

**ADDIS ABABA UNIVERSITY
FACULTY OF VETERINARY MEDICINE**

**THE EFFECT OF REPLACING MEAT AND BONE MEAL WITH
SOYBEAN MEAL ON THE PERFORMANCE OF BROILER CHICKENS**

**BY
KASSA SHAWLE RETTA**

**JUNE, 2008
DEBRE ZEIT, ETHIOPIA**

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A thesis submitted to the School of Graduate Studies of Addis Ababa University, Faculty of Veterinary Medicine in partial fulfillment of the requirements for the Degree of Masters of Science in Tropical Animal Production and Health

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DEDICATION

I dedicate this thesis manuscript to my families, my father Shawle Retta and my mother Beletech G/Silasie.

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ABBREVIATIONS AND SYMBOLS

AA	Amino Acid
AF	Abdominal Fat
ANF	Anti-nutritive Factor
ANOVA	Analysis of Variance
AOAC	Association of Official Analytical Chemists
BM	Breast Meat
BSE	Bovine Spongiform Encephalopathy
CDI	Center for Development of Industry
CEC	Commission for Environmental Cooperation
CF	Crude Fibre
CP	Crude Protein
CRD	Completely Randomized Design
CTA	Technical Centre for Agricultural and Rural Cooperation
DM	Dry Matter
DZARC	Debre Zeit Agricultural Research Center
EE	Ether Extract
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FCR	Feed Conversion Ratio
FE	Fat extract
GLM	General Linear model
GM	Genetic Modification
HB ₁	Hitchner B ₁
INFPD	International Network for Family Poultry Development
KATVETC	Kombolcha Agricultural Technical vocational Education and Training College
Kcal	Kilo Calorie
MAFRA	Ministry of Agriculture Food and Rural Affairs
m.a.s.l	Meter Above Sea Level
MBM	Meat and Bone Meal
ME	Metabolizable Energy
MJ	Mega Jules

MM	Mineral Matter
NCD	Newcastle Disease
NDF	Neutral Detergent Fiber
NFE	Nitrogen Free Extract
NSP	Non-starch Polysaccharides
OS	Oligosaccharides
SAA	Sulphur Containing Amino Acid
SBM	Soybean Meal
SPSS	Statistical Program for Social Studies
UK	United Kingdom

ABSTRACT

This study was carried out from November 30, 2007 to January 17, 2008 to determine the effects of the combination as well as full replacement of meat and bone meal (MBM) in broiler starter and finisher chickens diets with soybean meal (SBM) on daily feed intake, body weight gain, food conversion rate, water consumption, economic efficiency and carcass characteristics. A total of 306 day old broiler chickens were divided into 18 groups of 17 birds each and subjected to completely randomized design, such that three replicates were allocated to a diet. The diet was isocaloric and isonitrogenous that contained around 3000kcal/kg ME and 22%CP for starter and 3200kcal/kg ME and 20%CP for finisher phase. The diet (experimental) groups were diet 1 (commercial diet) used as comparison purpose; diet 2 (0%SBM + 26%MBM), diet 3 (6.5%SBM + 19.5%MBM), diet 4 (13%SBM + 13%MBM), diet 5 (19.5%SBM + 6.5%MBM), and diet 6 (26%SBM + 0%MBM). The birds were fed and watered *ad libitum*. At the end of the experiments, 2 broilers (one male and one female) from each replicate were selected and slaughtered to evaluate the development of different cut ups and abdominal fat. The result indicated that feed intake and body weight gain of the birds were significantly ($p<0.05$) higher for diet 1 for the entire period of feeding, followed by diet 5. The feed intake and body weight gain were not significantly different between diet 5 and diet 6 during the finisher phase. Both feed consumption and body weight gain were inferior for the groups placed in diet 2 for the whole weeks of feeding regime. The feed conversion ratio was not significantly different ($p>0.05$) for diet 1, diet 5 and diet 6 for the whole period of feeding. The highest feed conversion rate was recorded for diet 2. Higher water to feed ratio were observed in the whole production cycle for diet 1, diet 5 and diet 6. However, rate of survival was not significantly different among treatments ($p>0.05$). Lack of uniformity in body size and posture of birds was seen as the level of MBM inclusion was beyond 6.5%. Biological and economic efficiencies as measured by the amount of feed and feed cost required per kg live weight gain was significantly higher for the groups fed on diet 5 and diet 6 during the entire study period. The lowest abdominal fat percentage was observed for diet 1 and diet 6, and the highest was recorded for the treatment groups containing 13% - 26%MBM diets, although there was a tendency of increase in abdominal fat with the increase in the level of MBM. Diet 1 comprised significantly ($p<0.05$) higher eviscerated and breast weight percentage followed by diet 6. The results of this study showed that using MBM beyond 6.5% significantly depressed the body weight gain, feed consumption, FCR and increased

cost of production. SBM safely can substitute MBM in the finisher phase. Economically full SBM diet and 19.5% SBM and 6.5% MBM combinations could be interchangeably used for broilers without affecting the performance next to the commercial diet.

Key words: Broiler, Finisher, Meat and Bone Meal, Performance, Protein Source, Soybean Meal and Starter.

1. INTRODUCTION

Global human population is expected to increase from 6 billion today to more than 7.5 billion by 2020 (Persley, 2000). This burgeoning population may require a doubling of animal protein production and a corresponding increase of feed grains. This is due in part to improved economic standards leading to increased demand for high-quality animal protein. The fastest way of meeting the growing demand for protein of animal origin is through increasing the productivity of livestock and poultry products at affordable prices by lowering the cost of production to bring animal protein within the reach of more people that badly need it. High feed cost is the single most important constraint to the expansion of animal production, which account for about 70% of the total production costs of broiler meat (Teguia and Beynen, 2005). Thus, exploring of full potential of all feed resources is a corner stone of successful poultry production.

The other reason for seeking alternative protein source is the occurrence of Bovine Spongiform Encephalopathy (BSE) in the world in the last few years, which has raised a great concern on risks for human health due to the human variant of BSE, the Creutzfeldt-Jakob disease. This is a fatal disease that is acquired after consuming BSE contaminated cattle products and causes progressive neurological degeneration (CEC, 2000). The disease was being transmitted to animals by the use of concentrated feed incorporating meat and bone meal (MBM) from infected animals (Speedy, 2004). As a preventative measure designed to stop the transmission of this disease to non-infected animals and to minimize the potential risks to humans, the use of animal byproducts in the manufacture of animal feeds given to ruminant animals was prohibited. This decision was further extended to all processed animal proteins (except fish meal) given to all farm animals intended to the production of human food, which included poultry in the European Union (CEC, 2000). Authorities from other countries such as Saudi Arabia, a major broiler chicken importer, also adopted this policy. In several other countries, there has been an increasing trend in marketing broilers as non-traditionally fed or raised in an attempt to meet a new perception of value to some customers. One of these non-traditionally grown broilers is fed diets exclusively formulated with plant-based ingredients, and therefore, it is sometimes advertised as an "all-veg" broiler (Vieira and Lima, 2005).

In the past, meat and bone meal was a primary protein source in animal diets in many areas in the world (Hard, 2004). Now a day soybean meal is the most used and preferred protein source in animal feed worldwide. This is due to its relatively high protein content of 44 to 50 percent; a balanced amino acid composition and its consistent availability and constantly competitive price (Brookes, 2000). It has also a high content of potassium, which is an electrolyte known to induce water consumption. World production in protein-rich substances (primarily soybeans) increased by 60 percent between 1985 and 2000. The abundant availability of competitively priced soybeans on world markets today should be able to replace the protein material formerly derived from meat without undue difficulty and only at a modest addition to compound feed costs (Brookes, 2001).

Ethiopia has a total population of 65 million chicken most of which are kept under the traditional type of management (FAO, 2000). However, due to the liberalization of the economic system in the country, small and large scale commercial chicken farming systems are developing. These developing systems use improved rations as inputs which are available in local markets. There are also some cases where improved feedstuffs are imported from abroad. In general, commercial chicken feeds are expensive and sometimes unavailable. It is essential, thus, to look for alternative feedstuffs such as soybean, which are available and affordable. So the knowledge of the nutritional characteristics of soybean and its optimal levels of inclusion in poultry ration is very crucial to the sector especially at this time when animal feeds originating from meat are becoming expensive and risky.

Therefore, the objectives of this study were:

- To select the best level of replacement of meat and bone meal (MBM) by soybean meal (SBM) that gives optimum performance and carcass characteristics of starter and finisher broilers;
- To determine the economic impacts of replacement of MBM by SBM in starter and finisher broilers.

2. LITERATURE REVIEW

2.1. Poultry production systems

2.1.1. The traditional/village poultry production system

Most village chicken production systems in Africa are based on indigenous or native domestic fowl (*Gallus domesticus*) and are characterized by a low level of inputs and output. The main input is the feed from household refuse as well as that scavenged around the village. Provision of other inputs such as housing, additional feed and health care vary greatly between and within countries, depending on the farmer or household's socio-economic circumstances. With such low inputs, the village chicken is capable of generating cheap and readily harvestable meat and eggs for immediate home consumption and sale for income generation, while at the same time performing useful social functions. In some communities small livestock, particularly village chickens, are important in breaking the vicious cycle of poverty, malnutrition and disease. Indigenous chickens in Ethiopia are small in body size and are low producers of meat and eggs. Egg production is estimated to be 40 to 60 eggs per bird annually with an average egg weight of 40grams. The mature weight ranges from 1 to 1.7kg (Table 1).

The village chicken production system in developing countries is often marginalized by policy-makers, scientists and development workers; because of its low productivity compared with the commercial poultry production system (Tadelle and Ogle, 2001). In Ethiopia, the average flocks size ranges from 7-10 birds per household consisting of 2-4 adult hens, a male bird and a number of growers of various ages (Tadelle, 1996). Women are responsible for looking after household poultry and often the earnings from the sale of eggs and chicken is their only source of cash income. It is, therefore, important to actively involve women in the process of poultry development.

Table 1. Performances of scavenging and specialized commercial chickens

Parameter	Scavenging Village chicken	Commercial Chickens
Age at mature weight (weeks)	>24	< 8 for broilers <20 for layers
Egg production (eggs/hen/year)	40-60	>250
Egg weight (g)	30-49	>60
Mature weight (kg)	1-1.7	>2
Mortality rate (%)	Chicks >60 Adults 45-100	<20

Source: Tadelles and Ogle (2001)

2.1.2. Commercial poultry production systems

Large scale commercial system

According to Drechsel *et al.* (2000), the most profitable and attractive forms of livestock farming-especially in and around the cities are probably poultry and egg production. But the establishment of larger poultry farms requires an initial investment. The success of commercial poultry farms is largely dependent on a variety of factors, of which the major components are improved management, proper nutrition and effective disease prevention and control (Lobago *et al.*, 2005). In the tropics, intensive poultry units are located close to urban centers. Potential consumers of the products of intensive poultry farming are urban populations, local authorities and the hotel industry. Export outlets in some countries of the sub-region may also come up (CDI, 1996). However, the system is constrained by lack of technical information for producers, inadequate structuring of the production phases (inadequacy or lack of hatcheries, egg tray production), frequently deficient feed quality and supply, precarious husbandry conditions, lack of training of husbandry staff or inappropriate production tools. In addition, high mortality rate is observed in farms, due to the uncaring of hygienic rules and the low relative protection potency of vaccine.

