76	39.25	39.14	35.16	NS
Feed conversion ratio	3.89^{c}	3.66^{b}	3.97^{c}	3.00^{a}	3.12^{ab}	0.11	*
Feed cost/kg gain (₦)	299.22^{c}	171.44^{b}	150.30^{b}	122.64^{a}	117.85^{a}	3.26	*
% change in cost/kg feed	0^{d}	20.08^{dc}	22.99^{c}	26.34^{b}	30.19^{a}	1.23	*
Mortality (%)	3.10	2.98	3.12	3.11	3.09	2.99	NS

^{abc}: Means on the same row with different superscripts differ significantly ($p<0.05$)
NS: Not significant ($p>0.05$)
SEM: Standard error of means
LOS: Level of significance
*= $p<0.05$
Av: average
Cost on feed was calculated base on the price of ingredients as at February 2013

Table 4.8: Apparent nutrient digestibility of broiler chickens fed diets containing different levels of Sorghum Brewer's Waste with enzyme supplementation.

	Levels of SBW (%)						
Parameters	**0**	**30**	**35**	**40**	**45**	**SEM**	**LOS**
Crude Protein	88.48[a]	88.51[a]	88.76[a]	84.35[b]	84.33[b]	1.39	*
Crude Fibre	66.44[a]	66.68[a]	66.71[a]	64.73[ab]	59.61[b]	0.42	*
Ether Extract	80.45	80.92	80.73	79.56	79.54	1.35	NS
Ash	79.35[a]	77.42[ab]	77.39[ab]	77.61[ab]	70.55[b]	0.63	*
Nitrogen free extract	92.47[a]	92.45[a]	88.12[ab]	83.73[b]	76.62[c]	0.47	*

[abc]: Means on the same row with different superscripts differ significantly ($p<0.05$)
SBW= sorghum brewer's waste
NS: Not significant ($p>0.05$)
SEM: Standard error of means
LOS: Level of significance
*= $p<0.05$

4.3.4 Effects of Sorghum Brewer's Waste (SBW) diets with enzyme supplementation on Carcass Characteristics of Broiler chickens.

The result of the carcass study of finishing broiler chickens fed different levels of SBW supplemented with Rovabio® enzyme is shown in Table 4.9. Dietary treatments supplemented with enzymes had significant ($P<0.05$) effects on the breast, wing, thigh, back, gizzard and liver. Significant ($P>0.05$) effects were not observed on the live weight, dressed weight, dressing percentage, drumstick, heart, spleen, intestinal length and weight of the birds.

The percentage breast, wings, gizzard and liver of birds fed up to 45% SBW were significantly higher when compared with those on the control diet.

Table 4.9: Effects of different levels of Sorghum Brewer's Waste diets supplemented with Rovabio® enzyme on Carcass Characteristics of Broiler chickens

	Levels of SBW (%)						
Parameters	**0**	**30**	**35**	**40**	**45**	**SEM**	**LOS**
Live weight (g)	1550	1600	1500	1590	1590	102.99	NS
Dressed weight (g)	1135	1189	1194	1250	1256	22.25	NS
Dressing (%)	73.23	74.31	79.60	78.62	79.00	50.11	NS
Primal cuts	expressed	as	percentage	dressed	weight		
Breast	17.78^{b}	22.26^{ab}	23.50^{ab}	24.71^{ab}	28.88^{a}	4.32	*
Wings	10.14^{b}	11.31^{ab}	8.81^{c}	11.58^{ab}	12.96^{a}	0.17	*
Thigh	13.12^{ab}	12.21^{b}	13.20^{ab}	15.09^{a}	15.17^{a}	0.18	*
Drumsticks	13.15	13.11	13.47	13.15	14.09	0.56	NS
Back	21.01^{ab}	20.73^{ab}	23.15^{a}	19.98^{ab}	17.67^{b}	0.21	*
Organs expressed	as	percentage	dressed	weight			
Heart	0.83	1.03	0.80	0.76	0.90	0.09	NS
Spleen	0.16	0.17	0.23	0.16	0.19	0.05	NS
Gizzard	2.34^{b}	2.74^{ab}	2.77^{ab}	3.60^{a}	3.71^{a}	0.11	*
Liver	2.50^{c}	3.86^{ab}	3.98^{ab}	3.90^{ab}	4.21^{a}	0.54	*
Intestinal weight	3.11	3.14	3.13	3.21	3.25	0.91	NS
Intestinal length(cm)	2.94	2.25	2.45	2.47	2.78	0.80	NS

^{abc}: Means on the same row with different superscripts differ significantly ($p<0.05$)
SEM: Standard error of means
SBW: sorghum brewers waste
LOS: level of significance.

