

**NUTRITIVE VALUE OF MALTED SORGHUM SPROUT IN BROILER CHICKEN
DIETS**

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**DEPARTMENT OF ANIMAL SCIENCE,
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AHMADU BELLO UNIVERSTY,
ZARIA, NIGERIA**

DECEMBER, 2018

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B. Agriculture (A.B.U., Zaria) 2009
P15AGAN8047**

**A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES,
AHMADU BELLO UNIVERSITY, ZARIA IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE AWARD OF MASTER DEGREE IN ANIMAL SCIENCE**

**DEPARTMENT OF ANIMAL SCIENCE,
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DECEMBER, 2018

DECLARATION

I hereby declare that the work in this dissertation titled “**NUTRITIVE VALUE OF MALTED SORGHUM SPROUT IN BROILER CHICKEN DIETS**” was carried out by me in the Department of Animal Science, Faculty of Agriculture A.B.U., Zaria under the supervision of Prof. G.S. Bawa and Dr. P.A. Onimisi. 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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CERTIFICATION

This dissertation titled “**NUTRITIVE VALUE OF MALTED SORGHUM SPROUT IN BROILER CHICKEN DIETS**” by **LASISI OLAYEMI TAIYE** meets the regulations governing the award of Masters of Science (Animal science) Ahmadu Bello University, Zaria and is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

This Dissertation is dedicated to God my creator, giver of peace in the eye of every storm, my Ebenezer. This work is dedicated to Mama Las (mummy), for your love, provision, accommodation, patience and most importantly prayers. Also, to Late Daddy Las (1942-2013) for your support calm, gentle demeanour and propulsion to enable me follow my dreams. The good Lord bless you Ma and rest well Sir.

ACKNOWLEDGEMENTS

I express my sincere gratitude to my wonderful and loving supervisors Prof. G. S. Bawa and Dr. P.A. Onimisi, for their unreserved patience and understanding, seeing me through to the end of this programme.

Mr. and Dr. (Mrs.) J.S. Olajide, for your all round support. Mr. and Mrs. S. Otanwa I appreciate you for your moral support, allowing my 3 year old apprentice (Master A. Otanwa) to help spoil work in the pen sometimes but made me smile through the stress mostly, God bless you. My heart goes out to all my siblings for the calls and encouraging words that helped steady me on my failing feet.

My lecturers and mentors; Prof. S. O. Ogundipe, Prof. J. T. Amodu, Prof. S. Duru, Prof. T. Olugbemi, Dr. S. B. Abdul, Dr. O.M. Daudu, Prof. M. D. Alegbejo, Prof. and Mrs. O. Olufajo Mr Kwano, I. and other staff of Biochemical Laboratory, Animal Science Department I do really appreciate your comments and impartment of knowledge, making my programme a success.

Mr. G. O. Adebayo, Mr. E. Dania and Mr. T. Barau, God bless you all for helping with the stressful trips to the feed mill and back to the mixing flour and then to poultry pens, to the entire staff of Rebsons feeds and Labar feeds really appreciate you all.

My colleagues; Mr. T.A. Adeniyi, Mrs. S. Tanko, Mr. and Mrs. I. I. Onoja, Ishola, Mr. E. D. Bulus, Miss. J. Amadi, Mr. S. Eleagu, Mrs. T. R. Amuda and Mr. B. Kazeem. For everyone mentioned and those my human brain cannot remember, I pray for you all that for the simple reason that you blessed me God in his infinite mercy will give you the blessings of helpers in your every endeavour.

ABSTRACT

Two studies were carried out to determine the nutritive value of Malted Sorghum Sprouts (MSS) in broiler chickens. The first trial was conducted to determine the effect of graded levels of MSS in a isocaloric-isonitrogenous diets on performance, carcass, and hematological parameters. A total of two hundred and seventy birds were used for both the starter and finisher phases. There were five dietary treatments, replicated three times with eighteen birds per pen and a total of fifty four birds per treatment in a completely randomized design. Five isocaloric-isonitrogenous experimental diets were formulated to contain MSS at 0, 5, 10, 15 and 20% to compliment other energy components in the diets. The experiment lasted for eight weeks. In the second set of experiments, two hundred and seventy birds were allotted to five dietary treatments with three replicates per treatment containing eighteen birds per pen. Birds were fed five' isocaloric-isonitrogenous diets with Maxigrain® enzyme treatment i.e. MSS at 0% (Trt 1), 10% (Trt 2), 10% + Enzyme (Trt 3), 15% (Trt 4) and 15% + Enzyme (Trt 5). Data analysis revealed that dietary treatments had significant ($p < 0.05$) effect on feed intake, body weight gain, feed conversion ratio, feed cost/kg gain, carcass and blood parameters taken. Feed intake was significantly ($p < 0.05$) the lowest for birds fed diet 5 while those on diet 2 had the highest values. Body weight gain significantly ($p < 0.05$) decreased as the percent MSS increased in diets. Feed conversion and cost/kg gain significantly ($p < 0.05$) favored birds on diet 2 compared to those on diet 1, 3, 4 and 5 respectively. Blood parameters were significantly ($p < 0.05$) affected by experimental diets but differences were within expected limits. Feed intake was significantly the highest in Trt 1 and least in Trt 5. Trt1 was numerically the highest in final weight and weight gain but did not differ ($p > 0.05$) from trt3. Trts 2 and 5 recorded the lowest final weight as daily weight gains were least for these treatments. Trt 3 had the best feed conversion ratio and cost/kg gain with Trts 4 being the lowest. Dietary treatments had effect on breast, thighs, and other cuts and organs while drumstick, wings, back and lungs showed no difference. Hb and TP significantly differed but not PCV though values were within recommended range. These studies showed that birds in treatment 1 gave the best results in both experiments but, MSS can be included at 5% or at 10% with enzyme treatment for good performance, reduced feed cost and better feed conversion ratio. Mortality was not significantly ($P > 0.05$) affected by MSS inclusion. It is therefore recommended that MSS in broiler diets should not exceed 10% levels of inclusion as the overall performance of birds become poorer with increased levels in the diet.

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CHAPTER ONE

1.0 INTRODUCTION

The poultry industry has suffered more than any other livestock industry as a result of inadequate supply and high cost of feed (Hill, 1989; Mtimuni, 1995; Leplaideur, 2004). Cereal grains constitute the major sources of energy in poultry diets in the tropics (Oluyemi and Roberts, 2000). However, maize has remained the chief energy source in compounded diets and constitutes about 50% of poultry ration (Ajaja *et al.*, 2002). Pressure on maize, wheat and recently cassava has been on the increase worldwide with emphasis being placed on export and other diversified uses mostly in flour based foods and ethanol production as an alternative source of fuel (Doki, 2007; Thornton, 2007). According to Etuk (2008), these trends require serious diversification of energy and protein feedstuffs for poultry, because the availability of cheap and good quality protein and energy sources remain the single most important limiting factor in poultry production in Nigeria (Bawa *et al.*, 2003; Abeke *et al.*, 2008). The fact that feed alone accounts for 70–80% of the recurrent production input in intensive monogastric animal production makes the utilization of multiple feed ingredients expedient (Mtimuni, 1995; Marie-Agnés, 2004). Field observations in Nigeria revealed the inclusion of sorghum and possibly wheat in poultry and rabbit diets (Ojo *et al.*, 2005a; Abubakar *et al.*, 2006; Etuk and Ukaejiofo, 2007) as alternatives.

Sorghum bicolor (L) Moench is widely grown in the semi-arid and arid savannah regions of Nigeria. Maunder (2002) reported that sorghum is a traditional crop in Africa and Asia and an introduced or hybridized crop in the western hemisphere. Sorghum is the world's fifth most

important cereal and is grown in semi-arid regions of Africa being well adapted to the harsh climate and naturally resistant to many pests (Belton *et al.*, 2003).

It benefits from an ability to tolerate drought, soil toxicities and temperature extremes effectively than other cereals. In terms of the nutritive value, cost and availability, sorghum grain is the next alternative to maize in poultry feed (Subramanian and Metta, 2000). Several varieties of sorghum have been developed and introduced in Nigeria (IAR, 1999). However, the diversity of chemical composition and anti-nutritional factors, mainly tannin resulting in variability in digestibility from 35 – 60% or more have been reported (Becker, 1992). Varieties of sorghum, climatic and soil conditions, fertilizer types are listed among the factors responsible for the variations in chemical composition of sorghum (Aduku, 1993; Tacon, 1995; Ngoka, 1997; Etuk and Ukaejiofo, 2007; Etuk, 2008). The usefulness of sorghum by-products has been reported world-wide (Mosimanyana and Kiflewahid, 1987; Mahabile *et al.*, 1990; Dowling *et al.*, 2003; Macedo and Aguilar, 2005; Nyannor *et al.*, 2007). Some varieties of sorghum have phenols concentrated in the outer layers of the kernel which serves as natural source of antioxidants for foods (Awika *et al.*, 2001). Taylor and Da Silva (2004) reported that sorghum bran could be a source of protein for industrial uses. Apart from serving as a staple food in Nigeria, sorghum grain is used for the production of beverages.

Malting of sorghum, like barley, involves steeping or soaking, germination, drying and curing in Kiln and polishing. The resultant malt extract is a useful input in breweries and food processing companies where it is utilized for the manufacture of malt drinks, syrups, beverages, baby foods, microbiological media and other useful products. Malted sorghum sprout (MSS) is a by-product of sorghum malting. The separated roots and shoots which are left after malt extraction from the young germinating sorghum seedlings are collectively called sorghum sprout

(Aletor *et al.*, 1998). Malted sorghum sprout has a lot of prospect as a feed stuff of the livestock industry. It is rich in organic nitrogen (Ikediobi, 1989). Malted sorghum sprout contains (g/kg); 226 crude protein, 48 crude fibre, 33 ether extract, 16 ash, 522 nitrogen free extract and 16.26 MJ/kg DM gross energy (Aning *et al.*, 1998). Aning *et al.* (1998) reported that magnesium was the most abundant mineral while potassium was the least in MSS. Among the trace minerals, Zinc is the most abundant while copper is the least. Sorghum sprout is reported to contain a considerable number of amino acids with low level of methionine, lysine and threonine (Aning *et al.*, 1998).

The anti-nutritional factors in MSS are tannin and hydrogen cyanide (Omogbai and Ojeaburu, 2010). Van Buren and Robinson (1969) reported that tannins affect the growth of animals in three main ways: they have an astringent taste, which affects palatability and decreases feed consumption; they form complexes with proteins which reduce its digestibility and they act as enzyme inactivators. Processing of Malted sorghum sprout was shown to have no significant ($P>0.05$) effect on growth (Fanimu and Akinola, 2006) but inclusion of enzymes in feed have shown positive results in counteracting the effects of anti-nutritional factors. This study was conducted to determine inclusion level of malted sorghum sprout on its utilization by broiler chickens and subsequent effect of enzyme treatment.

1.3 Objectives

Objectives of the study were to;

1. Determine the proximate and anti-nutritional factor components of malted sorghum sprout.
2. Determine the effect of MSS based diet on performance and carcass characteristics of broiler chicken.

3. Determine the effect of enzyme treatment of malted sorghum sprouts on the performance and nutrient digestibility by broiler Chicken.
4. Evaluate the cost effectiveness of MSS inclusion in broiler diets.

1.4 Hypotheses

Experiment 1

H_0 : Malted sorghum sprout cannot be effectively included and utilized in broiler chicken diets

H_A : Malted sorghum sprout can be effectively included and utilized in broiler chicken diets

Experiment 2

H_0 : Enzyme treatment cannot increase efficient utilization of malted sorghum sprouts in broiler diets

H_A : Enzyme treatment can increase efficient utilization of malted sorghum sprout in broiler chicken diets

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Broiler Chicken

Broiler chickens (*Gallus gallus domesticus*), or broilers, are a gallinaceous domesticated fowl, bred and raised specifically for meat production. They are a hybrid of the egg-laying chicken, both being a subspecies of the Red Jungle Fowl (*Gallus gallus*). Typical broilers have white feathers and yellowish skin. Most commercial broilers reach slaughter-weight at between five to seven weeks of age, although slower growing breeds reach slaughter-weight at approximately 14 weeks of age (Kruchten, 2002).

2.2 Factors Affecting Nutrient Requirements of Domestic Animals

Certain factors affect the levels of nutrients required for optimum performance of farm animals.

These includes –

- a. Texture of feed – feed particle size affects nutrient requirement. Coarse feed may not be consumed sufficiently by very young animals. Pelleting of a bulky diet will increase the nutrient density per unit volume thus increasing nutrient consumption.
- b. Energy content of the diet – the largest single dietary need of animals is energy. Energy is required for all processes of life. This energy is bound in molecules of carbohydrate, fat, protein and alcohol. Birds tend to satisfy their energy requirements first hence the energy content of the diet tends to influence the intake of other essential nutrients. Efficient utilization of proteins is dependent on the amount of energy available, hence, the concept Protein: Energy ratio in farm animal nutrition.