Modern poultry production in Ethiopia started in the early 1950's with the establishment of higher learning agricultural institutes (Tadelle and Peters, 2003). The activities of these institutions focused mainly on the introduction and distribution of exotic breeds (White and

Brown Leghorns, Rhode Island Red, New Hampshire, Cornish, Australoup, Light Sussex etc.) to farmers with management, feeding, housing and healthcare packages (Alemu and Tadelle, 1997). There have been a number of large commercial state farms in Ethiopia which are now being privatized and there are also increasing number of private investors involved in the business. Commercial farms with annual capacities of about 35,000 layers and 208,000 broilers are currently operating in and around Addis Ababa (Alemu and Tadelle, 1998; Tadelle and Peters, 2003). An annual egg production level of 250 per layer, a 60 days live weight of 1.8kg and a pullet mortality rate of 6.8% was reported for commercial farms in Ethiopia (Tadelle and Ogle, 2001).

Small-scale intensive system

Smallholder commercial poultry production is an important economic activity in the agricultural sector in that it provides farm income and employment for many households. The business can be owned and managed by all without any gender discrimination. Factors of production such as family labor, costs of construction materials, drugs and feed are effectively and efficiently managed in this system because of close personal involvement, supervision, and monitoring that enhances productivity (Akunzule, 2005). Poor ventilation and too high flock densities are characteristics of the housing system used. Most of the producers in this system get day old chicks and mixed feed from large enterprises. The producers do not, thus, have a say on the quality of feed and chicks. Seasonality of marketing, poor input delivery system, disease challenge, product processing and other problems are peculiar to this system.

In Ethiopia, the system is characterised by small flock size (usually 50-500 birds) and is organised along commercial lines (Alemu and Tadelle, 1997). This system of production is newly emerging in urban and peri-urban areas in and around Addis Ababa. Exotic birds (mostly broilers) are raised using relatively modern management methods. This activity is being undertaken as a source of income especially by ex-soldiers, high school dropouts, women headed and resource poor families (Alemu and Tadelle, 1998).

2.2. Major constraints of poultry development

According to Tadelle and Ogle (2001), the primary problem cited by the village poultry farmers was high mortality of chicks. The major causes of this problem as perceived by the community and in their order of importance were disease (63.8%), predation (21.8%), lack of feed (9.5%) and lack of information (4.9%) (Tadelle, 2003). Insufficient water was also one of the causes of mortality in chicks and older birds and a contributing factor to low productivity.

2.2.1. Feed availability and quality

The quality of mixed feed used in chicken production is generally poor. Most formulations available do not have vitamin and/or mineral premixes (Alemu and Guenther, 1992). Ingredients vary in nutritive value and there is no quality control. Unavailability of laboratory facilities for the chemical analysis of ingredients and prepared feeds also contributes greatly to the poor quality of food (Alemu and Tadelle, 1998). Exotic birds require high quality feed (grain), which could also be used directly by humans. Thus, in grain deficient countries like Ethiopia, adopting intensive poultry industry will be frustrated by the severe shortage of grain. Unless the grain production in the country is improved considerably such a system cannot be economically sustainable and socially acceptable (Tadelle and Peters, 2003).

2.2.2. Disease

The major causes of economic loss on commercial farms are diseases including coccidiosis, Gumborro (Infectious bursal disease), Newcastle disease and respiratory diseases (Alamargot, 1987). But mortality in local birds results mainly from predators and Newcastle disease. Newcastle disease is the most important disease in rural poultry production in the tropics. The mortality caused by Newcastle disease ranged from 50% to 100 % (Cummings, 1992; Sonaiya, 1990) and the severity is higher in dry season. However, this condition was found to be more severe in the rainy season in the central highlands of Ethiopia (Tadelle and Ogle, 2001).

2.2.3. Poor management practices

The introduction of commercial type of poultry keeping requires administration of improved management (provision of technical information for producers, adequate structuring of the production phases, feed quality control, appropriate production tools, applying hygienic rules and vaccination programs) and effective disease prevention and control practices (Lobago *et al.*, 2005), which are considered as non-existent in most of poultry production systems in the tropics.

2.3. Improvement options of poultry production systems

Most poultry improvement programs in developing countries have been directed towards the introduction of specialized or exotic breeds, crossbreeding and management intensification (Kitalyi, 1997). While there have been measurable improvements in egg and poultry meat production in the satellite layer and broiler production units started in developing countries; the high mortality of introduced breeds, low feed resource base at the village level and lack of understanding of the complex biological systems of the birds limit the success of the programs. A cultural and socio-economic relationship of the society also limits the success. Farmers maintain their local stock especially in the village chicken production system for social and economic reasons (Awan, 1993).

In Ethiopia, the fully modernized intensive approach may also be pursued since the country is moving towards self-sufficiency in cereal crop production. In the short run, it would be preferable to concentrate on broiler rather than egg production due to the fact that poultry meat brings a higher price per kg and has a feed conversion ratio of less than 2:1 compared to greater than 4:1 for eggs (Alemu and Tadelle, 1998). Measures to maximize the efficiency of intensive poultry production would include improved feed formulation and preparation, the use of pellets rather than mash, and improved management and disease control techniques. Furthermore, production sites should be restricted to localize grain surplus areas adjacent to large urban markets.

2.4. Broiler production and factors affecting broiler performance

2.4.1. Broiler production

Broiler production plays a major role in food security for the rapidly increasing Ethiopian human population to meet the growing demands of animal protein in the country. Their short production cycle, high feed efficiency and high biomass per unit of agricultural land are particularly attractive for the Ethiopian production system. Broilers in developing countries are normally run as hatched, keeping male and female together. This has an advantage in that broilers run as hatched will produce a variety of carcasses, which will suit the various demands of the consumer. At eight weeks of age, the males usually weigh 200g or so more than the females and will have had a better food conversion ratio. Females on the other hand produce a more attractive carcass that may fetch a higher price (Smith, 2001).

2.4.2. Broilers growth rate

The average daily weight gain plays an important role in the optimum growth of the birds and is not uniform for each week and varies considerably depending on age and sex. Under normal practical conditions, a broiler must gain an average of 50grams or more per day (Butcher and Nilipour, 2005) (Table 2).

Table 2. Weekly body weight gain for average straight run broilers 1 to 49 days

Days of Age	The least weight expected	Average Daily Weight Gain (g/week)
7	4.0 times the chick weight	12
14	2.4 times the 7 day weight	27
21	Above 0.45kg	42
28	Above 0.91kg	57
35	Above 1.36kg	65
42	Above 1.81kg	71
49		76

Source: Butcher and Nilipour (2005)

2.4.3. Feed efficiency

The economical results of broiler production are highly dependent on the efficiency of conversion of feed to product (Washburn, 1980). On average, feed represents about 60% of the live cost of broilers processed (based on an average broiler of 2.27kg with a feed conversion ratio of 1.87) (Milton, 2003). Feed efficiency deteriorates as the bird grows primarily due to increased maintenance costs and as a result feed contributes relatively more to total live cost as bird weight goes up. Approximately 54% of the cost of raising a 1.81kg broiler is attributable to feed, while it accounts for 63% of the cost of a 2.72kg broiler. Obviously the relative impact of feed also increases when the price goes up. A two point (0.02) difference in feed conversion ratio (FCR) is typically regarded as economically significant. Feed conversion rate is relatively easy to measure and is often used to evaluate competitive performance, assess flock supervisor performance and formulate grower contracts (Milton, 2003).

Breed, growth rate, fat content, sex, feed quality, season, bird density, bird health, environment, management, and flock mortality influence FCR (Milton, 2003). It is typically expressed as the ratio of feed consumed, divided by the live weight of the bird (Washburn, 1980).

Diet energy level

As the nutrient level of the diet is reduced, birds eat more feed. This means that the bird is not eating to physical capacity, because the bird was able to almost double its normal intake on the very low nutrient dense diet. This amazing ability to adjust feed intake resulted in no real difference in 49day body weight. As the birds eat more feed at constant growth rate, then feed efficiency starts to deteriorate (Ensminger *et al.*, 1990).

Sex of birds

The feed efficiency of female broilers will usually be higher (less efficient) than male birds of corresponding weight after about 30 days of age. The reason for this is that female birds tend to deposit proportionally more fat in the carcass. Body fat takes nine times much feed energy to produce as does muscle. The reason for this is that fat contains more energy than

protein per unit of weight, and more importantly, muscle is only about 20% protein by weight, the remainder being water. For this reason it is usually uneconomical to grow female broilers much beyond 45 days unless special emphasis is placed on reducing fat deposition. Likewise with heavy male birds, feed efficiency is going to be greatly influenced by the growth of fat versus muscle (MAFRA, 2008).

Age of birds

As birds get older, their feed efficiency will increase with decreasing manner. This situation is simply due to the fact that heavy birds use increasing quantities of feed to maintain their body mass, and less is used for growth. In the 7-day old bird, about 80% of feed is directed to growth and only 20% is needed to maintain the small body size, consequently feed is used very efficiently. In an 8-week old bird these numbers are reversed such that only 20% of feed is used for growth, and 80% is needed to maintain the ever-increasing body mass; feed efficiency, therefore, deteriorates (MAFRA, 2008).

Environmental temperature

The broilers' maintenance needs are greatly influenced by the temperature of its environments. After initial brooding, the bird must use some of its feed to maintain its body temperature. Under ideal conditions of around 20-25°C, the bird uses a minimum of feed to maintain body temperature. In cooler conditions, more diet energy must be used to maintain body heat (and so less feed is used for growth) and consequently feed efficiency will deteriorate (MAFRA, 2008).

Bird health

Obviously an unhealthy bird is likely to have poor feed efficiency. The main reason for this is that feed intake is reduced, and so again proportionally more feed is directed towards maintenance. With enteric diseases there can be more subtle changes in feed utilization because various parasites and microbes can reduce the efficiency of digestion and absorption of nutrients (MAFRA, 2008).