CHAPTER FIVE

5.0 DISCUSSION

5.1 Proximate composition of sorghum brewer's waste (SBW).

The value of dry matter obtained for SBW in this study was within the range reported for barley based brewers dried grain (Babatunde *et al.*,1975 ; Bello *et al.*,1984 ; Alawa *et al*., 1988 ; Udedibie and Emanalom 1993 ; Lufadeju *et al.*,1996; Adama and Ribadu 2003 and Olorunnisomo *et al*., 2006). The slight difference in the value obtained in this study and those from other researchers could be due to variations in the moisture content of the by- product before dry matter determination. The value of crude protein obtained from this study was higher than the values reported by Dogari (1985) for sorghum beer residue. However, these values were similar to those obtained by Abdulmalik (1997) for sorghum beer residue and Adama *et al.* (2007). It was also slightly similar to the values reported for barley- based brewers dried grain and maize/ sorghum based brewers dried grains obtained by Babatunde *et al.* (1975) and Udedibie and Emanalom (1993), respectively. The differences in these values can be as a result of the concentration of protein in the residue after the extraction of starch due to fermentation and microbial growth.

The crude fibre value of sorghum brewers waste was higher and therefore in contrast to the values reported by Udedibie and Emanalom (1993) and Adama *et al.* (2007) but lower than the values reported for barley based brewers dried grains by Alawa *et al.* (1988) and Olomu (1998). The crude fibre result confirms that SBW is high in fibre which will likely have a detrimental effect on the performance of monogastric animals if fed at very high levels. The higher crude fibre value of SBW observed in this study was probably due to a high concentration of the fibrous testa in the residue after the removal of starch.

The ash value obtained was found to be higher than the values reported by Babatunde *et al*. (1975), Abdulmalik (1997) and Olomu (1998) for sorghum beer residue. However, the value obtained was lower than the values reported by Udedibie and Emanalom (1993) and Adama *et al.* (2007). The value of ether extract obtained from this study was found to be higher than the values reported for maize/ sorghum based brewer's dried grains by Udedibie and Emanalom (1993), but similar to the reports of Adama *et al.* (2007). The differences in the values of ether extract from various researches can be due to the variations in cereal grains used, the method and degree of accuracy of laboratory techniques used for the analyses. When maize grit is used, the germ containing most of the fat is removed. Sorghum grain on the other hand according to Udedibie and Emanalom (1993) was used without removing the testa and germ containing fat. The process of fermentation reduced the carbohydrate component while the fat content was increased. The nitrogen free extract obtained was similar to the values of Yunis and Cahaner (1999) and Adama *et al*. (2007).The metabolizable energy content obtained in this study was not in agreement with the values reported for maize/ sorghum brewers' grain and sorghum beer residue by Udedibie and Emanalom (1993) and Abdulmalik (1997), respectively.

5.2 Experiment 1: The Effects of graded levels of Sorghum Brewer's Waste (SBW) diets on the Performance, Carcass Characteristics and Nutrient Digestibility of Broiler Chickens.

5.2.1 The broiler starter phase (1-4 weeks)

Final weight, average daily feed intake, average daily gain, feed conversion ratio, feed cost per kg gain and mortality were not significantly ($P>0.05$) affected by the dietary treatments. The overall result showed that SBW up to 40% in broiler starter diets was accepted by broiler chicks. This was in consonance with the findings of Olomu (1984) who reported that broiler chicks can tolerate up to 37% BDG without adverse effects. Onwudike (1983) reported that feeding diets

containing 30% BDG did not affect growth parameters of broiler chickens. Deltoro and Fernandez (1981) also suggested up to 40% BDG to broiler chickens from 0 to 12 weeks of age without any effect on feed intake.