- c. Environmental condition – Temperature, climatic conditions have marked effect on energy requirement and hence on feed intake and other nutrients. Animals tend to eat less in warm/hot than in cold environments prevailing during rainy/harmattan seasons. Ambient temperatures also influence the requirement for vitamins.
- d. Age – nutrient requirements change with age of the animals. Age relates to growth and increased metabolic activities.
- e. Sex – boars, bucks (male farm animals) require more energy and nutrients than, sows, does (female animals).
- f. Physiological/Productive state – rate of growth, egg production, amount of milk produced, pregnancy lactation can affect the nutrient requirements of farm animals. Mature cockerel will have low requirement for amino acids (nutrients) than the laying hen producing eggs.
- g. Physical activity – active farm animals require more energy and nutrients than inactive or less active animals e.g. Athletes and non-athletes.
- h. Size of the animal and breed – large animals and people need more feed and hence nutrients than smaller animals. Breed effect is important e.g. light breed and heavy breed.
- i. Effect of health status – this can affect the requirement for nutrients. Diseased condition or ill-health, absence or presence of internal parasites. Animals recovering from illness need more energy and nutrients than healthy animals e.g. diarrhea.
- j. Balance between nutrients – the balance between amino acids, dietary protein levels versus individual amino acids, this may affect the metabolic utilization of individual nutrients and hence their requirements.

- k. System of management – in poultry and pigs, floor or cage rearing, intensive or extensive management system can affect requirements for specific nutrients.
- l. Presence of anti-nutritional factors – availability of nutrients from various feedstuffs may be affected by certain substance (anti-metabolites) e.g. phytase, oxalate may render ions of Zn, Mn and Ca completely unavailable to the animal.
- m. Destruction or loss of nutrients in feed/feedstuffs – improper processing e.g. overheating of a feedstuff may result in denaturation of protein or the browning reaction of Millard's reaction.
- n. Stress – stresses occur in everyday life and these may affect nutrient requirements e.g. hot weather and vitamin C treatment in feed or water. (www.Unaab.edu.ng)

2.3 Sorghum Malting

Although sorghum has shown that it has huge potential for use in the production of European-type lager beer and research into the use of sorghum has been extensive in recent times, research studies on sorghum are limited when compared to studies carried out on barley (Ijasaan *et al.*, 2011). Sorghum, an indigenous African cereal, is well adapted to the semi-arid and sub-tropical conditions prevailing over most of the African continent. An advantage of sorghum is that it can yield a crop under harsh environmental stress, such as drought, where temperate cereals fail to grow. This property is important, especially in a world that is regarded in some quarters as getting hotter (Agu, 1997).

In recent times, researchers working on wheat are decoding the genes in wheat that will enable wheat to survive “harsh” environmental conditions (e.g., The International Wheat Genome Sequencing Consortium). The abundance of grain sorghum (Rooney, 1969) and its low price

(Haln, 1966) should encourage local use of sorghum. The extensive pioneer studies on sorghum (Novellie and De Schaepdrijver, 1986) and many other follow-up research studies have resulted in the successful use of sorghum and malt in brewing continental beers in Nigeria, Mexico, Cuba, Israel, America, South Africa and some other countries of the world. When brewing with sorghum malt, the problems usually highlighted are inadequate enzyme levels, especially those hydrolysing starch and those degrading endosperm cell walls (Etok and Palmer, 1990). Although the levels of the starch-hydrolysing amylases which develop in sorghum during malting appear to be low when compared with those found in barley malt, extract yields as high as those obtainable from well-modified barley malt were obtained from sorghum malt when an adapted mashing procedure was used that gelatinised sorghum starch and protected its enzymes.

Research studies on sorghum suggest that as a tropical cereal, the optimum temperature required to produce good quality sorghum malt is 30°C (Agu and Palmer, 1998), especially under well-controlled laboratory malting conditions. There is limited information on the quality of sorghum malt produced commercially at the high temperature of 30°C. Another application of sorghum malt is as an ingredient during the preparation of weaning foods, a common practice in the rural communities of some African countries (Mosha and Svanberg, 1990).

Protein-energy malnutrition (PEM) and other nutritional deficiencies during infancy are still a problem in developing countries. This is mainly due to the thin liquid gruels (porridges) based on the local staple food, usually a cereal such as maize, millet, sorghum, rice and cassava that are used as weaning porridges (Gopaldas *et al.*, 1988; Mensah *et al.*, 1995). The thin gruel may be more easily consumed but its energy density is too low to meet the energy requirements of children. The addition of a small amount of malt flour, sometimes called Amylase-Rich Flour (ARF) or Power Flour (PF), to the already prepared thick starch-based food could be the solution

to the dietary bulk problem (Svanberg and Sandberg, 1988). Small quantities of ARF when added to freshly prepared thick gruels liquefy them due to the action of amylases, reducing their viscosity without lowering their nutrient and energy density (Svanberg and Sandberg 1988; Thaoge *et al.*, 2003). Other benefits that result from malting are the reduction of anti-nutritional factors (e.g. phytate), enhancement of the vitamins riboflavin, niacin, pyridoxine and ascorbic acid content (Malleshi and Klopfenstein, 1996), improvement of the minerals Ca, Mg, Zn and P availability (Glennie *et al.*, 1983) and imparting flavour and sweetness to the porridge (Taylor and Dewar, 2001). Malting has also been shown to improve the *in vitro* digestibility of sorghum protein (Bhise *et al.*, 1988) and starch (Wang and Fields, 1978), improve the composition and content of essential amino acids (lysine, methionine and tryptophan) (Wang and Fields, 1978; Taylor and Dewar, 1993).

Table 2.1: Proximate composition and Metabolisable Energy of Malted sorghum sprout

Parameters	Malted sorghum sprout
Dry matter	84.23
Crude protein	22.43
Crude Fibre	4.67
Ether Extract	2.42
Ash	6.3
NFE	64.18
Metabolisable Energy (Kcal/kg)	3274

Fafiolu *et al.* (2004)

2.3.1 Benefits of sorghum malting and the uses of sorghum malt

Sorghum malting, results in high levels of amylases, reduces anti-nutritional factors, enhances vitamin content, improves mineral content, increases in vitro digestibility of sorghum protein, improves the composition and content of essential amino acids, increases the in vitro starch digestibility and also makes grains to be readily solubilised during the brewing process, reducing the viscosity of porridges whilst maintaining their nutrient and energy density, imparting flavour and sweetness to porridge

2.3.2 Sorghum malting process

Like barley malting, sorghum malting involves three main steps: steeping, germination and drying/kilning (Novellie and De Schaepdrijver, 1986)

2.3.2.1 Steeping

Steeping, the first step of the malting process is the immersion of the grain in water. It is practiced chiefly as a means of achieving imbibitions of water by the dormant grain and thereby initiating biochemical processes leading to seed germination (Brookes *et al.*, 1976; Briggs, 1998). Steeping is also carried out to clean and to remove broken grains. A moisture content of 33 to 35% (wet basis) should be achieved during steeping of sorghum grains (Daiber and Taylor, 1995). The more water that is taken up during steeping (within limits) the higher is the resulting malt quality (Dewar *et al.*, 1997b). Factors associated with the grain that affect the rate at which the grains absorb water include: grain structure- softer grains absorb more water than hard grains, and grain size- smaller grains absorb moisture more rapidly (Pitz, 1989). The

temperature, time of steeping (soaking in water), milling, germination, drying, grain cleaning and aeration required for steeping can also affect the rate at which the grain absorbs water and are therefore chosen to achieve a good level of hydration in order to produce good malt (Olkku *et al.*, 1991). The optimum steeping temperature and time required for sorghum grains to reach appropriate water content is 25–30°C and 16-40 hours, respectively (Briggs *et al.*, 1981; Morrall *et al.*, 1986; Dewar *et al.*, 1997a). Traditional South African sorghum malting employs a continuous steep of 6-8 hours (Taylor and Belton, 2002). Aeration, either by draining the water from the grain periodically (air-resting) or by sparging air through steeping water, is necessary for production of a good quality malt (Novellie and De Schaepdrijver, 1986). During steeping, the grain swells and softens, while the living tissues resume their metabolism (Briggs, 1998). There is a breakdown of complex carbohydrates and nutrients leach out from the grain into the steep water (Pathinara *et al.*, 1983).

2.3.2.2 Germination of sorghum seeds

Germination normally takes about 6 days. The germination of sorghum occurs rapidly between 20°C and 30°C with an optimum of 25–28°C (Morrall *et al.*, 1986; Palmer, 1989; Dewar *et al.*, 1997a). The germination phase of sorghum is physiologically very active. Important physiological processes associated with the germination phase are the synthesis of amylases, proteases and other endogenous hydrolytic enzymes (Palmer, 1989). The hydrolytic enzymes migrate from the germ into the endosperm where starch and protein are hydrolysed to sugars and amino acids, respectively (Glennie *et al.*, 1983). These are then transported into the germ where they are further metabolised by the growing seedling (Taylor and Evans, 1989; Priest and Campbell, 1996). During germination the hard endosperm is converted into more friable malt.

The conditions that can impact greatly on the quality of the finished sorghum malt during the germination phase are grain moisture content, temperature, length of germination time and oxygen availability. Germinating sorghum grains have the tendency to rapidly lose water taken up during steeping and therefore it has been found necessary to spray germinating grains at intervals during the germination phase because the higher the level of moisture content (within limits), the higher the resulting malt quality (Morrall *et al.*, 1986; Palmer, 1989; Dewar *et al.*, 1997a). Other ways to maintain good humidification are to germinate the grain in an atmosphere of near-water saturation (Palmer, 1989) or by continuous passage of moist air through the malting environment (Morrall *et al.*, 1986). The germination step is complete when the whole of the endosperm (the storage part of the grain) which naturally sustains the development of the growing embryo or germ (the living part) during germination, has modified (partially attacked by enzymes) (Briggs *et al.*, 1981; Dewar *et al.*, 1995).

2.3.2.3 Drying/kilning and milling

Drying/kilning is the final stage of the malting process. The purpose of drying is to stop the growth of the green malt at the end of the germination process and to produce a shelf-stable product complete with active enzymes by reducing the moisture content and water activity (Novellie and De Schaepdrijver, 1986). During this phase, the germinated sorghum grains are dried at a temperature of about 50°C for 24 hours. The dried malt is then milled without the removal of external vegetative parts from the grain. The resultant product has a moisture content of around 10% (Daiber and Taylor, 1995).

2.4 Sorghum Malting Technologies

Commercial sorghum malting is carried out using two different processes; pneumatic malting, referred to as industrial malting, and floor malting, referred to as commercial malting (Novellie and De Schaepdrijver, 1986). Products of the latter technology are widely sold for home brewing but not to the brewing industry, while malt produced by the former are employed in industrial scale brewing of the opaque sorghum beer. The steeping process is common in both processes and the differences occur during the germination and drying processes.

2.4.1 Floor malting

Floor sorghum malting takes place outdoors whereby steeped grain is spread in a layer of 10–30 cm thick on a concrete floor that is slightly sloped to allow drainage of water (Taylor and Dewar, 1993). The layer of grain might be covered with shade cloth to reduce evaporation and to help prevent birds and rodents from feeding on the grain. Grains are watered intermittently with a hosepipe and are not normally turned. The temperature of the malt bed can only be controlled to some degree by making the bed thicker or thinner. A thick bed retains metabolic heat and is used during the winter season, while a shallow bed which allows faster dissipation of metabolic heat is employed during summer. Malted grains are dried under the sun or by forced draught as with pneumatic malting (Novellie and De Schaepdrijver, 1986; Priest and Campbell, 1996). The uncontrolled weather conditions and not turning the grains during floor malting encourages the formation of “hot spots” with a high load of bacteria and often result in malts with low and inconsistent quality (Briggs, 1998). Not turning also encourages the stratification of the grain bed into different layers that are mainly differentiated by the water activity, whereby the malt is progressively wetter from the top of the bed to the bottom layer (Taylor and Belton, 2002).

2.4.2 Pneumatic malting

Pneumatic sorghum malting is most commonly carried out in Saladin boxes, which comprise of a rectangular chamber with a perforated steel false floor containing the malt (1–1.5 meters deep) and a second chamber or plenum below it (Novellie and De Schaepdrijver, 1986). Air is blown by means of a fan into the lower chamber and through the bed of malt to provide oxygen for germinating grain, to remove carbon dioxide and to maintain a uniform temperature throughout the malt bed. The germinating grain is watered at intervals by spraying and it is turned by means of helical screws mounted on a carrier which traverses up and down the length of the box. The malt is then force dried with a flow of warm, dry air from a furnace (Novellie and De Schaepdrijver, 1986). The uniform temperature that is maintained and turning the grain at intervals during germination discourages the entangling of roots and shoots, the development of “hot spots” and by so doing, the microbial growth is reduced. Generally, pneumatic malting produces better quality malt than floor malting due to better control of germination temperature and moisture. However, it is more expensive, it requires more energy and maintenance, whereas floor malting requires no sophisticated equipment and very minimal energy costs (Dewar *et al.*, 1995). For these reasons most sorghum malting in South Africa is still by the floor malting procedure even if it produces inferior malts as compared to the pneumatic malting method.