2.4.4. Feed consumption and water requirements

Animals should receive a daily diet in enough quantities containing adequate nutrients to meet their requirements for good health and welfare. When considering the amount of food and nutrients animals require, a number of factors need to be taken into account: physiological state; management systems; nutritional composition of feed; breed, age, sex, size and state of health of animals; growth rate; previous feeding levels; feeding frequency; level of activity and exercise; maximum periods of food deprivation (e.g. during transportation); and climatic factors. Therefore, it is not appropriate to specify a complete range of the quantities of food and nutrients required as minimum standards (Animal Welfare, 2003).

Feed and water consumption are very closely related. Lott and his colleagues (2003) estimate the correlation between feed and water consumption at 0.98. When water consumption changes, 98% of the time feed consumption changes. However, when there is an increase or decrease in feed or water consumption, there is a corresponding increase or decrease in the other. If water intake is down on any given day, most likely feed intake is also down on that day.

Food and water supplied to the broiler chickens are important components of maintaining good standards of broiler chicken welfare. Nutrient composition, frequency and quantity of feed, contaminants within the feed and water, and access to the feeders and drinkers are all-important parameters. The adequacy of the ration to meet the requirements of the flock can be assessed by monitoring the body weight of the broiler chickens and measuring against a recognized body weight standard for a particular breed, sex and production system (Animal Welfare, 2003).

Protein and energy content of the feed

High levels of L-lysine-HCL improved feed conversion, while fillet meat yield (% of carcass) is not affected (Baker and Han, 1993). Tryptophan may become a limiting nutrient as crude protein levels of diets are reduced. Tryptophan levels in ingredients and feed are much more difficult to assay than are the other common amino acids, and in part, this situation leads to variability in research results aimed at quantifying the response to

tryptophan (Leeson *et al.*, 2001). For the starter, grower and finisher periods, requirements for available lysine have been established at around 1.15%, 1.00% and 0.90%, respectively (Morris *et al.*, 1999).

Birds fed with higher protein diet give better performance as reflected by the lowest feed conversion ratio (FCR) and abdominal fat. Protein and ME intakes significantly increases for birds fed with higher protein levels of 20 and 23%. On the other hand, there is a significant reduction in abdominal fat for the higher protein diet (Kassim and Suwanpradit, 1996). There seemed to be a close relationship between fat deposition and the energy-protein ratio. The smaller the ratio, the lesser fat accumulates.

The energy content of the diet must be considered in formulating a ration to meet the desired intake of all the essential nutrients other than the energy itself, including the intake of the essential amino acids. For example, if the producer uses a high energy feed, the protein content of the feed must be high, if the bird is to ingest adequate amount of protein (Ensminger *et al.*, 1990).

The work of Summers and his colleagues (1992) confirm that higher energy diets often produce greater weight gain due to the increased fat deposition as the birds consume greater quantities of energy to satisfy its essential amino acid requirements. Based on two energy levels, 3200 kcal/kg (high) and 2800 kcal/kg (low), Holsheimer and Veerkamp (1992) reported that high-energy diets have a higher gain and better feed to gain ratio than chicks on the low energy diets at 6, 7 and 8 weeks of age and the high-energy diets give higher skin and fat yields. At a fixed level of diet protein and amino acids, more fat will be deposited as energy concentration increases (Leeson *et al.*, 2001).

Regarding energy to protein ratio in the feed, it is established that as the dietary calorie to protein ratio is widen, energy intake and carcass fat deposition increases, while body water content decreases (Bartov *et al.*, 1974). Decreasing the dietary energy to protein ratio also increase meat yield and decrease carcass fat content (Salmon *et al.*, 1983; Diambra and McCartney, 1985).

2.4.5. Body composition and carcass yields

The quantity of feed consumed is essentially controlled by energy concentration and the requirement of chicks for protein to achieve maximum growth increases as the density of dietary energy increases. If energy is limiting, dietary protein will be used inefficiently since it will be used as another source of energy instead of being converted into body protein.

Eviscerated carcass yield generally increases with increasing body weights. But body fatness often increases when the birds are near their mature body size. Mansour *et al.* (2004) observed an increase level of abdominal fat percent with advancing slaughter age. Some adipose tissue in the body cavity will be lost at evisceration, so the percentage carcass yields decrease slightly at high carcass weights. Breast meat yield, which often has a higher economic value than meat from other parts of the poultry carcass increases with increasing body weight (Rose, 1997). Feed restriction resulted in lower breast percentage compared to *ad libitum* feeding (Mansour, *et al.*, 2004). Broilers fed diets containing nutrient density with a high calorie-CP ratio had increase level of abdominal fat. By restricting energy intake during the last ten days pre-slaughter, while providing the daily minimum requirement of all other nutrients, Arafa *et al.* (1983) were able to significantly reduce the percent fat pad without significantly affecting yield of broilers. Teeter and Smith (1985) showed that 25% reduction in feed intake of broilers from 28 to 39 days of age reduced abdominal fat by almost 50%.

Lysine and the sulfur amino acids (SAA) are known to exhibit specific effects on carcass composition. Lysine exerts specific effects on body composition at dietary levels higher than that required for maximum growth rate, which also results in an improved feed conversion ratio (FCR) as compared to methionine and valine (Hickling *et al.*, 1990; Moran and Bilgili, 1990; Schutte and Pack, 1995). Several authors have recently shown that lysine supplementation, at levels above the requirement for maximal growth rate, results in specific and significant effects on body composition. That is the case for breast meat (BM) yield (Hickling *et al.*, 1990; Moran and Bilgili, 1990). Similarly lysine can modify fat deposition and reduces abdominal fat (AF) percentage.

2.4.6. Mortality

The total mortality is related to slaughter age *i.e.* the longer the growing cycle the higher the mortality. ACP (2006) has defined a benchmarking standard of 5% mortality irrespective of slaughter age. Whilst final mortality and leg culls are lag indicators of welfare; daily mortality/sudden mortality levels and seven day mortality are examples of indicators which can be used to demonstrate trends where action can be taken within the crop cycle. However, for the reasons previously described, mortality is a relatively crude measure of bird health (Manning, 2007).

2.5. Nutritional value and limitations in soybean meal (SBM)

2.5.1. Nutritional value and inclusion levels of SBM

Next to cereals, oil meals are most widely used group of ingredients in poultry feed (mainly as a source of protein). Consequently, most protein sources are considered to be largely interchangeable from the point of view of feed manufacturers and hence, price tends to be the key determinant influencing which meals are used. Nevertheless, different oil meals have different nutritional values, and some (notably Soya meal) are considered to be a necessary ingredient in certain compound feeds (*i.e.*, demand is less price responsive than direct substitute ingredients), whilst others tend to be used only when price considerations allow. The main reason for the dominance as a protein ingredient is its relatively high protein content of 41-50 % (dry matter basis) depending upon the amount of hull that is removed and processing method that is being used (Liener, 1994 ; CRC, 1983). The high protein content (480 g/kg) coupled with its highly digestible, well-balanced amino acids makes soybean meal (SBM) a valuable protein source in diets for humans and monogastric animals (Irish and Balnave, 1993). Indeed, SBM is the most commonly used vegetable protein source in poultry diets.

Results from a recent survey indicate that typical amounts of soybean meal added are 30 to 40 percent in monogastric (poultry) diets (Brookes, 2000; Brookes, 2001). With the single exception of methionine, soybean meal is an almost ideal protein supplement for all types of poultry. When blended with corn or grain sorghum, soybean meal provides a good balance of all the essential amino acids needed by poultry except for methionine. However,

methionine is economically provided by supplements produced by the chemical industry, allowing simple corn-soybean meal diets to effectively meet the amino acid requirements of the chick (Brookes, 2000).

Arafa *et al.* (2001) compared the effect of feeding diets containing all-vegetable protein versus mixture of vegetable and animal protein sources on the performance and carcass characteristics of broiler chicks. They found that live body weight, feed consumption and feed conversion ratio of chicks fed on vegetable protein diets such as soybean meal (containing 38.65% SBM), corn gluten meal and/or sunflower seed meal were not significantly different from those of the control fish meal diet. Chicks fed SBM diets has no significant effect on percentage of dressing, liver, gizzard, heart, abdominal fat, kidney and total edible parts. El-Deek *et al.* (2002) reported no significant difference in carcass characteristics due to SBM levels in the diets. Similarly, Arafa *et al.* (2001) found that carcass characteristics were not significantly affected by feeding chicks either on animal or vegetable protein sources.

The nutritional composition of feed will vary as any given ration mix serves specific livestock types. Thus it varies by animal type, age of animal and the purpose it is being raised (e.g., eggs, meat, milk). In general, non-ruminants like pigs and poultry require protein rich feeds whilst ruminants require feeds with higher fiber and energy content. In terms of preferences for different protein sources, Soya meal is the most used source and is generally considered as the standard against which alternatives are measured. General preference for Soya according to Brookes (2001), reflects its high level of protein, abundant and consistent availability, consistent price competitiveness relative to alternatives – this does, however vary with time, it has a higher level of lysine (but slightly lower levels of methionine and cystine) than other vegetable-based products like rapeseed meal and its higher digestibilities (Brookes, 2001).

2.5.2. Limitations (anti-nutritional factors) in SBM

Several anti-nutritional factors have been found to be associated with SBM, which affect protein and energy utilization in diets for pigs and poultry (Campbell and van der Poel, 1998). Heat labile ANF, such as lectins will interfere with absorption of nutrients in the small intestine by animals (Liener, 1994). Trypsin inhibitors interfere with the enzymes

trypsin and chymotrypsin. Trypsin and chymotrypsin are secreted into the small intestine by the pancreas and aids in the digestion of dietary proteins that have been consumed by an animal. The trypsin inhibitors bind to enzymes and causes trypsin and chymotrypsin to become non-functional and therefore protein digestion is impaired (Liener, 1994; Caine, *et al.*, 1998). The trypsin inhibitors have the greatest effect on poultry and swine. Protease inhibitors and lectins, can be inactivated by toasting or extruding. However, both under and over-processing of SBM will lead to reduced lysine and cystine digestibility and subsequently to a reduced average daily gains in broilers (Parsons *et al.*, 1992; Perilia, *et al.*, 1997). Protein and amino acid digestibility is also affected by the presence of high levels of phytic acid in SBM. Phytic acid binds phosphorus and zinc and causes them to be unavailable to the animal. Much of the phosphorus and zinc are present in soybeans in the bound form, so various methods have been proposed to increase their availability. Microbial phytase was added to corn-soybean layer diets and egg production, egg weights and feed consumption were found to be significantly increased (Um and Paik, 1999). Genetically modifying soybean by inserting a fungal phytate enzyme has been shown to be an effective way of increasing the availability of phosphorus in feeding applications with poultry and swine (Denbow, *et al.*, 1998). The amount of indigestible carbohydrates, in particular, the amount of oligosaccharides (OS) and non-starch polysaccharides (NSP) affect the nutritive value of SBM. It contains approximately 5-6% OS, which are mainly a-galactosides. Bacterial degradation of a-galactosides in the hindgut can lead to increased hydrogen production and impaired nutrient utilization as well as causing diarrhea and a depressing effect on growth in poultry (Saini, 1989; Coon, *et al.*, 1990; Leske, *et al.*, 1991). Feeding whole soybean or soybean products that have only had a portion of the oil extracted to monogastric animals will increase the amount of unsaturated fatty acids that are being consumed, which causes the fat deposits to become soft (higher in unsaturated fatty acids) and undesirable in some markets.