5.2.2 The broiler finisher phase (5-8 weeks)

The significant ($P<0.05$) decrease in performance observed for final weight, average daily gain and feed conversion with increasing SBW levels in the diets at the finisher phase agreed with the findings of Ojewola and Longe (1997) and Chand (2007) who reported that brewers dried grain inclusion in the diet led to decrease in body weight, weight gains of birds and poorer feed conversion ratio. The relatively poor performance in these growth parameters observed in birds fed T5 which contained 40% SBW was indicative of the detrimental effect of inclusion of high level of fibrous feed ingredients in broiler diets

There was no significant ($P>0.05$) difference in average daily feed intake across the treatments. This result was similar to the findings of Esonu (2008); Hamid and El Zubeir (1990) and Kulh (1998) who reported non- significant higher feed intakes for high spent grain based diets compared with those containing low inclusions of spent grains. Supplementation of broiler diets with medium energy and protein products such as SBW is a practical approach for reducing the high cost of feeding livestock, especially poultry in Nigeria, as observed in this study. This agreed with the findings of Abdulmalik (1997) and Ayodeji and Fasuyi (2005) who reported reduced feed cost with increasing levels of sorghum beer residue in diets of livestock. The inclusion of SBW in the diets also had no significant ($P>0.05$) effects on mortality rate. This agreed with the findings of Abdulmalik (1997) who reported that there was no adverse effect of sorghum beer residue inclusions on animal health.

5.2.3 Nutrient digestibility of Broiler Chickens Fed Graded Levels of sorghum brewer's waste (SBW).

Significant ($P<0.05$) differences were observed for the retention of nitogen, crude fibre and nitrogen free extract. The relatively lower apparent retention on the diets containing 40% SBW in this study may be attributed to tannin, which is usually present in sorghum grain, particularly the red variety which is commonly used in the production of local beer. This finding agreed with Abdulmalik (1997) who reported significant ($P<0.05$) depressions in the retention of crude protein, nitrogen free extract and ash due to the increasing level of tannin as the level of sorghum beer residue increased in the diets of rabbits.

SBW inclusion in the diets brought about non significant ($P>0.05$) decline in digestibility coefficients of ether extract and ash. This agreed with the findings of Babatunde *et al*. (1975) who also observed insignificant decreases in dry matter, energy, nitrogen and ether extract digestibilities when BDG based diets were fed to growing pigs. According to these authors, the decline in dry matter digestibility may be attributed to increases in the dietary levels of crude fibre as BDG levels increased in the diets.

This was contrary to the report of Yaakugh *et al*. (1988) who observed significant ($P<0.05$) depressions in the digestibility of dry matter, energy, protein, ether extract, crude fibre and ash as the levels of BDG replacing maize increased in the diets of pigs.

The crude fibre levels in this study were higher than the NRC recommendation for broiler chickens. With increase in the level of SBW in the diets, feed intake reduced and this consequently resulted in a reduction in the amount of feed available for digestion. It has also been reported by Adewusi and Matthew (1994) that as the dietary fibre content increased in the diets of rats, there was a corresponding decrease in true digestibility of the diets.

The droppings of the broiler chicks fed the test diets were observed to be slightly loose and watery and this phenomenon increased with increase in the percentage of maize replaced with SBW. Onifade (1993) and Adama (2007) attributed this phenomenon to higher crude fibre content of diet and the possible presence of non-starch polysaccharide which when present in the gastro intestinal tract (GIT) of monogastrics, leads to increase in faecal excretion with concomitant increase in water content of faeces.

5.2.4 Carcass characteristics of Broiler Chickens Fed Graded Levels of sorghum brewer's waste.

The live weight, and dressing percentage of birds decreased significantly ($P<0.05$) with increase in the levels of SBW. This could be as a result of the depressed intake of feed by birds which may be due to the high crude fibre content of the feed. This agreed with the findings of Ojewola and Longe (1997) and Chand (2007) who reported that higher inclusions of brewer's dried grain in the diet led to a decrease in live weight and carcass weight of birds. This also agreed with Adama *et al*. (2007) who also reported a reduction in the dressing percentage of birds as the level of sorghum brewer's dried grains (SBDG) increased in the diet which was as a result of the reduced feed intake and consequently reduced growth rate. The breast, thigh, back, gizzard, liver, intestinal length and intestinal weight were significantly ($P<0.05$) affected by dietary treatments. Birds fed diets containing 30 or 40% SBW had better results for most of these parts. This result however was in contrast to the findings of Adama *et al*. (2007) who reported that feeding up 20% sorghum brewer's dried grains (SBDG) enhanced breast yield. Gizzard of birds fed T4 (30% SBW) and T5 (40% SBW) were the largest, most probably due to the high level of fibre in these diets. Gizzard size is said to be influenced by the degree of feed coarseness resulting from increased muscular activities during grinding (Fanimo *et al*., 1996). Significant ($P<0.05$)