2.5 Sorghum Malt Quality

In the sorghum malt industry, sorghum malt quality for opaque beer brewing is defined mainly in terms of its diastatic power (DP), which is the measure of the joint, and amylase activity

measured in sorghum diastatic units (SDU) per gram of malt (South African Bureau of Standards, 1970). Generally, sorghum malt has a lower DP than barley and is required to have a minimum DP of approximately 28 SDU/gram for brewing the South African opaque beer (Dewar *et al.*, 1995). Free Amino Nitrogen content (FAN), which comprises of small peptides and amino acids (the products of protease activity) is another parameter used to define sorghum malt quality. A minimum of 110 mg FAN/100 g is required for opaque beer brewing (Dewar *et al.*, 1995). The type of the sorghum grain cultivar is also another factor that can contribute to the malt quality.

To produce good quality malt, it is essential that the tannins be inactivated, otherwise they can bind to the malt enzymes and affect hydrolysis of starch and proteins during brewing (Beta *et al.*, 2000). It is also required that a high proportion of the grain must germinate for the production of a good quality malt. A measure of the percentage of grains which can be expected to germinate if the grain is malted normally at the time of the test is referred to as the germinative energy (GE) and is recommended to be greater than 90% (Dewar *et al.*, 1995). The resistance of the grain to mould infection is also sometimes taken as a quality criterion because grains that are susceptible to infection by moulds do not malt well (Briggs, 1998).

2.6 Utilization of Energy in Poultry Diet

Feed costs represent a major cost in poultry production (about 70%), with dietary energy sources occupying the greatest portion (70 to 75% of the diets) (Van der Klis *et al.*, 2010). Birds tend to eat feeds mainly to satisfy their energy requirements and once this is met, they will not consume any more feeds, even if the requirements of other nutrients like protein, vitamins or minerals have not been met (Singh and Panda, 1992). For this reason, the energy contents of the diets play a pivotal role in formulating diets for poultry. Most of the dietary energy comes from plant

sources in the form of starch from cereal grains. These cereal grains provide the energy component which accounts for 60 to 70% of the nutrient requirement of poultry. Protein is supplied by plant and animal sources. Plant sources are safer than animal sources but the former often lack nutrient balance. This may affect the utilization of nutrients and growth of birds on such diets. Protein sources may also supply a substantial amount of energy and their interaction with the main energy sources has a bearing on the overall energy supply and utilization. So, it is important to determine the energy value of diets containing vegetable protein sources. The performance of birds is closely associated with feed nutrients and energy utilization, which is primarily related to availability of more nutrients and energy from the feed ingredients (Olukosi *et al.*, 2008).

In poultry research, Metabolizable Energy (ME) and Net Energy (NE) are usually used to measure energy availability to and utilization by the birds. Metabolizable energy can be accurately determined from the difference between the gross energy of the feed and the gross energy of excreta derived from such feeds (NRC, 1994). Metabolizable energy has been commonly accepted and extensively used to compare energy values of feedstuffs and diets for poultry and energy requirements are commonly expressed in this form. Net energy is a more accurate measure of energy utilization, as it measures the amount of gross energy that is used for productive purpose. It can be measured in a number of ways, including direct and indirect calorimetry, which is expensive. The comparative slaughter technique is cheaper and often mimics the natural rearing environment more than does calorimetry (Sakomura *et al.*, 2003).

There are a number of constraints in vegetable protein sources, which reduce their optimal utilization, thus limiting the benefits of these feeds to broiler chickens. This results in reduced digestibility and poor performance of the birds. From the results obtained by Hossain *et*

al. (2012) in one of their studies revealed that the nutrient digestibility and overall performance of the broiler chickens fed on vegetable protein diets were comparatively poorer than those of birds fed on conventional diets.

2.7 Crude Fibre Requirement of Birds

The maximum crude fibre requirement of broiler birds have been put at 5- 6% (Oloju, 1995; Aduku, 2004). Crude fibre does not give any contribution to nutrients of the feed, but it is a source of dietary fibre which is essential for bowel movement and helps in preventing ailments of the gastro-intestinal tract.

High fibre levels in weaning diet can lead to irritation of the gut mucosa, reduced digestibility, vitamin and mineral availability. Fruits with high fibre contents are desirable in adult diet. Fibre diets promote the wave-like contractions that move food through the intestine. High fibre diet food expands the walls of the colon, easing the passage of waste, thus making it an effective anti-constipation. It also lowers cholesterol level in the blood, reduce the risk of various cancers, bowel diseases and improve general health and well being. Crude fibre has a negative effect which includes high fibre content, which affects bioavailability of nutrients and toxic/anti-nutritional factors contained in these ingredients which are deleterious to the animals' healthy growth (Dafwang, 2006). Viscosity-promoting potential of crude fibre has also been shown to reduce the overall digestive absorptive efficiency by preventing nutrients from being available at the absorptive sites in the intestinal mucosa. Udedibia and Enangi (2009) reported that young broilers could not tolerate total replacement of maize with a mixture of sun-dried cassava tuber meal, brewers' dried grains and palm oil, probably due to its high fibre and possibly HCN content. Onifade (1993) and Onifade and Babatunde (1997) reported that high fibre content was

found to interfere with nutrient availability for growth and maintenance. Both Hedge *et al.* (1978), and Trait and Wright (1990) observed that high fibre in the diet could be the cause of decrease in the availability of nutrients which is as a result of reduction in the period of exposure of the feed to digestive enzymes which in turn impairs absorption of nutrients.

2.8 Enzyme Treatment of Poultry Diet

The main goals of enzyme treatment of poultry diets include: enhancing the overall digestibility of the feed to render certain nutrients biologically more available, reducing environmental pollution from animal excreta by reducing dry-matter excretion, removing or destroying the anti-nutritional factors in cereals and allowing the use of a wide range of ingredients while upholding optimal, quality bird performance and provide great flexibility in least-cost feed formulation. It is worthy of note that artificial enzymes must be able to withstand processing of feed, resist the acidic conditions and proteolytic enzyme activity in the proventriculus and gizzard. (Esuga, 2007)

2.8.1 Adding enzymes to practical cereal based diets

Numerous researchers have demonstrated that the soluble-NSP fraction and not the total NSP fraction, is responsible for anti-nutritive responses. These NSPs can bind to large amounts of water, and as a result, the viscosity of fluids in the digestive tract is increased. The increased viscosity causes problems in the small intestine because it reduces nutrient availability (particularly fat) and results in increased amounts of sticky droppings. To counteract these anti-nutritional effects, enzymes are often added to feed. The feed industry formulates poultry diets on the bases of least cost. Under these circumstances, the price of cereal and the nutrient content will determine whether a cereal enters the computed formulation. With the introduction of

enzymes, nutritionists should be able to make available the release of more nutrients in any particular cereal and its by-products making it more competitive with corn. Treatment of feeds with enzymes could increase the energy available by 6 – 8 %.

Phytase use is reported to reduce phosphorus excretion by as much as 40% for broilers. When phytase was added to layer diet, increased egg production and positive effects on egg weight were reported (Simons and Versteegh, 1991). The hidden benefits of using glycanases in birds fed viscous cereals include; reduction in output of manure containing large amounts of undigested nutrients, and alleviation of problems associated with wet droppings, such as increased percentage of dirty eggs, increased gas production (i.e., ammonia) and increased fly and rodent populations in the shed. However, glycanase treatment was not the answer to problems associated with phosphorus levels in pig and poultry manure. This led to the development of phytase for use in monogastric animal diet. Phytase increases the digestibility of phytate from around 25% to between 50 % – 70% in poultry and its use has been on the increase since banning the use of animal protein sources, such as meat and bone meal, in the European Union. It is also understood that phytase can improve the digestibility of other nutrients as well as energy (Ravindran *et al.*, 1999; 2000; Kornegay, 2001).

2.8.2 Enzymes for poultry diets based on non-viscous cereals

Although the insoluble NSP have mainly been regarded as nutrient diluents in the diet, they can also affect digesta transit time and gut motility. Another facet of the role of insoluble NSP in poultry diets that is worthy of reiteration is their ability to act as a physical barrier to digestive enzymes, such as amylase and proteases, thus reducing their efficient digestion of nutrients embedded in the cell wall matrix of grains. Evidence in literature appears to suggest that

enzymes with affinity for insoluble NSP can elicit a positive response in growth performance of broilers (Cowan, 1995). This breakdown of cell wall matrix, especially the insoluble components, may facilitate easier access of digestive enzymes to their substrates within the short feed transit time in birds. Wiseman and McNab (1998) also showed that the rate of starch digestion in vitro correlates closely with the AME values of different wheat varieties. It suggests that the accessibility of aminolytic enzymes to starch granules differs depending on the wheat type, and some of the key factors influencing it may relate to the cell wall architecture of the wheat. Bedford (2002) demonstrated that a considerable amount of nutrients such as starch remains encapsulated in the cell walls in the small intestine of chickens and was removed upon xylanase treatment. Indeed, D'Alfonso (2003) reported significant variation in the nutritive value of corn (93 samples examined) for chickens with ileal digestibility energy value varying by 2.04MJ/Kg DM and starch digestibility ranging from 84% to 90%. This variation was reduced by an enzyme product containing xylanase, protease and amylase. Cowieson (2005) speculated that the ability of enzymes, in particular glycanases, to enhance the nutritive value of some corn-soy diets is probably mediated through changes in cell wall architecture of the grain, rather than the viscosity reduction as is often the case for viscous grains.

2.8.3 Substrate structure and enzyme affinity

Matching an enzyme activity with a substrate does not guarantee the efficacy of the enzyme in degrading the substrate. Currently most of the glycanases used in the poultry industry are targeted at the soluble-carbohydrate in an endo-active manner i.e. cleaving the molecules from the middle to reduce the molecular size with little or no monomeric sugars released (Bhat and Hazlewood, 2001). Substrate specificity depends largely on the source of the enzyme. Choct *et al.* (2004) reported three xylanases that are of different substrate affinities. A xylanase derived

from *Thermomyces lanuginosus*, significantly increased the soluble NSP content of the small intestine digesta, but decreased its viscosity, whereas xylanase derived from *Humicola insolens* markedly increased both the content of the soluble NSP in the small intestine as well as its digesta viscosity. This clearly demonstrated that the xylanase from *T. lanuginosus* had affinity for both soluble and insoluble arabinoxylans, e.g. whilst releasing soluble NSP from the insoluble cell wall xylans, it also degraded them in smaller polymers, but that from the *H. insolens* had affinity for only the insoluble cell wall xylans. The third xylanase used in this study was from *Aspergillus aculeatus*, which effectively degraded the soluble arabinoxylans, but had no effect on the insoluble fractions. The NSP degradation patterns appear to indicate that enzymes having affinity for both soluble and insoluble NSP will be more efficacious. However, these differences, in general, did not translate into apparent differences in bird performance despite some numerical trends. Each gram of Maxigrain® contains cellulase (10,000 i.u.), Beta-glucanase- (200 i.u.), Xylanase-(10,000 i.u.), Phytase- (2500 FTU). Cellulase breaks down cell-wall for more energy and relocked nutrients. Xylanase and β -glucanase degrade non starch polysaccharides in feeds. Phytase efficiently releases bound phosphorus from plant phytatae and also liberates minerals and amino acids.

2.8.4.1 Benefits of enzyme utilization in monogastric animal diets

Not all compounds in animal feed are broken down by animals' own digestive enzymes, and so some potential nutrients are unavailable to the animal (McDonald *et al.*, 2010). To alleviate this problem, in the 1950s, pioneering scientists added enzymes called amylases and proteases to the diets of various farm animals and observed benefits in productivity. Feed enzymes help fundamentally to improve the efficiency of meat and egg production by changing the nutrient

profile of feed ingredients (Bedford and Partridge, 2010). Enzymes are most commonly used when the dietary ingredients contain relatively higher amounts of fibre (Bedford, 2000). For example, the various forms of fibre in pig diets will not be well digested by the pig; as a result, a large portion of the fibre in the diet passes through the small intestine intact, and the only breakdown that can occur is through fermentation by bacteria and yeast in the caecum and large intestine. Among monogastric animals pigs and poultry are important beneficiaries these days from exogenous enzyme treatment diets, and are even used extensively for the latter (McDonald *et al.*, 2010). The benefits of enzyme utilization in monogastric diets include the following; optimization of metabolizable energy and feed conversion efficiency, increased use of low cost non- conventional feed ingredients, reduction in requirement of di-calcium phosphate (DCP) or bone meal in feed, significant improvement in better quality and dropping consistency of faeces, improvement in weight gain, improvement in egg production and shell quality.

Monogastric animals do not have the endogenous enzymes to hydrolyse non-starch polysaccharides contained in fibrous feed materials as seen in Table 2.2.

2.8.5 Sources of supplementary enzymes

Commercial enzymes are mostly derived from fungal and sometimes from other sources such as protozoans which are cultured and the enzymes produced by these microbes extracted from the culture. Some of the available supplementary enzymes and their origins are presented in Table 2.3.

2.8.6 Mechanism of enzyme actions

Enzyme action involves the formation of a complex between the enzyme and the substrate to be acted upon. The complex then undergoes breakdown yielding the products and the unchanged enzyme. The complexes are formed between the substrate or substrates and relatively few active centres on the enzyme (McDonald *et al.*, 1983) It may be due partly through the mechanism of decreasing digester viscosity (Dingle, 1995). Sundu *et al.* (2005a) reported that using mannan degrading enzymes reduce jejunal digesta viscosity of birds fed palm kernel meal diet by 3 – 4%. When mannan degrading enzymes were used in combination with a mixed enzyme preparation (Maxigrain®) a greater reduction of about 27% was found in jejunal digesta viscosity.