2.6. Nutrient content and inclusion levels of meat and bone meal (MBM)

Meat and bone meal (MBM) is the dried and rendered product from mammalian tissues and contains bone, viscera, lean tissue, and fat (Kirstein, 1999; Narodoslowsky, 2003). Meat and bone meal has been studied and used in poultry diets as a source of CP, P, and Ca for many years (Sell, 1996; Johnson and Parsons, 1997; Parsons *et al.*, 1997). Because of the heterogeneous nature of sources of MBM and the variation in rendering procedures,

proportion of these raw materials as well as the species origin contributes to the large variations in the quality of meat and bone meal (Adedokun and Adeola, 2005). Depending on the proportion of bone to soft tissue used in the manufacture, the finished product is designated as meat meal (containing greater than 55g/100g CP and less than 4.4g/100g phosphorus) or meat and bone meal (containing less than 55g/100g CP and greater than 4.4g/100g phosphorous (Ravindran, *et al.*, 2002). The proportion of bone to soft tissues used in the manufacturing process results in the finished products being named as low ash (ash<20%) or high ash (ash >20%) meal. Raw material source and processing conditions are two of the major factors that affect protein quality of MBM (Liu, 2000).

The poultry and swine industries are the predominant consumers of meat and bone meal because of its high calcium, available phosphorus, and lysine contents. Researchers at the University of Georgia have fed up to 40 percent meat and bone meal in a corn-soybean meal basal diet and found that the upper acceptable limit in the diet was about 10 percent (Miles and Jacob, 1998). These researchers emphasized that feeding higher levels in the diet will cause imbalances of calcium and phosphorus (Miles and Jacob, 1998).

In contrary an average protein of 50% MBM is used in broiler diets at levels as high as 17% without any adverse effects on broiler weight gain or FCR (Wilder *et al.*, 1957, as cited by Liu, 2000). In Australia, Sathe and McClymont (1965) reported that 25 to 30% protein provided by low quality MBM in chick diets containing 20% protein was a maximum level. However, the results also showed that high quality MBM could be used to provide 35% of total protein in chick diets with growth rate equivalent to that for a soybean meal diet. Runnels (1968) showed that a MBM inclusion rate of 7.5% was the best level for optimum chick weight gain although 10% MBM could be used if energy and EAA in the diets were maintained at normal levels. 10% inclusion of MBM to replace soybean meal yielded an adverse effect on chick weight gain and FCR, But with no significant effect on feed intake. This is in agreement with findings for growing chicks or pigs (Sathe and McClymont, 1965; Evans and Leibholz, 1979).

Salmon (1977) stated that an increase of MBM from 7.5 to 15% in turkey diets reduced weight gain. Evans and Leibholz (1979) reported that pig performance was linearly depressed as MBM replaced soybean meal at increasing levels from 2.5 to 10% in corn-based diets. These early studies showed little agreement for the inclusion level of MBM in

poultry and pig diets. Usually, MBM inclusion level is restricted to 5%. The problems associated with the use of high inclusion of MBM in broiler or young-pig diets are AA imbalance, high dietary Ca and P level and salmonellae contamination (Liu, 2000). Fat content in the MBM samples was high in comparison to most plant protein ingredients. In this regard, the high fat level in MBM may represent a risk of auto oxidation in storage.

The high ash (34.85%) content of MBM could be used at up to 12.98% and the low ash (25.87%) MBM at up to 17.76% without adversely affecting body weight, feed utilization, mortality or tibia ash content when the ration was formulated on a digestible amino acid basis (Drewyor and Waldroup, 2000). Ash contents were negatively correlated with crude fat, crude protein, and gross energy. The levels of crude protein and crude fat had a positive relationship to gross energy (Dale, 1997; Shirley and Parsons, 2000). The larger, positive correlation of crude protein with gross energy was due probably to the fact that high protein samples were always associated with low ash contents. Increasing ash contents resulted in decreased amino acid concentrations (Shirley and Parsons, 2000).

Considerable variation was observed in the contents of crude protein (38.5-67.2g/100g), Ash (13.0-56.5g/100g) crude fat (4.3 -15.3g/100g), and gross energy (9.4-22.3MJ/kg) of MBM (Ravindran *et al.*, 2002). Protein solubility in potassium hydroxide ranged widely among different samples (7.0-62.0%), with a coefficient of variation of 58%, but the variation in pepsin nitrogen digestibility was similar (84.3-94.4%), with a coefficient of variation of 3.2% (Ravindran *et al.*, 2002).

The amino acid composition of MBM has a wide variation with histidine, methionine, and cystine showing the highest variability (coefficients of variation, 26.3-33.5%). Proline, alanine, glutamic acid, and arginine had the lowest variability (coefficient of variation, 9.1-11.5%). On average, the protein in MBM was found to be a poor source of cystine and histidine, and a rich source of non-essential amino acids (Ravindran *et al.*, 2002). The digestibility of essential amino acids also varied substantially. The coefficient of variation for the digestibility of most amino acids ranged from 13-16%, but the digestibility of cystine was a notable exception, with a coefficient of variation of 28.3%. Cystine in MBM was poorly digested (average, 36.5%) and the digestibility varied widely from 14.8 to 56.3% (Ravindran *et al.*, 2002).

Although MBM has a high level of Lysine heat damage during processing may decrease content and digestibilities, of Lys and also TSAA and consequently result in a reduction in the overall AA balance. Additionally, MBM protein is deficient in Try and a number of other essential AA due to the presence of large quantities of bone or connective tissues (Eastoe and Long, 1960). Amino acid imbalance is one of the constrains in the usage rate of MBM in animal diets. However, supplementation with synthetic AA to compensate the deficiencies may increase the inclusion level of MBM in animal diets.

Wang and Parsons (1998) showed that the nutrient content of 32 MBM samples obtained from different commercial manufacturers varied widely; protein from 40 to 60% ash from 20 to 47%, true digestibility of Lys and Cys from 68 to 92% and 20 to 71% respectively. Sibbald (1979) reported that Lys and Cys digestibilities of 21 MBM samples ranged from 45 to 86% and 30 to 64%, respectively. Batterham *et al.* (1986) found that Lys availability varied from 48 to 88%. This variation is a consequence of different systems being used in processing MBM and because no fixed ratio among the components which include meat residues, organ, bone, associate fat and to some extent, hair and blood is used by manufacturers in the production of MBM. Different production of MBM leads to differences in chemical composition and nutrient quality, specifically available energy and protein.

3. MATERIALS AND METHODS

3.1. Study site

The study was conducted at the Debre Zeit Agricultural Research Center. Debre Zeit is located at 47 km South of Addis Ababa at an altitude of 1900m above sea level, latitude of 8° 44`N and longitude of 38° 57`E. The average (25 years) annual rainfall is 851mm with an average minimum and maximum temperature of 8.9°C and 26°C, respectively. The average relative humidity is 58.6 percent (DZARC, 2002).

3.2. Study animals

Cobb 500 strain of broiler chicken kept under station condition represents the study animals. Cobb begins a breeding line of all white birds called White Rocks. These birds along with the Vantress male, the oldest male line breed and known as the original dominant white Cornish male, provide the foundation of today's pedigree Cobb lines. It was the Cornish and the Barred Plymouth Rock that gave rise to the first of the modern, commercial breeds, the Cobb. Initially, a genetically dominant, White Plymouth Rock was developed to meet the demand for a white-feathered bird that did not have dark stub feathers on the carcass. This white male could be mated to different colored females but the progeny would always be white (Thear, 2005). Then, a Cornish (Indian Game) male was crossed with White Rock females and the progeny were subsequently selected for fast growth. An interesting aspect of this selection was the change in the frequency of pea combs. A pea comb is a small comb with triple ridges. Initially, nearly 100% of the birds had such a comb. However, fast growth is associated with single combs, and selection produced birds that were 90-100% single-combed. It was this line that produced the Cobb 500, a white-feathered table bird (Thear, 2005).

Cobb 500 is developed for intensive, indoor production; it is certainly a fast grower compared to Ross birds and has been known to grow too quickly for its legs to cope with its weight. The males are particularly prone because of their even larger size. In intensive conditions, they achieve a weight of 1.8 to 2.3kg (4 to 5lb) in five to six weeks (Animal Legal and Historical Center, 2003). In a free-range environment, where they are fed a lower protein ration, they achieve this weight in around 12 weeks. The breed has proven its ability

to perform well in a wide range of environments, market situations and legislative demands, satisfying demand for maximum meat output. It has an excellent feed conversion ratio; feed conversion continues to fall by 0.1 every five years. The Cobb 500 broiler exhibits consistently better uniformity than its major competitor across a wide range of body weights, as a recent industry comparison of birds at the same age demonstrates (Thear, 2005). This advantage is seen both within each sex and across the sexes. High meat yield, particularly from breast portions, is the goal of many customers. The Cobb 500 has been selected for meat yield and has an impressive record; with breast meat increased from 14% in 1987 to 20-21% today (Thear, 2005).

Cobb has long recognized the importance of selecting for good health. However, Cobb 500 broilers, which are commonly used in the UK, were found to be substantially more susceptible to lameness than Ross broilers. The incidence of lameness would probably have been even higher (Kestin *et al.*, 1999), but exercise helps to develop and strengthen their leg muscles (Thear, 2005).

3.3. Diet preparation and experimental design

Birds were provided daily with a known amount of feed and water *ad libitum*. Feed and water were weighed every morning and offered to the respective groups. Refusals were also collected every morning and weighed and the difference between offers and refusals were calculated. The refusals were thoroughly mixed with the respective treatment feed and given back to the birds. A plastic chick fountain and a flat circular plastic feeder were used during the first week of the trial. Defatted soybean meal was purchased from a local oil factory in Addis Ababa. Five diets were obtained by replacing meat and bone meal (MBM) with soybean meal (SBM) and a commercial diet for comparison purpose. Twenty six percent MBM gradually replaced by 0% (26%MBM), 25% (19.5% MBM + 6.5% SBM), 50% (13% MBM + 13% SBM), 75% (6.5% MBM + 19.5% SBM) and 100 % (26% SBM) levels of soybean meal were respectively designated as diets 1(commercial diet), 2, 3, 4, 5 and 6 (Table 3). The ration contains around 22% and 20% crude protein and 3000kcal/kg and 3200kcal/kg of metabolizable energy for starter and finisher broiler chicks, respectively.