increases were observed in the intestinal length and weight of the birds as the level of SBW increased in the diets. This however, agreed with the reports of Dogari (1985) and Hamid and El Zubeir (1990) who observed significant increase in the gut length and gut weight as the level of sorghum beer residue and sorghum gluten meal increased in the diets of broilers, respectively. Pond *et al*. (1981) linked the bulky nature of high fibre diets with increase in weight/ volume of the stomach and various segments of the gastrointestinal tract (GIT) thereby resulting in increased capacity of the GIT to accommodate more of large quantities of bulky materials.

5.3 Experiment 2: The Effects of different levels of Sorghum Brewer's Waste (SBW) diets supplemented with Rovabio® enzyme on the Performance, Carcass Characteristics and Nutrient Digestibility of Broiler Chickens.

5.3.1 The broiler starter phase (1-4weeks)

Results from this study showed that Rovabio® enzyme supplementation of sorghum brewer's waste diets had significant ($P<0.05$) effect on the average daily intake and feed cost/ Kg gain. The average feed intake of chicks fed 40% SBW with enzyme supplementation was similar to those fed 45% SBW. The significant effect in the feed consumed by birds for all the dietary treatments in this study was similar to the findings of Amin *et al*. (2011) who reported increased feed intake of birds as brewer's dried grain level supplemented with enzyme increased in broiler diets. The result from this study showed that supplementation of exogenous enzyme in the diets of broilers significantly improved feed intake up to 45% level of SBW and this was comparable with the results obtained in birds fed graded levels of SBW without enzyme supplementation as observed in the starter phase of experiment1.

The feed cost/kg gain for birds on Treatments 3 and 5 were significantly decreased when compared with those of the control diet with enzyme supplementation. This implied that for profit

maximization, Rovabio® enzyme was economical compared to other dietary treatments up to 45% level of SBW. This was not in agreement with the findings of Almiral *et al*. (1995) who reported that inclusion of β- Glucanase enzyme in a diet based on 30% barley decreased the feed cost per kg gain of broiler chickens over the control diets which had no supplemental enzyme. This better performance as reported by these authors was attributed to positive effects of enzyme in promoting growth by increasing the effectiveness of nutrient utilization at that level. Marquardt (1994) also reported that exogenous amylase further assisted in the digestion of starch in early weaned animals.

5.3.2 The broiler finisher phase (5-8weeks)

There were significant ($P<0.05$) effect of Rovabio® enzyme supplementation on average daily feed intake, feed conversion ratio and feed cost/ kg gain of broiler birds. This result was in agreement with the findings of Atteh (2004) and Uduaka (2005) who reported that enzyme supplementation improved some of the performance characteristics of broilers. Furthermore, Erubetine *et al.* (2002) observed that the addition of enzymes like amylases and xylanases enhanced the utilization of non- starch polysaccharide components while proteases enhanced the utilization of proteinous components of feed. Olorunisomo *et al.* (2006) reported that increasing the levels of sorghum brewer's dried grain in the diets of West African Dwarf Goats stimulated higher intakes of feed and reduced the feed cost per kg gain.

The feed cost /kg gain of birds fed 40 and 45% SBW were considerably lower than those on other treatments. The result from this study indicated that the inclusion up to 45% SBW in the diet with enzyme supplementation did not affect growth performance negatively; rather it reduced the cost of feeding thereby increasing the profit margin. This was in consonance with Atteh (2004) who

reported that enzyme supplementation played significant roles through improvement on growth performance of broilers. Furthermore, the non significant (P>0.05) effect of enzyme supplementation on weight gain obtained in this study agreed with Iyayi and Davies (2005) who reported that at the finisher phase, enzyme supplementation did not significantly improve weight gain.

5.3.3 Nutrient digestibility of Broiler Chickens Fed different Levels of sorghum brewer's waste (SBW) supplemented with enzyme.