Since the use of mannan degrading enzymes increased digestibility of dietary fibre, (NDF), protein and lipid, this may indicate that protein and lipid are located inside the cell walls that contain mannan. So when mannan is broken down by exogenous enzymes, the access of endogenous protease and lipase to attack protein and lipid is enhanced. When a combination of enzymes containing mannan degrading enzymes and a multi-enzyme preparation (Allzyme SSF) was used, dry matter digestibility and NDF digestibility were further increased. The increase in nutrient digestibility probably helped to increase the apparent metabolizable energy of a palm kernel meal supplemented with enzyme. Importantly the moisture content of faeces was drastically reduced by 16-23% when mannan degrading enzymes were included in palm kernel meal diets (Sundu *et al.*, 2004b). This is beneficial to the problem of coping with wet faeces, one of the main challenges facing the poultry industry today.

Table 2.2: Endogenous Enzymes in Poultry

Organ	Enzyme produced	Substrate acted upon	End product
1. Mouth (Saliva)	Alpha amylase	Starch	Glucose, Maltose, Dextrins
2. Proventriculus	Pepsin	Protein	Peptides
3. Pancrease	Amylase	Starch	Glucose, Maltose, Limit Dextrins
	Lipase	Fat	Fatty acids, Monoglycerides
	Trypsin/Chymotrypsin/Elastase/Carboxypeptidase	Proteins /Peptides	Amino acids and small peptides
4. Intestinal Mucosa	Oligo-1,6- glucosidase	Dextrin	Glucose
	Maltase	Maltose	Glucose
	Sucrase	Sucrose	Glucose
	Amino-peptidase	Peptides	Amino acids
	Dipeptidases	Dipeptides	Amino acids

Source: Card and Neshien (1972)

Table 2.3: Sources of Supplementary Enzymes

Enzyme	Origin
1. Xylanase	<i>Bacillus subtilis</i>
2. Hostazyme	<i>Trichoderma longibrachiatum</i>
3. Avizyme	<i>Trichoderma longibrachiatum</i>
4. Natugrain	<i>Trichoderma longibrachiatum</i>
5. Allzyme	<i>Aspergillus niger</i>
6. Grindazyme	<i>Aspergillus niger</i>
7. Roxazyme	<i>Trichoderma viride</i>
	<i>Trichoderma longibrachiatum</i>
8. Biofeed	<i>Humicola insolens</i>
9. Maxigrain	<i>Aspergillus oryzae</i>

Source: Bio-ingredient Ltd (2000) (Unpublished data)

2.9 Responses to Enzyme Treatment by Chickens

2.9.1 Broiler chickens

One of the main reasons for supplementing wheat and barley-based poultry diets with enzymes is to increase the available energy content of the diet and increase energy digestibility (Partridge and Wyatt, 1995 and Ven der Klis *et al.*, 1995). Enzyme treatment improves carbohydrates digestibility, reduces gut viscosity, and improves fat utilization (Almirall *et al.*, 1995). The improvements from enzyme treatment are variable because of the variability in the NSP content of wheat. Classen *et al.* (1995), Schuttle *et al.* (1995) and Ven der klis *et al.* (1995) reported improvements of 5-16%, 3.1-4.5%, and 4.5-12.4% respectively. The increase in available metabolizable energy with the use of enzymes is difficult to predict, as nutrient ratios, such as energy: protein and other factors also play an important part in poultry-feed formulations. The importance of energy compensation in feed formulation was demonstrated in a cost-benefit study in Australia in 1991 (unpublished data). A wheat-based diet was formulated with or without enzyme treatment, a 5% increase in AME was observed in the diets with enzyme treatment, without compensating for the result of improved growth and-feed efficiency, the cost per kilogram broiler in the enzyme-treated group was 1.3% lower than in the wheat-control group. Compensating for the additional energy further improved production characteristics and also reduce feed cost, giving a reduction in cost per kilogram broiler of 8.8% compared with the wheat control. Partridge and Wyatt (1995) reported similar benefits when allowances were made for the improvements in energy and amino acid digestibility. The problem facing the feed formulator is estimating the correct energy allowance for wheat-based diets. Typically, a

conservative 5-6% upgrading of the AME of wheat is recommended for commercial situations. This allowance effectively improves the energy value of wheat to about 13800KJ/kg in a least-cost matrix, bringing the value of a wheat-enzymes combination closer to that for maize and allowing the use of less supplementary energy. Amino acid adjustments may also be made, as enzyme treatment also improves protein digestibility (Bedford, 1992; Patridge and Wyatt, 1995). Typically, the digestibility of proteins should be expected to increase by 10% with added enzymes (Bedford, 1992; Ward, 1995). Responses to enzyme treatment depend on the bird's age, which is apparently related to both the type of gut micro-flora present and the physiology of the bird. Older birds, because of the enhanced fermentation capacity of the micro-flora in their intestines, have a greater capacity to deal with negative viscosity effects (Vukic Vranjes and Wenk 1993; Allen *et al.*, 1995; Choct *et al.*, 1995).

The dry matter content of the litter of wheat-or barley-fed broilers is improved (reduced sticky droppings) by adding enzymes to their diets (Wiedmer and Volker, 1989; Jansson *et al.*, 1990; Mohammed, 1995). The improved litter condition reduces ammonia build up in sheds and reduces the incidence of hock burns and breast blisters. Also birds fed high-barley or high-wheat diets have been shown have elevated intestinal weight, which negatively affects the carcass yield. This negative effect was reduced after supplementation with the appropriate enzymes (Francesch *et al.*, 1989; Jeroch and Danicke, 1993). It has been suggested that supplementation with enzymes could increase the energy available in wheat by 6-8% and would result in growth rates similar to, and feed: gain ratios better than, those obtained with a control wheat diet as can be seen in Table 2.4.

2.9.2 Laying hens

The responses of laying hens to enzyme-supplemented feeds are also well documented. Typically, enzymes added to layer feed appear to have little effect on egg mass but improve feed efficiency (Benabdeljelil and Arbaoui, 1994; Vukic Vranjes and Wenk, 1993), energy utilization (Wyatt and Goodman, 1993; Vukic Vranjes and Wenk, 1993), and laying rate (Poultry International, 1996). Wyatt and Goodman (1993) reported that corn-fed layers exhibited better feed efficiency than those fed enzyme-supplemented barley-based diet.

Studies have shown that nutritive value of feedstuffs such as barley, wheat, rye, lupin, corn, soy bean meal have been improved using several exogenous enzymes (McCracken and Quintin, 2000; Preston *et al.*, 2000; Hughes *et al.*, 2000; Lazaro *et al.*, 2003 and Danicle *et al.*, 2003). Bekatorou *et al.* (2007) upgraded the nutritional value of Brewery Spent Grain (BSG) and Malt Spent Rootlets (MSR) through treatment with *Aspergillum oryzae*, *A. awamori* and *Phanerochaete chrysosporium* (white rot-fungus) for animal feed production. These authors also reported that the used BSG has a moisture content of about 60%. This is to allow cultured fungi to efficiently metabolize the BSG. However, limited efforts have been shown to improve the nutritional value of commonly available cheap agro industrial by-products such as wheat offal, corn bran and brewery dry grain. Wheat Offal (WO) and Corn Bran (CB) are by-products of milling process for wheat and corn respectively, while Brewer Spent Grain (BSG) is produced in the mashing stage in beer production (Bekatorou *et al.*, 2007). When BSG is properly dry, it is known as Brewery Dry Grain (BDG). BSG consist of about (%w/w on dry matter) 16-25% cellulose, 12-28% lignin, 11-26% apparent starch (glucose, maltodextrins and residual starch), 15-25% crude protein, 15-20% crude fibre, 6-10% digestible fibre, 6-10% lipids and 3- 5% total ash (Bekatorou *et al.*, 2007)

Table 2.4: Evaluation of male-broiler performance when nutrient matrix is upgraded in an enzymes-supplemented wheat-based diet

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

Source: Guenter, 1994, University of Manitoba.

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

Nevertheless, enzyme supplementation improved the utilization of barley diets. Increased energy utilization in laying hens appears to be due to microbial fermentation of solubilized NSPs (Vukic Vranjes and Wenk, 1993) and the subsequently higher absorption of volatile fatty acids (Choct *et al.*, 1995). Wet litter arising from the use of barley and newly harvested wheat could result in an increased incidence of dirty egg shells and ammonia build up in poultry pens. Adding enzymes to both wheat and barley-based diets has been shown to reduce the moisture content of fecal matter in layers (Marquardt *et al.*, 1994) this means that barley could effectively be used if diets were supplemented with the appropriate enzymes.

Egg-yolk pigmentation should also be considered if maize was excluded from the diets. Wheat and barley contain very low levels of xanthophylls and if these grains were fed to layers, the yolk would be practically colourless and consumers would reject them. The diets therefore need to be supplemented with dietary carotenoids. The quantity required is well documented because of the extensive use of wheat and barley in the layer feed (Bird, 1994). Pigments are fat-soluble compounds and are therefore less efficiently absorbed in the presence of highly viscous compounds such as those found in barley-based diets (Benabdeljelil and Arbaoui, 1994; Poultry International, 1996). Therefore, if barley and wheat-based diets are being supplemented with enzyme where yolk coloration is desired, appropriate pigments should be added.

2.10 Enzyme Supplementation and Improved Poultry Health

Morgan and Bedford (1995) reported that coccidiosis problems could be prevented by using enzymes. Birds fed a wheat-based diet with or without enzyme (glycanase) supplementation showed vastly different responses to coccidiosis challenge. Growth was depressed by 52.5% in

the control group but by only 30.5% in the enzyme supplemented group, which also had a much better lesion score. An increase in digesta passage rate and a reduction in excreta moisture were often noted when enzymes were added to poultry diets, which may be detrimental to the life cycle of the organism (Ravindran *et al.*, 1999).

Elevated levels of intact soluble NSPs detrimentally increased the activity of fermentative microorganisms in the small intestine. Enzyme (xylanase) supplementation largely eliminated fermentation in the small intestine and improved the performance of the birds. A reduction in the moisture content of poultry excreta was often noted when enzymes (glycanases) were included in the diet (Kornegay, 2001).

2.11 Enzyme Synergy with Antibiotics

Researchers have observed a synergistic response to antibiotic and enzyme supplements in broiler feeds containing wheat (Schurz *et al.*, 1993; Broz and Perrin-Voltz, 1994; Allen *et al.*, 1995; Choct *et al.*, 1995; Langhout and Schutte, 1995; Pijssel, 1996) and in those containing barley (Broz and Perrin-Voltz, 1994; Vukic Vranjes and Wenk, 1993).

Typically, weight-gain and feed conversion responses are observed for each supplement, with a degree of non-additive synergism. The importance of established gut microflora in the digestion of fibre is greater in older birds than younger birds, with the positive effects of enzymes in layers appearing to activate microflora to degrade the NSP solubilized by enzyme action (Choct *et al.*, 1995). The beneficial effects of enzymes in barley-fed layers could be eliminated by the addition of flavomycin, a compound that reduced the fermentative capability of gut micro-flora (Vukic Vranjes and Wenk, 1993). Allen *et al.* (1995) reported that the inclusion of antibiotics in the

gut of broilers not only improved production parameters, including weight gain, but also increased the viscosity of digesta. This result is the opposite of that observed when enzymes are added to the diet. These data indicated that both high and low viscosities are associated with improved nutrient utilization. Presumably, enzymes and antibiotics have different modes of action and therefore increase nutrient utilization in different pathways.

2.12 Future Prospects of High Fibre Feed Resources

2.12.1 The use of NSP as energy sources

Large amounts of grain by-products, such as wheat bran and rice bran, and non-conventional ingredients, such as malted sorghum sprout, copra meal (coconut) and sunflower meal, are available for use in poultry diets in many parts of the world, but these materials are characterized by their by-products containing large amounts of arabinoxylans and cellulose as the main NSP. The structure of polymers is well characterized and the enzyme technology is available for a complete breakdown of these substrates. Cellulose is a straight chain 1-4 glucan and requires a combination of cellobiohydrolase, endoglucanase and 3-glucanases. Rice bran, for instance, contains approximately 20-25% NSP, half of which is cellulose (Saunders. 1986). Copra meal and palm kernel meal contain high levels of mannans and galactomannans, with a total NSP level reaching 70%. Of particular significance is the increased use of grains for biofuel production, which yields the so-called distillers' grains. Distillers dry grains (DDGs) accounts for approximately 30% of dry grains for ethanol production, and it contains 25-28% protein, 8-9% fat, the remainder is believed to be NSP. These figures agree well with the 42.1% NDF content reported for

DDGs (Spiehs *et al.*, 2002). It is estimated the world produces as much as 60 million tons of DDGs each year. The nature of the NSP is not known, but it may be deduced that they would be composed mainly of cellulose and arabinoxylans. Currently DDGs is used predominantly in cattle feed although in some countries it is also used in swine rations. The potential of using enzymes to DDGs for the release of metabolisable energy for monogastric animals is enormous. However, the current enzymes are not designed to degrade NSP to monomeric sugars within the food transit time of the chicken and pre-treatment is necessary in order to yield sophisticated enzymes and fine-tuning of pre-treatment -procedures. All these NSP not only represent a large source of potential energy but also prebiotics with specific functions for poultry.