Table 3. Layout of the experimental design

Treatment groups	No. of chicks/ replication					
	Broiler starter phase			Broiler finisher phase		
	R1	R2	R3	R1	R2	R3
Commercial diet (T ₁)	17	17	17	17	17	17
26%MBM + 0% SBM (T ₂)	17	17	17	16	16	16
19.5%MBM+6.5%SBM (T ₃)	17	17	17	17	14	17
13%MBM + 13% SBM (T ₄)	17	17	17	16	17	16
6.5%MBM +19.5%SBM(T ₅)	17	17	17	17	17	17
0%MBM + 26% SBM (T ₆)	17	17	17	17	17	16
Sub total	102	102	102	100	98	99

R1= replication 1, R2= Replication 2, R3= Replication 3

Three hundred and six day old Cobb 500 broiler chicks received from Alema Farms located at Debre Zeit were used for the experiment and the chicks were weighed using sensitive balance and randomly allotted to six dietary treatments replicated three times. Each replica has seventeen (17) birds and subjected in a completely randomized design (CRD) at the beginning of the experiment.

The different types of feedstuffs included as feed ingredients and the respective nutrient composition of starter and finisher rations for the experimental design are presented in Table 4, 5 and 6.

Table 4. Proximate compositions (%) of soybean meal and meat and bone meal used for the trial

Feed stuff	DM (%)	CP (%)	CF (%)	FE (%)	NFE (%)	MM (%)	Ca (%)	P (%)
MBM	97.69	42.90	0.00	18.74	4.09	34.27	12.70	0.97
SBM	95.14	44.31	7.89	9.86	31.45	6.50	0.29	0.60

Table 5. Ingredients and nutrient composition of starter diets

Feed stuff (kg/100kg)	Diets					
	1	2	3	4	5	6
Maize	-	58.00	57.50	57.75	57.50	57.00
MBM	-	26.00	19.50	13.00	6.50	-
SBM Eth.	-	-	6.50	13.00	19.50	26.00
Noug cake	-	12.50	13.00	12.75	13.00	13.50
Broiler premix ¹	-	1.00	1.00	1.00	1.00	1.00
Salt	-	0.50	0.50	0.50	0.50	0.50
Soybean oil	-	2.00	2.00	2.00	2.00	2.00
Total	-	100.00	100.00	100.00	100.00	100.00
Laboratory result composition after chemical analysis						
DM (%)	90.57	93.93	93.60	92.31	92.45	92.36
CF (%)	5.79	6.15	5.87	6.73	9.04	6.52
CP (%)	22.27	21.14	23.56	22.30	23.19	22.55
FE (EE) (%)	6.21	10.41	14.00	9.49	9.69	9.80
NFE (%)	60.39	48.06	43.87	51.63	49.98	54.76
MM (%)	5.70	14.25	12.71	9.85	8.11	6.38
Ca ⁺⁺ (%)	1.19	4.00	3.17	2.18	1.46	0.88
P (%)	0.47	0.78	0.74	0.61	0.36	0.33
ME (Kcal/kg DM)	3542.89	3389.82	3675.15	3467.42	3345.60	3647.43

¹ Broiler premix 1% per kg contains: **Vitamins:** Vitamin A,1000000IU; VitaminD3, 200000IU;Vitamin E, 1000mg; Vitamin K, 225mg; vitamin B1, 125mg; vitamin B2, 500mg; vitamin B3, 1375mg; vitamin B6, 125mg; vitamin B12, 1mg; vitamin PP,4000mg; folic acid, 100mg; Choline Chloride, 37500mg; Biotin, 0mg. **Trace elements:** Iron, 0.45%; Copper,0.05%; Manganese, 0.6%; Cobalt, 0.01%; Zinc,0.7%; Iodium, 0.01%; Selenium, 0.04%; **Minerals:** Calcium, 29.7%. **Other Additives:** Anti—oxidant (BHT) 0.05%.

Table 6. Ingredient and nutrient composition of finisher diets

Feed stuffs (kg/100kg)	Diets					
	1	2	3	4	5	6
Maize	-	60.00	60.00	60.00	60.00	60.00
MBM	-	26.00	19.50	13.00	6.50	-
SBM Eth.	-	-	6.50	13.00	19.50	26.00
Sorghum	-	8.50	8.50	8.50	8.50	8.50
Noug cake	-	2.00	2.00	2.00	2.00	2.00
Premix general ¹	-	1.00	1.00	1.00	1.00	1.00
Salt	-	0.50	0.50	0.50	0.50	0.50
Soybean oil	-	2.00	2.00	2.00	2.00	2.00
Total	-	100.00	100.00	100.00	100.00	100.00
Laboratory result composition after chemical analysis						
DM%	90.97	92.63	92.44	92.37	91.77	91.77
CF%	6.34	3.87	3.26	4.93	4.70	4.66
CP%	19.82	16.57	17.92	18.46	17.52	18.32
FE (EE)%	6.46	11.44	8.26	7.17	8.90	8.35
NFE%	61.96	56.13	60.36	59.12	61.98	61.96
MM%	5.42	11.99	10.20	10.32	6.90	6.71
Ca++%	1.17	0.89	0.92	0.89	0.87	0.85
P%	0.62	0.79	0.81	0.79	0.65	0.64
ME Kcal/kg DM	3518.93	3740.87	3695.02	3482.70	3736.75	3718.13

¹ Broiler premix 1% per kg contains: **Vitamins:** Vitamin A,1000000IU; VitaminD3, 200000IU;Vitamin E, 1000mg; Vitamin K, 225mg; vitamin B1, 125mg; vitamin B2, 500mg; vitamin B3, 1375mg; vitamin B6, 125mg; vitamin B12, 1mg; vitamin PP,4000mg; folic acid, 100mg; Choline Chloride, 37500mg; Biotin, 0mg. **Trace elements:** Iron, 0.45%; Copper,0.05%; Manganese, 0.6%; Cobalt, 0.01%; Zinc,0.7%; Iodium, 0.01%; Selenium, 0.04%; **Minerals:** Calcium, 29.7%. **Other Additives:** Anti—oxidant (BHT) 0.05%.

3.4. Housing and management

Litter system housing, which is partitioned into 18 equal-sized pens, was used to keep the experimental animals. Before placing the experimental birds into the pens, the whole unit was cleaned, disinfected and littered with properly dried tef (*Eragrostis tef*) straw. Subsequently, the necessary sanitary precautions were observed, which includes daily cleaning of the feeders and drinkers. The house was electrically heated using 250 watt bulbs, two per house. Experimental chickens were vaccinated for NCD; HB1 at 2nd day and Lasota at day 23 through ocular routes and Gumboro at day 7 and 21 with drinking water.

3.5. Collection of performance parameters

The body weights of birds were taken as a group at the beginning and weekly thereafter until the end of the study using sensitive balance. Mortality data and cause of mortality were recorded every day. Then, mean weekly feed and water consumption, body weight gain, feed conversion ratios, cost of feed per unit body weight gain, rate of mortality and other related parameters were used to evaluate the difference among the treatments.

Feed conversion ratio was evaluated by dividing feed intake by the weight gain (Khawaja *et al.*, 2007). Feed intake per bird and the cost of feed per kilogram were used to calculate the cost of feed consumed by a bird for the period. The cost per kilogram of weight gain was calculated according to the procedure of Sonaiya *et al.* (1986) and Ukachukwu and Anugwa (1995), which involves taking the product of cost per kilogram of feed and feed-to-gain ratio of birds consuming such diets. The economic benefit was estimated by considering partial budget analysis assumptions. The partial budget was analyzed taking into consideration the whole feed expense, water cost and prices of eviscerated carcass according to the principles developed by Upton (1979), whereby other costs were assumed to be similar for all the treatments. The costs of the different diets (cost/kg) at the starter, finisher and entire period of feeding were noted.

$$\text{Partial production cost/live weight gain} = \frac{\text{Feed cost consumed (Birr)} + \text{water cost (Birr)}}{\text{Price of eviscerated carcass (Birr)}}$$

At the end of the 7th week, two broilers (one male and one female) per treatment were randomly removed and starved over night. They were then weighed and slaughtered by cervical dislocation as described by Oluyemi and Roberts (2000). The slaughtered birds were plucked manually after scalding in hot water. Eviscerated percentage was calculated by removing the viscera, head, shank, lungs and heart but with liver, gizzard and neck and computed as percent of the live weight.

The abdominal fat and breast weight were measured individually and equated with percent live weight and drumstick and thigh together, liver and gizzard were measured and expressed as percent of the live weight. Abdominal fat around the proventriculus and gizzard and against the abdominal wall and the cloacae was collected and weighed using the sensitive balance to the nearest gram. Its percentage was calculated as the proportion of slaughter weight multiplied by hundred.

3.6. Laboratory analysis of feed samples

Representative samples of all the feed ingredients used in the study were sent to National Veterinary Institute for chemical analysis and analyzed for proximate principles. The chemical composition of the experimental diets and the test materials (meat and bone meal and soybean meal) were analyzed using the method of A.O.A.C. (1990). Samples were taken from the formulated feed. The determination of the dry matter (DM %), crude protein (CP %), mineral matter (MM %), crude fiber (CF %), fat extract (%), nitrogen free extract (%), Ca (%) and P (%) were determined. ME were estimated by employing the formula proposed by Wiseman (1987) $ME (Kcal/kg DM) = 3951 + 54.4EE - 88.7CF - 40.8Ash$.

3.7. Statistical analysis

Variance between treatments was analyzed using the General Linear Model (GLM) procedure of the Statistical Analysis Systems using SPSS (release 15.0, 2006) software. When the analysis of variance revealed the existence of significant differences among treatment means, then Duncan Multiple Range Test (Duncan, 1955) was used to locate treatment means that were significantly different from one another. Before analysis mortality count data were transformed using the square root method.

4. RESULTS

4.1. Feed consumption

The mean feed consumptions of the starter's treatment ration by the experimental chicks are given in Table 7. Mean total feed consumption was significantly higher ($P < 0.05$) for the groups fed on the commercial starter ration (diet 1) followed by the groups placed on diet 5 (diet containing 19.5% SBM + 6.5% MBM), diet 4 (13% SBM + 13% MBM) and diet 3 (6.5% SBM + 19.5% MBM). There was no significant ($P > 0.05$) difference in intake between chicks kept on starter diet 3, 4 and 5. The least mean daily feed intake was observed for the diet 2 (0% SBM).