Increasing the level of SBW from 0 to 45% in the ration brought about corresponding increase in the crude fibre level of the diets. SBW inclusion beyond 40% in the diet brought about significant decline in percentage digestibility of crude protein, crude fibre, ash and ether extract. Adewusi and Matthew (1994) and Udedibie and Emanalom (1993) reported that as the dietary fibre content increased in the diets of rats and broiler chickens fed diets supplemented with enzyme respectively, there were corresponding decreases in true digestibility of nutrients.

The droppings of the birds were found less watery compared with the droppings of those observed in Experiment 1. This was in line with the findings of Iyayi and Davies (2005) who observed that enzymes reduce wet -dropping-syndrome as a result of reduction in viscosity of intestinal content, thereby minimizing the risk of coccidiosis.

5.3.4 Carcass analysis of Broiler Chickens Fed Different Levels of sorghum brewer's waste with enzyme supplementation.

The result of the carcass analysis showed that there were significant effects of enzyme supplementation on breast, wings, thigh, back, gizzard and liver. Enzyme supplementation on 40

to 45% SBW performed significantly better on breast, wing, thigh, gizzard and liver percentages when compared to those on the control diets. The live weight of birds across the treatments showed no significant difference which was a pointer to the non significant effects observed in the final weight of birds at the finisher phase. This could be as a result of proper utilization of nutrients in all the treatments with enzyme supplementation. The dressing percentage, drumstick and intestinal weight of birds fed 45% SBW with enzyme supplementation were numerically highest, though significant differences were not observed in all the treatments. The overall result in this carcass evaluation was in agreement with Iyayi and Davies (2005) who reported that enzyme supplementation had significant effect on carcass weight especially the economic parts of broiler chickens.

CHAPTER SIX

6.0 SUMMARY AND CONCLUSION.

The need to improve the performance of broiler chickens while at the same time, reducing the cost of feeding through the use of cheaper feed ingredients cannot be over emphasized. This study was designed to determine the effects of feeding sorghum brewer's waste (SBW) on the performance, nutrient digestibility and carcass characteristics on broiler chickens. It was also designed to evaluate the cost: benefit analysis of raising broiler chicks on enzyme-supplemented diets containing SBW.

Inclusion of SBW at 33.33% of the diets without enzyme supplementation and 40 to 45% with supplementation of enzyme gave maximum financial returns in this study. Based on the result of this study, the use of SBW in the diets of broiler chickens is recommended to broiler producers in order to maximize their profits. The result of studies conducted on the effect of SBW and enzyme supplementation in enhancing nutritional qualities and effective utilization had revealed that SBW is a potential energy source for broiler chickens. The following observations were made from the two feeding trials:

The inclusion of SBW at 0, 10, 20, 30 and 40% levels in the diets of broilers during the starter phase did not significantly affect the performance characteristics measured which showed that starter birds can tolerate 40% level of SBW.

At the end of the broiler-finisher phase, a regression analysis was used to predict the optimum level of SBW upon feed cost per kilogram gain of the birds and 33.33% was obtained.

Feed intake was significantly higher on birds fed 40% and similar to those on 45% SBW supplemented with Rovabio multi-enzyme. This result showed that enzyme supplementation

enabled birds to feed above 33.33% optimum level of SBW without enzyme supplementation obtained in the first feeding trial. N106.58 and N111.37 were saved on the cost of birds to gain 1kg at 40% and 45% SBW respectively, with enzyme supplementation compared with the control. However, there was no significant difference on the cost to gain 1kg on all the dietary treatments without enzyme inclusion in Experiment 1

Crude fibre digestibility improved up to 40% SBW on enzyme supplementation which was comparable with the 30% highest CF digestibility recorded on SBW diets without enzyme supplementation in Experiment 1. Digestibility of crude protein also improved up to 35% on enzyme inclusion. This was an improvement on the 30% optimum %CP digestibility obtained in the first trial.

Carcass analysis revealed that enzyme supplementation up to 45% SBW significantly improved carcass weight, percentage breast, wings and thigh in Experiment 2 which was comparable with the results obtained in Experiment 1

Conclusion

It was concluded that SBW at 33.33% level of inclusion in broiler diets without enzyme supplementation improved their performance at the least cost. Sorghum brewer's waste can also be included up to 45% with enzyme supplementation in the finisher diets of broilers without adverse effects on performance.

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