2.13 Tailoring Enzymes for their Secondary Effects

It is possible that the digestibility of feed components could be tailored to produce end products with specific effects on the gut micro-flora and the immune system. Austin *et al.* (1999) reported that a single cloned endo. 1-4 xylanase produced much the same range of oligosaccharides from different types of wheat fed to chickens. This means that a specific range of oligomers can be produced from a given NSP source in-situ with a particular enzyme. Some of these carbohydrates may be used to stimulate the development of beneficial micro-flora in the gut. The gut harbours a highly evolved and complex microbial ecosystem containing a vast number of diverse populations. For example, microbes make up approximately 60g/kg of the wet weight of poultry excreta. The proper feeding of poultry should therefore consider the provision of "correct" substrates for the micro-flora to keep it stable. The consequences of altered rate of nutrient digestion in the gut may be manifested in the number and type

of microorganisms present in the gut. Production of xylo-oligosaccharides by the use of xylanases in wheat-based diets could be one way to encourage the development of a healthy gut micro flora (Vahjen *et al.*, 1998). Indeed, the direct benefit of enzyme supplementation for poultry health has been demonstrated. Thus, Sinlae and Choct (2000) demonstrated that broilers fed a wheat-based diet with xylanase had a negligible number of *Clostridium perfringens* compared with the control birds. A more detailed study by Bedford and Apajalahti, (2002) showed that xylanase supplementation of birds fed wheat-based diets markedly reduced the coliforms, lactic acid bacteria, enterococci and the total bacterial count in the small intestine. Another example is the use of specific carbohydrate entities to boost the immune system or reduce the load of pathogens in the gut. Manno-oligosaccharides have been reported to enhance the immune functions in poultry (Spring *et al.*, 2000). Producing specific manno-oligomers from copra meal and palm kernel meal in situ is possible.

2.14 Deactivation of Anti-nutrients in Feed

In addition to NSP, many feed ingredients contain a number of anti-nutritive factors. These include inhibitors of various digestive enzymes (protease inhibitors), polyphenolics (lignin and tannins), lectins, alkaloids, saponins and glucosinolate. For example, breakdown of glucosinolate in rapeseed using thioglucosidase has been tried (Lawrence *et al.*, 1995; Huo *et al.*, 1993) demonstrated that trypsin inhibitors in soybean were completely deactivated by a protease within 80 minutes *in vitro*. Another exciting area of development will be the use of specific strains of micro-organisms that produce a high level of enzymes as feed additives. Copper *et al.* (1995) applied such an approach to degrade an anti-nutrient in pasture species, fluoroacetate, which is a significant problem in Africa, Central

America and Australia. Under a strictly controlled experimental condition, they used a strain of rumen bacterium *Butyrivibrio fibrisolvens* which was genetically engineered to produce an enzyme to degrade fluoroacetate. The approach was highly effective.

It is envisaged that in the near future enzymes that are more stable and can withstand pelletisation of feed would be developed. Enzymes with longer shelf life are also expected as researchers also look for other non-conventional sources of producing enzymes for industrial use at cheaper cost. Enzymes will play very vital roles in animal feed production and invariably human nutrition.

In Nigeria, both human and animals especially monogastrics compete for the same energy rich foods, but with the use of enzymes, more food will be made available for human use as the inclusion rate of high fibre diet in monogastric feed is increased.

The importation of animal feed grade wheat in Nigeria has been increasing steadily. To get the best out of animal feed grade wheat there is need to appropriate enzymes. The consumption of a high fibre diet is known to increase faecal moisture content (Atteh, 2003). Wet litter leads to increased incidences of bacterial and protozoan diseases. The use of enzymes reduces wet faecal droppings which is beneficial in wet humid tropical environment like Nigeria.

Various low-energy raw material feed ingredients such as brewer's dry grain (BDG), palm kernel meal (PKM), rice offal (RO), maize offal (MO) and other offal's abound in Nigeria. The use of supplementary enzymes complexes used as feed additives will offer a practical means of enhancing their nutritive quality. It is also envisaged that in future, enzymes that are mostly derived from fungal, bacterial and at times other sources such as protozoans will be cultured and extracted locally in Nigeria, making them cheaper and readily available. Enzymes will play an indispensable role in 21st century animal production.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Experimental Site

The experiment was conducted at the Teaching and Research Animal Farm of the Department of Animal Science, Ahmadu Bello University, Samaru-Zaria located within the Northern Guinea Savannah zone on latitude $11^{\circ} 9' 45''$ N and longitude $7^{\circ} 38' 8''$ E, with an altitude of 610m above sea level (Ovimaps, 2012).

3.1.1 Source of Experimental Birds

All birds used in this study were of Hubbard flex® breed obtained from Zarm Farms Ltd. Ilemona Offa, Kwara State.

3.1.2 Source and Processing of Malted Sorghum Sprout

Malted sorghum Sprout was sourced from Nigerian Breweries Plc Kakuri-Kaduna. It was dried in the sun for four days and then incorporated into broiler diets.

3.2 Laboratory Analysis

3.2.1 Proximate and Anti-Nutritional Factor Analyses

The proximate composition of malted sorghum sprout (MSS) was determined at the Biochemical Laboratory of the Department of Animal Science, Ahmadu Bello University Zaria. The analysis for each of the samples was done in triplicates.

The nitrogen content was determined using the macro Kjeldahl method of A.O.A.C. (1990) and Crude protein (CP) calculated as $N \times 6.25$. The Ash content was determined as the residue remaining after incinerating sample at 600 °C for 3 hours in a Muffle Furnace. The A.O.A.C (1990) method was employed for the Ether Extract (EE) and Crude Fibre determinations. Anti-nutritional factors content were determined at the Food Science Laboratory of Department of Animal science, Ahmadu Bello University, Zaria.

3.3 Experiment 1:- Effect of feeding varying levels of malted sorghum sprout on growth Performance of broiler chicks (0 - 4 weeks)

3.3.1 Design and Management of Experimental Birds

Two hundred and seventy (270) day - old broiler chicks were used in this study. The birds were assigned in a Completely Randomized Design (CRD) to five dietary treatments with three replicates consisting of 18 birds. The birds in each replicate were kept in compartments measuring 2m x 3m. Electric and kerosene stoves were used as heat sources for chicks at the brooding phase. All necessary routine management practices of sanitation, standard medication and vaccination (Intra ocular, Lasota and Gumboro) were administered at the appropriate time and recommended rates. Feed and water were provided *ad libitum*. The birds were weighed at the beginning of the trial and weekly thereafter. Weight gain, feed intake, feed conversion ratio, cost per kg weight gain were calculated. Mortality records were kept for duration of experiment. The feeding trial lasted for 28 days.

3.3.2 Experimental Diets

Five isonitrogenous diets (23% CP) were formulated comprising the following; Diet 1: maize based diet without MSS (Control), Diet 2: 5% MSS, Diet 3: 10% MSS , Diet 4: 15% MSS, Diet

5: 20% MSS and their proximate composition are shown in Tables 3.0 and 3.1. The diets were formulated to meet the nutrient requirement standards (NRC, 1994).

3.4 Experiment 2:- Effect of feeding varying levels of malted sorghum sprout on growth Performance of broiler finisher (5 - 9 weeks)

3.4.1 Design and Management of Experimental Birds

Two hundred and forty (240) broiler finisher chickens obtained from Experiment 1 were used for this study. At the end of the first trial, the birds were pooled together and placed on a common diet devoid of MSS for one week. The birds were subsequently allotted to five dietary treatments of 48 birds with three replicates of 16 birds each in a completely randomized design (CRD) and relative weights were matched for all treatments. All routine management and medications were carried out.

Feed and water were provided *ad libitum* while the amount of feed given and left over recorded. Birds were weighed at the beginning of the trial and weekly thereafter until they were 9 weeks. Weight gain, feed intake, feed conversion ratio, cost per kg weight gain were recorded and computed as required. Mortality records were kept for duration of experiment and expressed as a percentage of the total number of birds per treatment at the end of the experiment.

3.4.2 Experimental Diets

Five isonitrogenous (20% CP) were formulated comprising the following; Diet 1: maize based diet without MSS (Control), Diet 2: 5% MSS, Diet 3: 10% MSS , Diet 4: 15% MSS and Diet 5: 20% MSS in diets and their proximate composition are shown in Tables 3.2 and 3.3. The diets were formulated to meet the nutrient requirement standards (NRC, 1994).

Table 3:0: Composition of Starter Diet (0-4weeks) Containing MSS

Feed Ingredients (kg)	Dietary Levels of MSS %				
	0%	5%	10%	15%	20%
Maize	54.40	50.90	47.40	43.40	40.40
Malted sorghum sprout	0.00	5.00	10.00	15.00	20.00
Groundnut cake	21.00	19.50	18.00	17.00	15.00
Soyabean cake	20.00	20.00	20.00	20.00	20.00
Limestone	0.50	0.50	0.50	0.50	0.50
Bone meal	3.00	3.00	3.00	3.00	3.00
Salt	0.30	0.30	0.30	0.30	0.30
Lysine	0.30	0.30	0.30	0.30	0.30
Methionine	0.20	0.20	0.20	0.20	0.20
Premix*	0.30	0.30	0.30	0.30	0.30
Total	100	100	100	100	100
Calculated Analysis					
Metabolisable Energy (kcal/kg)	2859	2858	2857	2851	2856
Crude protein (%)	23.23	23.21	23.20	23.35	23.17
Crude fibre (%)	4.12	4.55	4.98	5.43	5.84
Ether extract (%)	4.67	4.50	4.33	4.17	3.99
Calcium (%)	1.05	1.05	1.06	1.07	1.07
Avail Phos (%)	0.52	0.53	0.54	0.55	0.57
Meth + Cys (%)	0.87	0.89	0.91	0.94	0.95
Lysine (%)	1.32	1.33	1.34	1.36	1.37
Cost/kg of diet (₦/kg)	82.28	79.41	76.53	73.78	70.78

*Biomix premix supplied per kg of diet: Vit. A,10000IU; Vit D₃ 2000iu; Vit E 23mg; Vit K 2mg; calcium pantothenate 2.5mg; Vit B₁₂,0.051mg; Folic acid 0.75mg; Chloride 300mg; Vit B₁ 1.8mg; VitB₂ 5mg; manganese 40mg; iron 20mg; zinc 30mg; copper 3mg; iodine 1mg; cobalt 0.2mg.

Table 3:1: Proximate composition of diets containing varying levels of malted sorghum Sprout used at the starter phase in Experiment 1

PARAMETERS	Dietary levels of MSS%				
	0%	5%	10%	15%	20%
Dry matter (%)	91.60	91.95	92.23	91.68	93.01
Crude Protein (%)	23.67	23.31	23.83	23.34	23.37
Crude Fibre (%)	7.37	7.50	8.00	7.63	7.01
Ether Extract (%)	5.88	6.25	6.12	5.76	5.66
Total Ash (%)	5.30	5.55	5.60	6.36	5.98
Nitrogen Free Extract(%)	57.78	56.39	56.46	56.91	57.98

Table 3:2: Composition of Experiment 1 broiler finisher diet (5-9wks) containing MSS

Feed Ingredients (kg)	Dietary levels of MSS,%				
	0%	5%	10%	15%	20%
Maize	60.40	56.90	53.40	49.40	46.40
Malted sorghum sprout	0.00	5.00	10.00	15.00	20.00
Groundnut cake	15.00	13.50	12.00	11.00	9.00
Soyabean cake	20.00	20.00	20.00	20.00	20.00
Limestone	0.50	0.50	0.50	0.50	0.50
Bone meal	3.00	3.00	3.00	3.00	3.00
Salt	0.30	0.30	0.30	0.30	0.30
Lysine	0.30	0.30	0.30	0.30	0.30
Methionine	0.20	0.20	0.20	0.20	0.20
Premix*	0.30	0.30	0.30	0.30	0.30
Total	100	100	100	100	100
Calculated Analysis					
ME (kcal/kg)	2922	2921	2920	2914	2918
Crude protein (%)	21.19	21.17	21.16	21.31	21.13
Crude fibre (%)	3.89	4.32	4.75	5.20	5.62
Ether extract (%)	4.54	4.37	4.20	4.04	3.86
Calcium (%)	1.04	1.04	1.05	1.06	1.06
Phosphorus (%)	0.51	0.52	0.54	0.55	0.56
Meth + Cys (%)	0.82	0.84	0.86	0.89	0.90
Lysine (%)	1.23	1.25	1.26	1.28	1.29
Cost/kg of diet (₦/kg)	80.78	77.91	75.03	72.28	69.28

*Biomix premix supplied per kg of diet: Vit. A,10000iu; Vit D₃ 2000iu; Vit E 23mg; Vit K 2mg; calcium pantothenate 2.5mg; Vit B₁₂,0.051mg; Folic acid 0.75mg; Chloride 300mg; Vit B₁ 1.8mg; VitB₂ 5mg; manganese 40mg; iron 20mg; zinc 30mg; copper 3mg; iodine 1mg; cobalt 0.2m

Table 3:3: Proximate composition of diets containing varying levels of malted sorghum sprout used at the finisher phase in Experiment 2

PARAMETERS	Dietary levels of MSS %				
	0%MSS	5%MSS	10%MSS	15%MSS	20%MSS
Dry matter (%)	93.11	92.65	91.23	92.70	92.01
Crude Protein (%)	21.36	21.41	21.33	21.39	21.27
Crude Fibre (%)	4.13	4.89.	5.10	4.77	5.34
Ether Extract (%)	4.89.	4.25	4.12	3.99	4.00
Total Ash (%)	5.38	5.16	5.75	6.14	6.08
Nitrogen Free Extract(%)	58.25	57.65	56.79	57.91	56.98

3.4.3 Blood Sampling and Analysis

At the end of the 28-day feeding trial, 2mls of blood samples were collected from two birds per replicate and put into Ethylene Diamine Tetra Acetic Acid (EDTA) treated Bijou Bottles (1mg/ml) for haematological and plain bottles for serum biochemistry analysis. Blood Samples were analysed within 3 hours of their collection at the Haematological Laboratory, Veterinary Teaching hospital, Ahmadu Bello University, Zaria. for; Total protein (TP), Haemoglobin concentration (Hb) and packed cell volume (PCV) using the procedure outlined by Lamb (1991)

3.4.4 Carcass Evaluation

At the end of the feeding trial, three birds were selected based on the average group weight from each replicate. They were fasted by withdrawal of feed only overnight, weighed, slaughtered and dressed at the Animal Products Laboratory of the Department of Animal Science, Ahmadu Bello University, Zaria.