Mean total feed consumption of the experimental birds during the finisher period is presented in Table 8. Chicks kept on MBM and SBM-containing treatments were inferior ($p < 0.05$) in terms of finisher feed intake when compared to those on diet 1. Chicks on diet 5 and diet 6 had the next highest intake. There was no significant difference ($p > 0.05$) in feed intake between chicks on diet 5 and diet 6. Chicks on diet 4, 3 and 2 occupied the third, fourth and fifth places. The level of MBM and feed consumption in the finisher phase were inversely related; intake increased when MBM level decreased.

Overall performance of broilers on the experimental diets for the whole period is presented in Table 9. Feed intake was significantly different ($p < 0.05$) among treatment groups. Broilers on diet 1 consumed the largest ($p < 0.05$) quantity (5.06Kg/ bird) of feed followed by those on diet 5. Mean total feed consumption was significantly lower for the group placed on diet 2 (2.43kg) when compared to all other treatment groups. The highest value of intake from soybean meal and MBM combined diet was observed for diet 5. This is an indication that their combination encouraged more feed intake than when SBM or MBM was fed separately.

The trends in the weekly feed intake by the different experimental groups during the whole study period are presented in Figure 1.

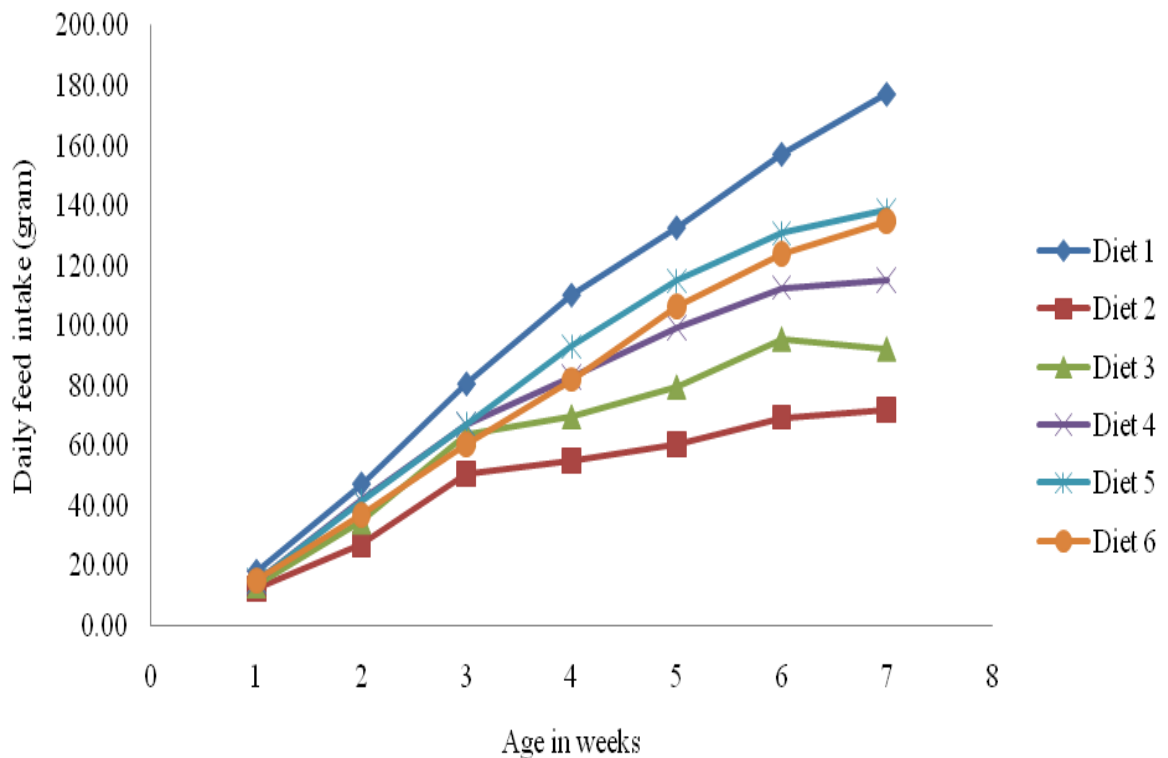


Figure 1. Average weekly feed intake during the study period in the different experimental groups

4.2. Body weight gain

The mean daily body weight gain significantly differed ($p < 0.05$) between treatments in the starter phase as shown in Table 7. The mean daily body weight gain of the group assigned to the commercial ration (diet 1) was significantly higher than the others, followed by that of the groups fed on diet 5. The diet containing 26% MBM (diet 2) resulted in the lowest daily body weight gain. The weight gain result indicated that as the level of MBM increased from 6.5% to 26%, the body weight gain decreased significantly ($P < 0.05$). This means there is an inverse relationship between the level of MBM and weight gain in this study similar to that of feed consumption.

The result of daily body weight gain in the finisher phase is presented in Table 8. Similar to the starter phase, statistically the highest daily gain was recorded for chicken kept on diet 1

(66.02g). Those chicken on diet 5 (52.17g) and 6 (49.36g) showed the next higher weight gain. When the level of SBM decreases from 19.5% to 0%, the weight gain also decreased significantly, means the least daily weight gain was recorded for diet 2 (20.05g/day).

Mean overall daily body weight gain of the groups fed on diet 1 (48.39g) was significantly ($p < 0.05$) higher than all the others during the entire experimental period (Table 9). All the treatments (diet 1, 5, 6, 4, 3 and diet 2) consistently decrease in their body weight gain in the presented order. The least gain was observed for diet 2 (15.29g/day). The higher levels of MBM significantly affect the weight gain of the treatment birds. There is a wide variation in body weight gain between the maximum weight gained by commercial diet and the minimum body weight gained by diet 2 as described above.

The trends in the daily body weight gains by the different experimental groups during the whole study period are presented in Figure 2.

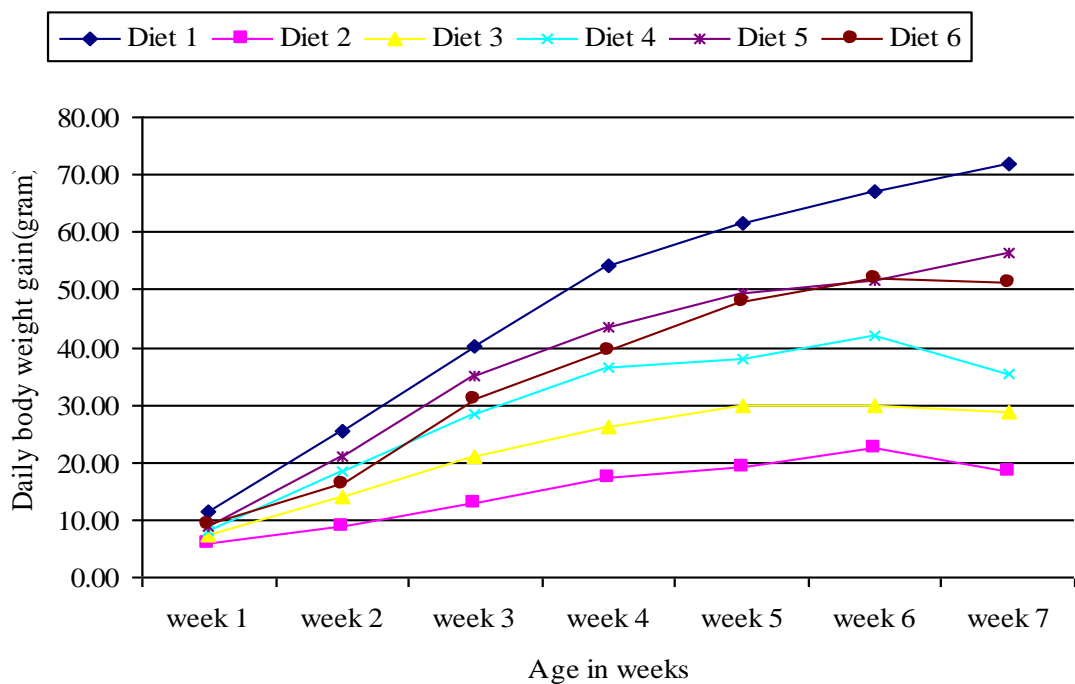


Figure 2: Daily body weight gain in the different treatment groups during the study period

Table 7: Response of broiler chicks to different dietary combinations of MBM in starter diets by SBM (0-21 days)

Parameters	Diets 1	Diets 2	Diets 3	Diets 4	Diets 5	Diets 6	SEM
Initial body weight (g/bird)	35.64±0.09 ^{NS}	35.78±0.07 ^{NS}	35.77±0.18 ^{NS}	35.78±0.09 ^{NS}	35.59±0.09 ^{NS}	35.78±0.18 ^{NS}	0.045
Mean daily weight gain(g/bird)	25.74±0.32 ^a	9.17±0.57 ^e	14.13±0.80 ^d	18.34±0.57 ^c	21.70±0.49 ^b	18.81±0.90 ^c	1.22
Total body weight gain (g/bird)	540.62±6.72 ^a	192.58±11.92 ^e	296.73±16.79 ^d	385.13±12.00 ^c	455.78±10.28 ^b	395.04±19.00 ^c	539.72
Final body weight (g/bird)	576.26±6.65 ^a	228.36±11.85 ^e	332.49±16.61 ^d	421.27±11.80 ^c	491.28±10.23 ^b	430.82±18.91 ^c	531.02
Mean daily feed intake(g/bird)	48.64±0.41 ^a	29.91±1.17 ^d	37.94±2.07 ^{bc}	41.11±0.51 ^b	41.16±0.78 ^b	36.79±1.09 ^c	3.95
Mean total feed intake (g/bird)	1021.39±8.51 ^a	628.03±24.62 ^d	796.81±43.53 ^{bc}	863.24±10.72 ^b	864.31±16.35 ^b	772.49±22.96 ^c	1741.66
FCR (feed : gain)	1.81±0.01 ^d	3.04±0.08 ^a	2.50±0.08 ^b	2.14±0.10 ^c	1.85±0.01 ^d	1.92±0.04 ^d	0.012
Mean daily water intake(ml/bird)	100.23±0.69 ^a	50.37±3.85 ^e	68.33±0.83 ^d	86.84±1.08 ^c	93.99±1.39 ^b	82.15±1.34 ^c	10.43
Mean total water intake(ml/bird)	2004.5±13.91 ^a	1007.4±77.00 ^e	1366.5±16.57 ^d	1736.8±21.58 ^c	1879.8±27.76 ^b	1642.9±26.80 ^c	4176.08
Water / feed ratio	2.06±0.03 ^c	1.68±0.06 ^d	1.81±0.09 ^d	2.11 ^b ±0.02 ^c	2.29±0.01 ^a	2.24±0.03 ^{ab}	0.007
Mortality*	0.00±0.00 ^{NS}	1.00±0.00 ^{NS}	0.58±0.58 ^{NS}	0.67±0.33 ^{NS}	0.00±0.00 ^{NS}	0.33±0.33 ^{NS}	0.303

^{abcdef} Means within a row followed by different superscripts are significantly different (p<0.05); NS = Non-significant

* Mortality count data were transformed by square root method

Values are means ± standard errors; SEM= Standard errors of mean square

4.3. Feed conversion ratio

Feed conversion ratio of the experimental chicks expressed as grams of feed consumed per unit body weight gain. Feed conversion ratio of the experimental chicks in the starter, finisher and whole period of growth were shown in Table 7, 8 and 9. Statistically there is no significant difference among chicks on diets 1, 5 and 6. The highest feed required for a unit of weight gain was observed for diet 2. Similar to weight gain, as the level of MBM was beyond 6.5% the feed required for a unit of gain also increased significantly in all phases of feeding.