Carcass weights, cut – up parts and organ weights were recorded. The prime cuts were all expressed as a percentage of dressed weight and organs as a percentage of live weight.

3.5 Experiment 3:-Effects of enzyme treatment of malted sorghum sprout based diets on performance of broiler chicks (0-4weeks)

3.5.1 Design and management of experimental birds

Two hundred and seventy (270) day - old broiler chicks Hubbard flex® breed were used in this study. The birds were assigned in a completely randomized design (CRD) to five dietary treatments with three replicates consisting of 18 birds each and replicates were kept in

compartments measuring 2m x 3m. Electric heaters and coal pots were used as heat sources for heating during the brooding phase. All necessary routine management practices of sanitation, standard medication and vaccination (intra ocular, Lasota and Gumboro) were administered at the appropriate time. Feed and water were provided *ad libitum*.

3.5.2 Data Collection

The birds were weighed at the beginning of the trial and weekly thereafter. Weight gain, feed intake, feed conversion ratio, cost per kg weight gain were documented. Mortality records were kept for duration of experiment. The feeding trial lasted for 28 days (4 Weeks).

3.5.3 Experimental Diets

Five experimental starter diets were formulated such that Diet 1, was the control without malted sorghum sprout, Diets 2 and 3 had 10% inclusion levels of malted sorghum sprouts, respectively and Diets 4 and 5 had 15% levels of malted sorghum sprouts, respectively but with enzyme incorporated in Diets 3 and 5 at the rate of 0.01%.

The experimental procedures were as described in Experiments 1 and 2 with the difference being the incorporation of enzyme in two of the three least performing treatments.

Table 3:4: Composition of broiler starter diet (0-4weeks) containing MSS and Maxigrain® enzyme

Feed Ingredients (kg)	Dietary levels of MSS%				
	0%MSS	10%MSS	10%+E	15%MSS	15%+E
Maize	54.40	47.40	47.40	43.40	43.40
Malted sorghum sprout	0.00	10.00	10.00	15.00	15.00
Groundnut cake	21.00	18.00	18.00	17.00	17.00
Soyabean cake	20.00	20.00	20.00	20.00	20.00
Limestone	0.50	0.50	0.50	0.50	0.50
Bone meal	3.00	3.00	3.00	3.00	3.00
Salt	0.30	0.30	0.30	0.30	0.30
Lysine	0.30	0.30	0.30	0.30	0.30
Methionine	0.20	0.20	0.20	0.20	0.20
Premix*	0.30	0.30	0.30	0.30	0.30
Total	100	100	100	100	100
Calculated Analysis					
ME (kcal/kg)	2859	2857	2857	2851	2851
Crude protein (%)	23.23	23.20	23.20	23.35	23.35
Crude fibre (%)	4.12	4.98	4.98	5.43	5.43
Ether extract (%)	4.67	4.33	4.33	4.17	4.17
Calcium (%)	1.05	1.06	1.06	1.07	1.07
Avail Phos (%)	0.52	0.54	0.54	0.55	0.55
Meth + Cys (%)	0.87	0.91	0.91	0.94	0.94
Lysine (%)	1.32	1.34	1.34	1.36	1.36
Cost/kg of diet (₹/kg)	82.28	76.53	76.53	73.78	73.78

*Biomix premix supplied per kg of diet: Vit. A,10000IU; Vit. D₃ 2000iu; Vit. E 23mg; Vit. K 2mg; calcium pantothenate 2.5mg; Vit. B₁₂,0.051mg; Folic acid 0.75mg; Chloride 300mg; Vit. B₁ 1.8mg; vitB₂ 5mg; manganese 40mg; iron 20mg; zinc 30mg; copper 3mg; iodine 1mg; cobalt 0.2mg, +E= Plus Enzyme

3.6 Experiment 4:-Effects of enzyme treatment of malted sorghum sprout based diets on performance of broiler finisher chickens (5-9weeks)

3.6.1 Design and Management of Experimental Birds

Two hundred and forty (240) day - old broiler chickens from experiment three were used in this study. The birds were pooled together and fed a basal diet for a week and then assigned in a completely randomized design (CRD) to five dietary treatments with three replicates consisting of 16 birds each and replicates were kept in compartments measuring 2m x 3m. Feed and water were provided *ad libitum*.

3.6.2 Data Collection

The birds were weighed at the beginning of the trial and weekly thereafter. Weight gain, feed intake, feed conversion ratio, cost per kg weight gain were calculated. Mortality records were kept for duration of experiment. The feeding trial lasted for 28 days (4 Weeks).

3.6.3 Experimental Diets

Treatments from Experiment 2 showing optimum level of inclusion will be fed to broiler finisher chickens for 28 days with enzyme treatment at 0.01%. Percent ingredients are shown in Table 3.5.

Table 3:5: Composition of broiler finisher diet (5-9wks) containing MSS and Maxigrain® enzyme

Feed Ingredients (kg)	Dietary inclusion levels MSS%				
	0%	10%	10%+E	15%	15%+E
Maize	60.40	53.40	53.40	49.40	49.40
Malted sorghum sprout	0.00	10.00	10.00	15.00	15.00
Groundnut cake	15.00	12.00	12.00	11.00	11.00
Soyabean cake	20.00	20.00	20.00	20.00	20.00
Limestone	0.50	0.50	0.50	0.50	0.50
Bone meal	3.00	3.00	3.00	3.00	3.00
Salt	0.30	0.30	0.30	0.30	0.30
Lysine	0.30	0.30	0.30	0.30	0.30
Methionine	0.20	0.20	0.20	0.20	0.20
Premix*	0.30	0.30	0.30	0.30	0.30
Total	100	100	100	100	100
Calculated Analysis					
Metabolizable energy (kcal/kg)	2922	2920	2920	2914	2914
Crude protein (%)	21.19	21.16	21.16	21.31	21.31
Crude fibre (%)	3.89	4.75	4.75	5.20	5.20
Ether extract (%)	4.54	4.20	4.20	4.04	4.04
Calcium (%)	1.04	1.05	1.05	1.06	1.06
Phosphorus (%)	0.51	0.54	0.54	0.55	0.55
Meth + Cys (%)	0.82	0.86	0.86	0.89	0.89
Lysine (%)	1.23	1.26	1.26	1.28	1.28
Cost/kg of diet (₦/kg)	80.78	75.03	75.03	72.28	72.28

*Biomix premix supplied per kg of diet: Vit. A,10000IU; Vit D₃ 2000iu; Vit E 23mg; Vit K 2mg; calcium pantothenat 2.5mg; Vit B₁₂,0.051mg; Folic acid 0.75mg; Chloride 300mg; Vit B₁ 1.8mg; Vit B₂ 5mg; manganese 40mg; iron 20mg; zinc 30mg; copper 3mg; iodine 1mg; cobalt 0.2mg, +E= Plus Enzyme

3.6.4 Blood Sampling and Analysis

At the end of the 28-day feeding trial, 2mls of blood samples were collected from two birds per replicate and put into Ethylene Diamine Tetra Acetic Acid (EDTA) treated Bijou Bottles (1mg/ml) for haematological analysis and that for serum biochemistry also collected in plain bottles at the Haematological Laboratory, Veterinary Teaching hospital, Ahmadu Bello University, Zaria. Blood Samples were analysed within 3 hours of their collection for; Total protein (TP), Haemoglobin concentration (Hb) and packed cell volume (PCV) using the procedures outlined by Lamb (1991)

3.6.5 Carcass Evaluation

At the end of the feeding trial, three birds were randomly selected based on the average group weight of each replicate. They were fasted overnight as feed only was withdrawn, weighed, slaughtered and dressed at the Animal Products Laboratory of the Department of Animal Science, Ahmadu Bello University, Zaria. Carcass weights, cut-up parts and organ weights were recorded. Prime cuts were all expressed as a percentage of dressed weight and organ weights as percentage of live weight.

3.6.6 Statistical Analysis

Data generated from the study were subjected to analysis of variance (ANOVA) using the general linear model procedure of statistical analysis (SAS, 2002). Significant differences between treatment means were separated using Duncan's Multiple Range Test (Duncan, 1955). All statistical procedures were used as outlined by Steel and Torrie (1980).

The Linear model of the experiment was:

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

Y_{ij} = Performance of the j^{th} animal fed the i^{th} level of malted sorghum sprout

μ = Overall mean

n_i = Effect of the i^{th} level of malted sorghum sprout

e_{ij} = Random error

CHAPTER FOUR

4.0

RESULTS

4.1 Proximate and Anti-Nutrient Composition of Malted Sorghum Sprout

The proximate and anti-nutrient composition of MSS is shown in Table 4.1. The average dry matter content was determined to be 93.16%, crude fibre, 11.98%, nitrogen free extract, 66.47%, crude protein, 18.92%, ether extract 1.09% and total ash 6.11%. The anti-nutritional factor content of malted sorghum sprouts were tannin 2.318mg/g, phytic acid content of 60.80mg/100g and hydrogen cyanide content of 1.944 mg/g as shown in the Table 4.1.

4.2 Experiment 1: Effect of varying levels of Malted Sorghum Sprout on Performance of Broilers chicks (0-4 weeks)

Table 4.2 shows the performance of birds fed graded levels of malted sorghum sprouts. Birds fed diets containing 0 and 5% MSS had significantly ($P < 0.05$) higher final weight, weight gain and daily weight gain than those on diets 3, 4 and 5. Birds on diet 3 differed significantly ($P < 0.05$) from those on diets 4 and 5. Birds on diet 5 had the lowest values for final weight and daily weight gain and differed significantly ($P < 0.05$) from birds fed the other treatments. Dietary treatments had no significant ($P > 0.05$) effect on feed intake of birds for treatments 1 to 3 but varied significantly for 4 and 5. Feed intake numerically decreased with increase in malted sorghum sprouts inclusion except for birds fed diet 2 which ironically had the highest values for

feed intake and was significantly ($P < 0.05$) different from birds fed the other diets. A non-significant ($P > 0.05$) feed conversion ratio was observed between birds fed diet 1 and 2. Cost/Kg gain values tended to decrease as malted sorghum sprouts increased in the diets with birds fed diet 2 having significantly higher ($P < 0.05$) values than those on other diets, diet 1 differed ($P < 0.05$) from diets 3, 4 and 5 which were also statistically ($P < 0.05$) different. Cost/Kg gain values tended to increase as malted sorghum sprouts increased in the diets with birds on diet 5 having the highest cost/kg and significantly higher ($P < 0.05$) than those of other diets, while diet 2 had the least value in contrast birds fed diet 4 differed ($P < 0.05$) from those on diets 3, 2 and 1 which were statistically ($P > 0.05$) different. Percent mortality across treatments showed that birds on diet 1 were significantly ($P > 0.05$) higher than those on diets 2, 3, 4 and 5.

Table: 4.1: Proximate Metabolizable energy and anti-nutrition factor content of MSS

Parameters	Composition
Dry matter %	93.16
Crude protein %	18.92
Crude Fibre%	11.98
Ether Extract%	1.09
Ash%	6.11
NFE%	66.47
Metabolisable Energy (Kcal/kg)	3115
Anti-nutrients	
Tannin (mg/g)	2.378
Phytic acid (mg/100g)	60.80
Hydrogen Cyanide (mg/g)	1.94

Table 4.2: Effect of graded levels of MSS on the performance of starter Broiler chickens (1-4 weeks)

Parameter	Graded Levels of MSS (%)					SEM
	0	5	10	15	20	
Initial weight (g)	100	100	100	100	100	0.00
Final weight (g)	1102 ^a	1130 ^a	1016 ^b	819 ^c	616 ^d	36.21
Avg. feed intake (g/bird/day)	61.08 ^a	62.81 ^a	59.59 ^a	52.94 ^b	49.62 ^b	1.93
Avg. daily wt gn(g/bird/day)	35.78 ^a	36.77 ^a	32.71 ^b	25.69 ^c	18.44 ^d	1.29
Feed conversion ratio	1.71 ^a	1.71 ^a	1.82 ^b	2.06 ^b	2.76 ^c	0.142
Feed cost/kg gain (₦)	140.69 ^c	135.79 ^a	139.28 ^b	151.99 ^d	195.35 ^e	0.00
Mortality (%)	0.33 ^a	0.00 ^b	0.00 ^b	0.00 ^b	0.00 ^b	0.00

a, b, c,d,e = Means in the same row having different superscript are significantly different (P<0.05).

Avg. Daily wt gain= Average daily weight gain, SEM=Standard error of means

4.3 Experiment 2: Effect of varying levels of Malted Sorghum sprout on performance of Broiler finisher (5-9 weeks)

Table 4.3 shows the performance of broiler finisher fed graded levels of malted sorghum sprouts. Dietary treatments had effect on performance parameters of the birds. Birds fed diets 1 containing 0% MSS had significantly ($P<0.05$) higher final weight, weight gain and daily weight gain than those on diets 2, 3, 4 and 5. Birds on diet 2 differed significantly ($P<0.05$) from those fed diets 3, 4 and 5. Birds on diet 5 had the least values for final weight, weight gain and daily weight gain which differed significantly ($P<0.05$) from all other dietary treatments. Dietary treatments had significant ($P<0.05$) effect on feed intake of birds across the treatments. Feed intake decreased with increase in malted sorghum sprouts showing no significant ($P>0.05$) difference only between birds fed diets 1 and 2, which had the highest values for feed intake, then following in descending order where intake of birds placed on diets 3, 4 and 5 which were statistically different ($p<0.05$). A non-significant ($P>0.05$) feed conversion ratio was observed between diets 2, 3, 4 and 5. Cost/Kg gain values varied with diet significantly but no trend was evident. Percent mortality across treatments showed no significant ($P>0.05$) difference.

Table 4.3: Effect of graded levels of MSS on the Performance of Broiler finisher Chickens (5-9 wks)

Parameter	Graded Levels of MSS (%)					SEM
	0	5	10	15	20	
Initial weight (g)	1265	1267	1265	1266	1264	0.00
Final weight (g)	2331 ^a	2179 ^b	1990 ^c	1986 ^d	1888 ^e	1.48
Feed intake (g/bird/day)	140.81 ^a	140.69 ^a	124.39 ^b	109.13 ^c	105.75 ^d	1.54
Avg. daily wt gn(g/bird/day)	38.09 ^a	32.58 ^b	25.89 ^c	25.72 ^c	22.30 ^c	2.50
Feed conversion ratio	3.74 ^a	4.38 ^b	4.86 ^b	4.28 ^b	4.95 ^b	0.45
Feed cost/kg gain (₦)	286.79 ^a	323.36 ^b	344.98 ^b	291.30 ^a	322.70 ^b	30.58
Mortality (%)	0.00	0.00	0.00	0.00	0.00	0.00

a, b, c =Means in the same row having different superscript are significantly different (P<0.05).

Avg daily wt gn= Average daily weight gain

SEM=Standard error of means

4.4 Haematological and Serum biochemistry parameters of Broiler finisher fed graded Levels of MSS

Table 4.4 shows the effect of graded levels of malted sorghum sprout on the haematological and serum biochemistry parameters of broiler finisher. Dietary treatments had no significant ($P < 0.05$) effect on packed cell volume (25-27.67%) and Total protein (3.33-3.53 g/dl) but had significant difference on Haemoglobin (8.30-9.17). The Haemoglobin count of birds fed diet 2 was significantly ($P < 0.05$) lower than those on other dietary treatments while all others were statistically similar having means that did not differ significantly ($P > 0.05$) from each other.

Table 4.4: Haematological and serum biochemistry parameters of Broilers fed graded Levels of MSS at the finisher phase (9th week)

Parameter	Dietary Treatments with graded levels of MSS					SEM	Normal range
	0	5	10	15	20		
Packed cell volume (%)	27.00	25.00	27.33	25.67	27.67	1.24	24-31
Haemoglobin content (%)	8.97 ^a	8.30 ^b	9.1 ^a	8.53 ^a	9.17 ^a	0.42	7-13
Total protein (g/l)	3.33	3.33	3.33	3.53	3.47	0.29	3.31-5.39

a, b, c=Means in the same row having different superscript are significantly different (P<0.05).

SEM=Standard error of means

MSS =Malted Sorghum Sprouts

4.5 Carcass characteristics of broiler chicken fed diets containing graded levels of Malted sorghum sprouts

The result of carcass evaluation of broiler birds fed graded levels of malted sorghum sprouts is presented in Table 4.5. The result showed that there were no significant differences between live weights of treatments 1 and 2, which differed significantly ($P < 0.05$) from treatments 3, 4 and 5 with no significant differences observed between the latter three. Dietary treatments had no effect on dressing percentages across the treatments. Drumstick, thigh, heart, wings, back, neck, shank, lungs, liver, gizzard, spleen, intestinal weight and abdominal fat expressed as percentage of the live weights were significantly ($P < 0.05$) affected by the dietary treatments. However no definite trend was observed. Treatments were statistically ($P > 0.05$) the same for drumstick, back, wings, heart and lungs. These results showed that the breast, thigh, neck, shank, liver and abdominal fat weights were statistically ($P < 0.05$) different but no trend was observed.

Table 4.5: The effect of graded levels of Malted Sorghum Sprouts on the Carcass Characteristics of Broiler Finisher Chickens

Parameters	Trt1 0%MSS	Trt2 5%MSS	Trt3 10%MSS	Trt4 15%MSS	Trt5 20%MSS	SEM
Live weight(g)	2250.00 ^a	2176.70 ^a	1886.70 ^b	1960.00 ^b	1840.00 ^b	74.95
Dressed wt(g)	1588.05 ^a	1601.97 ^a	1364.46 ^b	1396.89 ^b	1290.76 ^c	57.51
Dressing %	70.58	73.62	72.32	71.27	70.15	2.67
Prime cuts as % of dressed weight and organs weight expressed as % of live weight (g)						
Breast	20.99 ^a	21.80 ^a	20.83 ^a	18.57 ^b	18.31 ^b	0.81
Drumsticks	9.85	9.69	10.05	9.68	9.46	0.71
Thighs	11.10 ^b	12.72 ^a	10.94 ^b	10.89 ^b	11.42 ^b	0.59
Wings	8.75	8.22	8.83	8.17	8.35	0.43
Organs weight						
Liver	1.79 ^c	1.95 ^c	2.48 ^a	2.38 ^{ab}	2.06 ^{bc}	0.2
Gizzard	2.44 ^{ab}	2.40 ^b	2.45 ^{ab}	2.48 ^{ab}	2.71 ^a	0.15
Spleen	0.15 ^b	0.21 ^a	0.19 ^a	0.15 ^b	0.18 ^{ab}	0.03
Heart	0.45	0.53	0.50	0.50	0.53	0.04
Lungs	0.71	0.66	0.67	0.65	0.65	0.06
Abdominal Fats	1.08 ^{bc}	2.03 ^a	0.83 ^c	0.98 ^{bc}	1.30 ^b	2.71

*Means within the same row with different superscripts differ significantly (p<0.05)

SEM: Standard error of means

Trt=Treatment

4.6 Experiment 3: Effect of Graded levels of MSS on the Performance of Broiler starter Chickens Supplemented with Maxigrain® Enzyme

The performance of broiler birds fed 10% and 15% levels of inclusion of malted sorghum sprout at the starter phase was evaluated and subsequent treatment with enzyme was carried out for the same levels of MSS as shown in Table 4.6. The result showed a significant difference ($p < 0.05$) between Maxigrain® supplemented meals and non supplemented meals. The final weights were higher for enzyme supplemented meals and birds fed 10% MSS with Maxigrain® treatment performed significantly ($p < 0.05$) better than the birds fed control diet void of MSS. As seen also from the Table, enzyme supplementation of 15% levels of inclusion of MSS also showed significant difference. This result showed that enzyme treatment of diets containing MSS led to better utilization of this feed resource at the starter phase which was also reflected by the values for feed conversion ratios of the five diets. Treatment 3 with 10% inclusion of MSS had a feed conversion ratio of 1.53 the lowest observed while Treatment 5 with 15% inclusion of MSS had the highest. As MSS increased in diets there was a significant decrease ($p < 0.05$) in weight gain of broiler birds even though better utilization of MSS was evident with enzyme treatment, consumption was not improved.

Table 4.6: Effect of Graded Levels of MSS Supplemented with Maxigrain® Enzyme on the Performance of Broiler Starter Chickens

Parameter	Graded Levels of MSS (%)					SEM
	0	10	10 +EZM	15	15+EZM	
Initial weight (g)	85.67	85.00	85.67	85.33	86.33	-
Final weight (g)	797.30 ^a	630.57 ^b	897.10 ^a	550.17 ^b	613.69 ^b	53.48
Avg. feed intake (g)	54.43 ^a	42.28 ^{bc}	43.17 ^b	40.79 ^{bc}	39.43 ^c	1.58
Avg. daily wt gn(g)	25.42 ^a	19.49 ^b	28.98 ^a	16.60 ^b	18.83 ^b	1.89
Feed conversion ratio	2.14 ^b	2.18 ^b	1.53 ^a	2.47 ^c	2.13 ^b	0.13
Feed cost/kg gain (₦)	209.4 ^c	196.26 ^{bc}	138.76 ^a	213.79 ^c	185.69 ^b	11.59
Mortality (%)	0.00	0.00	0.00	0.00	0.00	-

a, b, c=Means in the same row having different superscript are significantly different (P<0.05). Avg. Daily wt gn = Average daily weight gain
 Avg. Feed intake= Average feed intake, SEM=Standard error of means

4.7 Experiment 4: Effect of graded levels of MSS on Performance of Broiler finisher Chickens Treated with Maxigrain® Enzyme

Table 4.7 reflects the performance of broiler birds fed 10 and 15% levels of inclusion of malted sorghum sprout at the finisher phase which was evaluated and subsequent treatment with enzyme carried out for the same levels of MSS. The final weights were higher for enzyme supplemented meals and birds fed 10 and 15% MSS with Maxigrain® treatment performed slightly better but not significantly ($p>0.05$) better than the birds fed control diet void of MSS, or MSS in diets without enzyme treatment. This result suggests that enzyme treatment of diets containing MSS led to better utilization of this feed resource at the finisher phase which was also reflected by the values for feed conversion ratios of the five treatments. As MSS increased in diets there was no significant decrease ($p<0.05$) in weight gain of broiler birds. This is because even though better utilization of MSS is evident with enzyme treatment, consumption is not improved this could be as a result of the anti-nutritional factors present in MSS which affect palatability.

4.8 Haematological and serum biochemistry parameters of Broilers fed MSS supplemented with Maxigrain® enzyme at finisher phase

Table 4.8 shows the effect of graded levels of malted sorghum sprout on the haematological and serum biochemistry parameters of broiler finisher fed experimental diets. Dietary treatments had no significant ($P>0.05$) effect on packed cell volume (23.67-26.67%) but did on Total protein content and Haemoglobin concentration. The haemoglobin concentration of treatment 2 did not

differ significantly ($P > 0.05$) from other treatment diets except for diet 4. Total protein showed significant difference ($P < 0.05$).

Table 4.7: Effect of graded levels of MSS supplemented with Maxigrain® enzyme on the performance of Broiler finisher chickens (5-9 weeks)

Parameter	Graded Levels of MSS (%)					SEM
	0	10	10+EZM	15	15+EZM	
Initial weight (g)	753.33	750.00	750.00	753.33	753.33	-
Final weight (g)	1833.33	1850.00	1916.67	1833.33	1923.33	45.19
Feed intake (g/bird/day)	108.83 ^a	92.88 ^b	89.47 ^b	82.78 ^c	81.59 ^c	2.01
Daily weight gain (g/bird/day)	38.57	39.29	41.67	38.57	41.79	1.65
Feed conversion ratio	2.82 ^d	2.37 ^c	2.15 ^b	2.15 ^b	1.97 ^a	0.09
Feed cost/kg gain (₦)	216.56 ^d	168.09 ^c	154.37 ^b	146.67 ^{ab}	135.69 ^a	6.09
Mortality (%)	0.00	0.00	0.00	0.00	0.00	0.00

a, b, c=Means in the same row having different superscript are significantly different (P<0.05).

SEM=Standard error of means

4.9 Carcass characteristics of broiler chicken fed diets containing graded levels of Malted sorghum sprout supplemented with Maxigrain enzyme

The result of carcass study of broiler birds fed graded levels of malted sorghum sprout is presented in Table 4.9. The result showed that there was significant difference in the live weights of the birds across the dietary treatments. Dietary treatments had effect on dressing percentage across the treatments except for treatment 5 which was statistically ($P < 0.05$) lower than other treatments. Breast, drumstick, thigh, wings, back, were expressed as a percentage of dressed weight while liver, gizzard, spleen, lungs and abdominal fat were expressed as percentage of the live weights were significantly ($P < 0.05$) affected by the dietary treatments with no particular trend though all treatments were statistically ($P > 0.05$) the same for neck and lungs. This result showed that the inclusion of enzyme in diets resulted significant difference ($P < 0.05$) across treatments for carcass percentage cuttings e.g. breast, back and abdominal fat etc.