The trends in the weekly feed conversion rates in the different experimental groups are presented in Figure 3

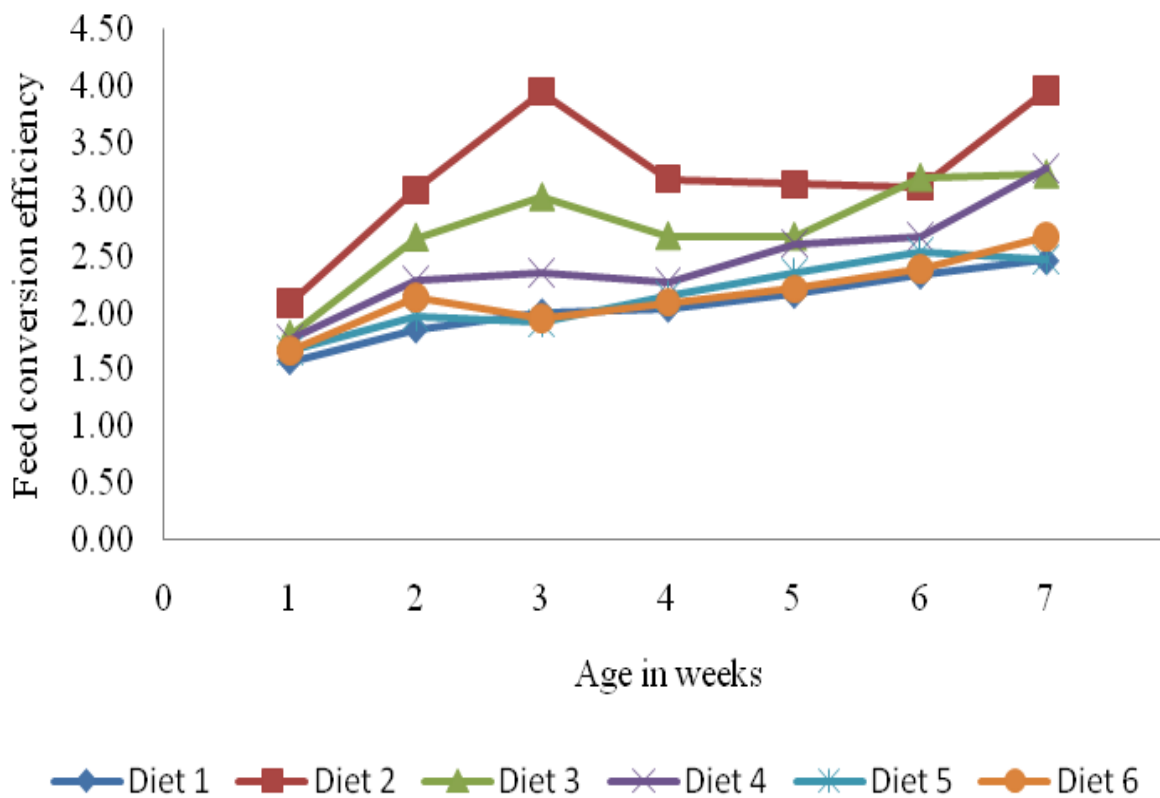


Figure 3. Feed conversion ratios in the different experimental groups during the study period

4.4. Water to feed ratio

The highest water to feed ratio in the starter phase was observed for chicken on diet 5 (2.29) and 6 (2.24). The least ratio were observed for diet 2 (1.68) and diet 3 (1.81). In this study, the level of SBM and the water intake were directly related; as the level of SBM increased the water intake also increased (Table 7).

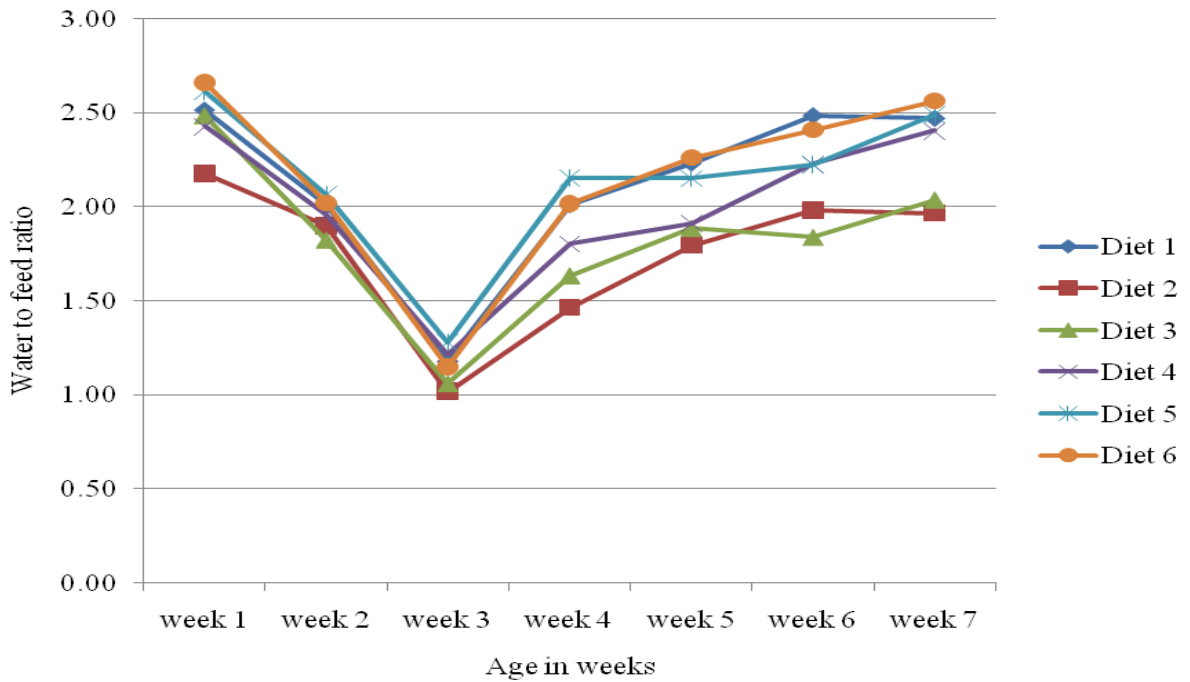


Figure 4: Water to feed intake ratio in the different treatment diet groups during the study period

Both in the finisher and entire period of the experiment, chickens on diet 1, diet 6 and diet 5 showed significantly higher water to feed ratio. The minimum ratio was recorded for diet 2 and diet 3.

Table 8: Effect of replacement of MBM in broiler finisher diets (22-49 days) by SBM

Parameters	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6	SEM
Initial body weight (g/bird)	576.26±6.65 ^a	228.36±11.85 ^e	332.49±16.61 ^d	421.27±11.80 ^c	491.28±10.23 ^b	430.82±18.91 ^c	531.02
Mean daily weight gain(g/bird)	66.02± 0.36 ^a	20.05±0.39 ^e	29.69±1.31 ^d	39.47±1.64 ^c	52.17±1.79 ^b	49.36±1.53 ^b	5.11
Total body weight gain (g/bird)	1782.56±9.61 ^a	541.29±10.60 ^e	801.76±35.25 ^d	1065.79±44.22 ^c	1408.58±48.33 ^b	1332.78±41.40 ^b	3726.24
Final body weight (g/bird)	2358.82±10.51 ^a	769.66±3.19 ^f	1134.25±50.18 ^e	1487.06±47.52 ^d	1899.86±56.43 ^b	1763.61±50.55 ^c	5317.67
Mean daily feed intake(g/bird)	149.75±1.34 ^a	66.62±2.47 ^e	87.47±3.99 ^d	106.40±3.59 ^c	123.80±1.80 ^b	116.04±2.93 ^b	24.28
Mean total feed intake (g/bird)	4043.07±36.19 ^a	1798.64±66.72 ^e	2361.68±107.78 ^d	2872.80±96.85 ^c	3342.72±48.68 ^b	3133.02±79.20 ^b	17699.85
FCR (feed : gain)	2.26±0.02 ^a	3.33±0.14 ^c	2.95±0.05 ^b	2.71±0.04 ^b	2.38±0.08 ^a	2.35±0.04 ^a	0.008
Mean daily water intake(ml/bird)	348.60±0.43 ^a	121.20±4.06 ^e	162.15±0.11 ^d	224.24±1.81 ^c	280.91±9.52 ^b	272.85±10.05 ^b	105.86
Mean total water intake(ml/bird)	9412.3±11.69 ^a	3272.5±109.72 ^e	4378.1±2.89 ^d	6054.6±48.74 ^c	7584.7±257.11 ^b	7366.9±271.48 ^b	77180.6
Water / feed ratio	2.33±0.02 ^a	1.82±0.04 ^c	1.86±0.08 ^c	2.11±0.07 ^b	2.27±0.04 ^{ab}	2.35±0.03 ^a	0.008
Mortality*	0.00±0.00 ^{NS}	0.33±0.33 ^{NS}	0.33±0.33 ^{NS}	0.33±0.33 ^{NS}	0.80±0.42 ^{NS}	0.33±0.33 ^{NS}	0.34

^{abcdef} Means within a row followed by different superscripts are significantly different (p<0.05); NS = Non-significant;

* Mortality count data were transformed by square root method;

Values are means ± standard errors; SEM= Standard errors of mean square

4.5. Mortality

No significant differences ($P>0.05$) in the rate of mortality were observed between chickens under the different treatment diets in the first 21 days of study period (Table 7). The incidence of mortality was lower for chick's fed diet 1 and diet 5 compared with other diets. Relatively higher mortality (5.88%) was recorded for diet 2 and diet 3 each (Figure 5); but not statistically significant from other diets. Some cases of paralysis were observed in the groups under diet 2 and diet 3.