Table 4.8: Haematological and serum biochemistry parameters of Broilers fed MSS with and without Maxigrain® enzyme treatment at the finisher phase

Parameter	Dietary Treatments with graded levels of MSS						SEM	Normal range
	0%	10%	15%	10+EZM	15+EZM			
Packed cell volume (%)	24.67	26.67	26.67	23.67	25.67	1.67	24-31	
Haemoglobin (g/dl)	8.10 ^{ab}	9.07 ^a	8.70 ^{ab}	7.87 ^b	8.53 ^{ab}	0.55	7-13	
Total protein (g/dl)	3.93 ^{ab}	3.73 ^{ab}	3.50 ^b	3.37 ^b	4.40 ^a	0.37	3.31-5.39	

a, b, c=Means in the same row having different superscript are significantly different (P<0.05).

SEM=Standard error of means

MSS=Malted Sorghum sprouts

EZM =Enzyme

Table 4.9: The effect of graded levels of Malted Sorghum sprouts on the carcass characteristics of Broiler finisher chickens

Parameters	Trt1 0%MSS	Trt2 10%MSS	Trt3 10%+EZM	Trt4 15%MSS	Trt5 15%+EZM	SEM
Live weight(g)	1833.33 ^c	1833.33 ^c	1916.67 ^{ab}	1883.33 ^{bc}	1923.33 ^a	49.31
Dressed wt (g)	1322.95 ^c	1389.82 ^b	1555.15 ^a	1390.17 ^b	1318.50 ^c	39.87
Dressing %	72.16 ^{ab}	75.81 ^{ab}	81.14 ^a	73.81 ^{ab}	68.55 ^b	4.75
Prime cuts as % dressed weight and organs expressed as % of live weight (g)						
Breast	17.48 ^b	17.98 ^b	17.95 ^b	21.57 ^a	18.59 ^b	1.28
Drumsticks	10.18 ^a	10.57 ^b	10.80 ^a	10.28 ^a	9.06 ^b	0.55
Thighs	10.73 ^{ab}	11.28 ^a	10.62 ^{ab}	10.27 ^{ab}	10.24 ^b	0.51
Wings	8.55 ^{ab}	8.38 ^{ab}	8.01 ^{ab}	8.67 ^a	7.78 ^b	0.44
Back	12.94 ^a	12.70 ^{ab}	12.21 ^{ab}	13.11 ^a	11.44 ^b	0.71
Organs weight						
Liver	2.39 ^b	2.96 ^a	2.18 ^b	2.79 ^{ab}	2.18 ^b	0.21
Gizzard	2.23 ^{abc}	2.52 ^a	2.17 ^{bc}	2.39 ^{ab}	1.95 ^c	0.16
Spleen	0.16 ^{ab}	0.11 ^b	0.18 ^a	0.12 ^{ab}	0.12 ^{ab}	0.03
Heart	0.58 ^a	0.53 ^{ab}	0.57 ^a	0.49 ^{bc}	0.45 ^c	0.03
Lungs	0.49	0.51	0.49	0.55	0.50	0.06
Abdominal Fats	1.15 ^{ab}	1.37 ^{ab}	0.84 ^b	1.08 ^{ab}	1.48 ^a	0.29

*Means within the same row with different superscript differ significantly.
SEM: standard error of means.

CHAPTER FIVE

5.0

DISCUSSION

5.1 Proximate Content of MSS

The proximate composition of MSS presented average dry matter content as 93.16%, crude fibre 11.98% and nitrogen free extract 66.47%, which were higher than those reported by Fafiolu *et al.* (2006) while the values for crude protein 18.92%, ether extract 1.09% and total ash 6.11% were lower which could have been affected by germination period length with different biomass. The crude fibre obtained in this study was also higher than that reported by Oduguwa *et al.* (2001), this could be as a result of the duration of time allowed for germination of sprouts. The higher ether extract values reported by Akinola (2002) and Fafiolu *et al.* (2006) may be as a result of the difference in breeds of chicken. The ash content of 6.11% agrees with earlier reports by Akinola (2002) but differs from that reported by Aning *et al.* (1998) which could be as a result of difference in sorghum used or length of germination period.

5.2 Experiment 1: Effect of Graded Levels of MSS on Performance of Broiler Starter Chickens (1-4wks)

The performance of broiler chicks fed varying levels of malted sorghum sprouts showed that there was a corresponding decrease in feed intake and weight gain as levels of MSS increased in

the diets. 5% level of MSS had significantly ($p < 0.05$) higher final weight above those fed greater levels of MSS but did not differ from the control. This trend was also observed in the values for feed conversion ratio as there was no significant difference ($p > 0.05$) between the control and 5% level of MSS inclusion but significantly different from others. These values contradicted earlier reports by Akinola *et al.* (2002) who reported no significant decrease in weight gain, feed intake and feed conversion ratio as levels of MSS increased in broiler diets. Fafiolu *et al.* (2006) on the other hand reported an increase in weight gain as levels of MSS were increased in layer hen diets, results showed that number of egg produced varied significantly ($p < 0.05$) across the dietary treatments. The mean values of 0.82, 0.61 and 0.41 were recorded for birds fed 0, 150 and 300 g/kg MSS respectively. The sharp reduction recorded for consumption of MSS diets may be due to the presence of certain anti-nutritional factors in the feed material. MSS is known to contain dhurrin a glucoside which on hydrolysis yielded equal quantity of HCN (Ikediobi, 1989). Tannin an ANF was also known to be present in MSS (Aning *et al.*, 1998; Oduguwa *et al.*, 2001). As MSS increased there was a corresponding decrease in the cost per Kilogram of feed but a significant ($P < 0.05$) increase in cost per Kilogram gain in weight of birds, which was also reported by Akinola *et al.* (2002). This could be due to the poor taste and bulkiness of the material with birds required to eat a lot.

5.3 Experiment 1: Effect of Graded Levels of MSS on Performance of Broiler Finisher Chickens (5-9 Weeks)

The performance of broilers fed varying levels of Malted Sorghum sprouts showed that birds fed 5% level of MSS had significantly ($p < 0.05$) higher final weight than those fed 10, 15 and 20%

levels of MSS but did not differ from the control at the finisher phase. This trend was also observed in the values for feed conversion ratio as there was no significant difference ($p < 0.05$) between the control and 5% level of MSS inclusion but significantly differed from others. These values disagree with earlier reports by Akinola *et al.* (2002) who reported no significant decrease in weight gain, feed intake and feed conversion ratio as levels of MSS increased in broiler diets. Fafiolu *et al.* (2006) on the other hand reported an increase in weight gain as levels of MSS were increased in layer hen diets. Number of eggs produced varied significantly ($p < 0.05$) across the dietary treatments. There was significant difference ($P < 0.05$) across dietary treatments for Haemoglobin concentration but not for Pack cell volume and Total protein and were within the range reported for healthy birds (Oladele and Ayo, 1999 and Odunsi *et al.*, 2007). This was in contrast to reports by Jegede *et al.* (2008) who observed a linear decrease in pack cell volume and Haemoglobin as MSS increased in diets of rabbits.

The carcass analysis of slaughtered birds showed no significant difference ($p > 0.05$) for drumsticks, thighs, wings and back, but not the case for all other cuts. There was no trend established though on variation of cuts as level of MSS increased or reduced, this could suggest that level of MSS in diet had no significant effect on carcass conformation as expressed in percentage of dressed weight. Organ weight also as expressed as a percentage of live weight did not have significant effect on heart and lungs but had significant effect on liver, gizzard and spleen with no pattern established with increase or reduction in MSS content. This was in contrast to reports by Jegede *et al.* (2006) who observed an increase in liver size as MSS increased attributed to the handling of tannin and cyanide content of MSS.

5.4 Experiment 2: Effect of graded levels of MSS on Performance of Broiler Starter Chickens Treated with Maxigrain® Enzyme

The performance of broiler birds fed 10 and 15% inclusion levels of malted sorghum sprout at the starter phase was evaluated and subsequent treatment with enzyme was carried out for the same levels of MSS. The result showed a significant difference ($p < 0.05$) between Maxigrain® supplemented meals and non supplemented meals in some cases. The final weights were similar for enzyme supplemented meals at 10% MSS with Maxigrain® and the control as both treatments performed significantly ($p < 0.05$) better than the birds fed other diets. Enzyme treatment of 15% levels of inclusion of MSS also resulted in no significant difference. This result suggested that enzyme treatment of diets containing MSS led to better utilization of this feed resource at 10% inclusion for the starter phase which was also reflected by the values for feed conversion ratios of the five treatments. Choct (2006) reported the degradation of β – mannan and 70% NSPs into soluble more digestible products for monogastrics as a result of enzyme addition to high fibre monogastric diet. Birds on treatment 3 with 10% inclusion of MSS had a feed conversion ratio of 1.53 while Treatment 5 with 15% inclusion of MSS had the highest. As MSS increased in diets there was a significant decrease ($p < 0.05$) in weight gain of broiler birds. This was because feed consumption also decreased with increase in levels of test ingredient as a result of anti-nutritional factors present which affect palatability causing a fall in consumption which could not be negated even by better utilization of MSS with enzyme treatment.

5.5 Experiment 2: Effect of graded levels of MSS on Performance of Broiler finisher Chickens Treated with Maxigrain® enzyme

Performance of broiler birds fed 10 and 15% levels of inclusion of malted sorghum sprout at the finisher phase was evaluated and subsequent treatment with enzyme carried out for the same levels of MSS. The result did not show a significant difference ($p>0.05$) between Maxigrain® supplemented meals and non supplemented diets. The final weights were higher for enzyme supplemented diets and birds fed 10 and 15% MSS with Maxigrain® treatment performed significantly ($p<0.05$) better than the birds fed control diet void of MSS, or MSS in diets without enzyme treatment. This result suggested that enzyme treatment of diets containing MSS led to better utilization of this feed resource at the finisher phase which was also reflected by the values for feed conversion ratios of the five treatments. As MSS increased in diets there was no significant decrease ($p>0.05$) in weight gain of broiler birds. This was because consumption didn't increase with enzyme inclusion and even though better utilization of MSS was evident with enzyme treatment, consumption needed to improve; this could be as a result of the anti-nutritional factors present in MSS which affected palatability. Also evident was no improvement in feed to gain ratio with enzyme treatment disagreeing with earlier reports that observed an improvement in weight gain and feed conversion efficiency in birds fed enzyme supplemented diets. The carcass analysis of the birds for various parameters considered such as weight of breast, thighs, wings, abdominal fat and organs all showed significant ($p<0.05$) differences across treatments with no pattern or trend established contradictory to earlier reports by Brenes *et al.* (1993) who reported size reduction of organs with enzyme treatment. The results of blood analysis showed significant ($p<0.05$) differences for parameters considered with no obvious trend.

CHAPTER SIX

6.0 Summary Conclusion and Recommendation

6.1 Summary

The proximate chemical analysis of malted sorghum sprouts showed that it is high in energy and complimented with relatively high protein content.

Experiment 1 showed that as levels of MSS increased, there was a decrease in weight gain and feed intake. Birds fed 5% levels of MSS tended to compete favourably with the birds placed on control diet.

Experiment 2 showed difference between 0 and 5% levels of MSS inclusion but then also showed no significant difference was observed at the finisher phase between 10,15 and 20% levels of inclusion. The Carcass characteristics showed no significant difference for drumsticks but a different case for all other cuts with no particular trend established.

Experiment 3 showed that with enzyme treatment and increase in MSS, feed cost decreased and feed conversion ratios for higher levels of MSS were better.

Experiment 4 which involved the finisher phase of birds also revealed a similar trend as enzyme inclusion in diets led to higher body weight and feed conversion ratio with no corresponding increase in feed intake and yet cost of feed remained significantly lower. The analysis of carcass for parameters such as abdominal fat, breast, thighs, wings etc showed differences with no pattern or trend established. Blood haematological and biochemistry parameters analysed i.e. packed cell volume, Haemoglobin concentration and Total protein values did not show any variation.

6.2 Conclusion

1. The proximate analysis of malted Sorghum sprouts showed that it has a very high potential as a feed resource having very high energy content and although it contains anti-nutritional factors like Tannin, Phytic acid and Hydrogen cyanide broiler birds could still metabolize it.
2. The study demonstrated that Malted Sorghum sprouts can be used in broiler diets to reduce cost at 5% level of inclusion optimally, with no significant reduction or negative effect on growth of birds but for levels higher than this.
3. Enzyme supplementation has a positive effect on utilization of MSS by broilers although 15% level of inclusion should not be exceeded in least cost feed formulations.
4. Inclusion of MSS results in a significant drop in cost of feed but must not exceed 5% without enzyme and 15% with enzyme.

6.3 Recommendations

From this study; MSS can be included in broiler diets at both starter and finisher phases but not beyond 5% level of inclusion in order not to affect performance of birds.

Enzyme treatment can improve the ability of birds to tolerate and utilize higher levels of MSS but this may not be justified economically at levels beyond 10% even though there are cost benefits as to justify the inclusion of MSS in broiler diet as regards cost of feed.

Possible work can be done on amino profile of MSS with research into amino acid treatment to improve its utilization or pelletizing of this feed resource.

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