Similar to the first phase of feeding, there were no significant ($p>0.05$) difference between the treatment groups in the second and whole period of the trial as shown in Table 88 and 9. Relatively in the finisher phase higher mortality (5.88%) was recorded in those on diet 5 (19.5% SBM +6.5% MBM). In the entire rearing period, the numerical value for mortality recorded from the group fed on diet 2 and diet 3 were the highest of all (7.84%) each. In contrary no mortality was observed for commercial diet during the entire study period. Mortality was relatively more pronounced during the starter phase of the experiment.

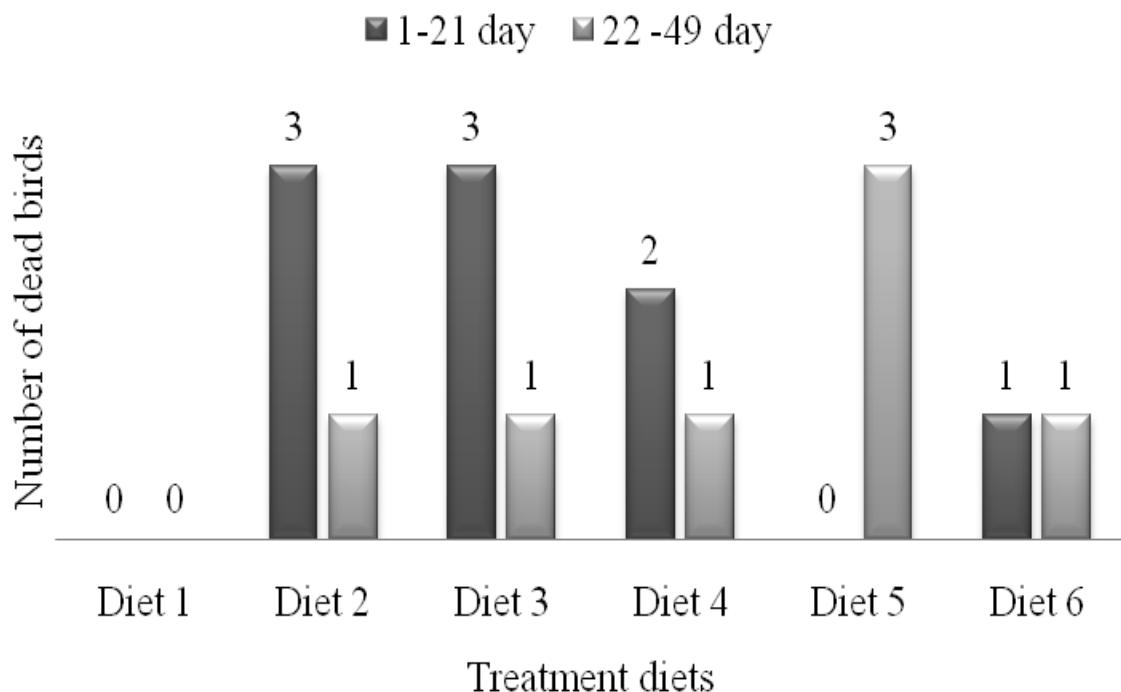


Figure 5: Mortality rates of chickens in the different experimental groups in the starter and finisher periods.

Table 9: Response of replacing MBM in broiler diets (0-49 days) by SBM

Parameters	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6	SEM
Initial body weight (g/bird)	35.64±0.09 ^{NS}	35.78±0.07 ^{NS}	35.77±0.18 ^{NS}	35.78±0.09 ^{NS}	35.59±0.09 ^{NS}	35.78±0.18 ^{NS}	0.05
Mean daily weight gain(g/bird)	48.39±0.22 ^a	15.29±0.07 ^f	22.89±1.05 ^e	30.23±0.99 ^d	38.84±1.18 ^b	35.99±1.05 ^c	2.32
Total body weight gain (g/bird)	2323.18±10.48 ^a	733.88±3.21 ^f	1098.49±50.33 ^e	1450.92±47.58 ^d	1864.36±56.52 ^b	1727.82±50.48 ^c	5330.10
Final body weight (g/bird)	2358.82±10.51 ^a	769.66±3.19 ^f	1134.25±50.18 ^e	1487.06±47.52 ^d	1899.86±56.43 ^b	1763.61±50.55 ^c	5317.67
Mean daily feed intake(g/bird)	105.51±.59 ^a	50.56±1.53 ^e	65.80±3.11 ^d	77.83±1.99 ^c	87.65±1.34 ^b	81.36±2.09 ^c	11.22
Mean total feed intake (g/bird)	5064.5±28.25 ^a	2426.7±73.38 ^e	3158.5±149.03 ^d	3736.0±95.43 ^c	4207.0±64.39 ^b	3905.5±100.16 ^c	25838.10
FCR (feed : gain)	2.18±0.02 ^a	3.30±0.09 ^d	2.88±0.06 ^c	2.58±0.02 ^b	2.26±0.06 ^a	2.26±0.02 ^a	0.01
Mean daily water intake(ml/bird)	237.85±0.21 ^a	89.16±3.38 ^e	119.68±0.29 ^d	162.32±1.38 ^c	197.18±5.92 ^b	187.71±6.07 ^b	42.69
Mean total water intake(ml/bird)	11416.8±10.16 ^a	4279.8±162.40 ^e	5744.6±13.74 ^d	7791.4±66.06 ^c	9464.5±284.39 ^b	9009.9±291.27 ^b	98371.10
Water / feed ratio	2.19±0.01 ^a	1.75±0.05 ^c	1.84±0.09 ^c	2.11±0.03 ^b	2.27±0.02 ^a	2.29±0.01 ^a	0.01
Mortality*	0.00±0.00 ^{NS}	1.14±0.14 ^{NS}	0.91±0.50 ^{NS}	0.80±0.42 ^{NS}	0.80±0.42 ^{NS}	0.47±0.47 ^{NS}	0.46

abcdef Means within a row followed by different superscripts are significantly different (p<0.05); NS = Non-significant

Values are means ± standard errors;

SEM= Standard errors of mean square

* Mortality count data were transformed by square root

4.6. Economic efficiency

As shown in Table 10, there were significant differences ($P < 0.05$) among treatment means. Diet 2 incurred the highest cost both in the starter (9.29 Birr), finisher (9.64 Birr) and whole period (9.53 Birr) to produce a unit of weight gain followed by diet 1 and diet 3. Diet 5 and 6 in broiler ration costs 5.73 and 6.01 Birr in starter phase, 7.30 and 7.36 Birr in the finisher phase and 6.91 and 7.05 Birr for the whole period of production, respectively, per kg of body weight gain. These two combinations were economically feasible than the use of commercial diet and high levels of MBM greater than 6.5% as measured by feed cost/kg of live weight gain. Both uniformity of birds size and posture of birds were negatively affected when higher level of MBM ($>6.5\%$) was included. Level of inclusion of MBM seems to have shown strong negative correlation with cost of feed consumed per kg live weight gain.

The economic return in terms of partial budget analysis from broilers raised under different treatment feed costs and water costs are presented in Table 11, respectively. In this experiment, the highest net profit of 23.59 birr per bird was obtained from the sale of processed broiler carcass reared under the feeding regimen of commercial diet followed by diet 6 (19.75 Birr) and diet 5 (19.64 Birr). The net benefit decreased as the level of MBM increased from 6.5% to 26%. The least profit was earned from diet 2 (2.36 Birr).

4.7. Mean slaughter and eviscerated weight

The different levels of SBM supplementation significantly affected carcass parameters ($p < 0.05$) in the current experiment (Table 12). The greatest increase in eviscerated yield (%) was achieved by chicken on diet 1 (73.80%) followed by those on diet 6 (70.54%) and diet 5 (69.21%), while the lowest yield (%) was observed in groups on diet 2 (66.17%). However, the value for chickens on diet 2 were not statistically different from those on diet 3 (66.93%), and diet 4 (68.57%). The eviscerated parts included were carcass parts, liver, gizzard and neck, but heart was not included in the saleable carcass.

Table 10. Average feed cost of starter, finisher and whole period of production and cost relative to a kg of body weight gain

Parameters	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6	SEM
Cost per kg of starter diet (Birr)	3.51	2.84	2.90	2.96	3.02	3.07	0.00
Cost per kg of finisher diet (birr)	4.04	2.90	2.96	3.01	3.07	3.13	0.00
Cost per kg of feed 1-49 th day (birr)	3.93	2.88	2.94	3.00	3.06	3.12	0.00
Feed cost/kg of gain (starter phase)	6.63±0.05 ^b	9.29±0.22 ^d	7.80±0.23 ^c	6.65±0.30 ^b	5.73±0.03 ^a	6.01±0.12 ^a	0.10
Feed cost/ kg of gain (finisher phase)	9.16±0.10 ^{cd}	9.64±0.40 ^d	8.72±0.15 ^{bc}	8.12±0.11 ^b	7.30±0.24 ^a	7.36±0.14 ^a	0.14
Feed cost/ kg of gain(1-49 th day)	8.57±0.08 ^c	9.53±0.25 ^d	8.47±0.18 ^c	7.72±0.06 ^b	6.91±0.18 ^a	7.05±0.08 ^a	0.07
Cost/total feed consumed (starter phase)	3.59±0.03 ^a	1.78±0.07 ^e	2.31±0.13 ^d	2.56±0.03 ^{bc}	2.61±0.05 ^b	2.37±0.07 ^{cd}	0.02
Cost/total feed consumed (finisher phase)	16.33±0.15 ^a	5.22±0.19 ^e	6.99±0.32 ^d	8.65±0.29 ^c	10.26±0.15 ^b	9.81±0.25 ^b	0.17
Total feed Cost (1-49 th day)	19.92±0.12 ^a	7.00±0.21 ^e	9.30±0.44 ^d	11.20±0.29 ^c	12.87±0.20 ^b	12.18±0.31 ^b	0.24

^{abcde} Means within a row followed by different superscripts are significantly different (p<0.05); NS = Non-significant;

Feed cost/kg gain=FCR X kg feed cost;

Cost/ total feed consumed= FCR X kg feed cost X total weight gained

Values are means ± standard errors; SEM= Standard errors of mean square

Table 11. Average production cost and returns fed different treatment rations

Partial production costs	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6
Day old chick cost	8.00	8.00	8.00	8.00	8.00	8.00
Total feed consumed(g)	5064.5	2426.7	3158.5	3736.0	4207.0	3905.5
Feed cost (Birr)	19.92	7.00	9.30	11.20	12.87	12.18
Water consumed (L)	11.42	4.28	5.74	7.79	9.46	9.01
Water cost	0.11	0.04	0.06	0.08	0.09	0.09
Total cost	28.03	15.04	17.36	19.28	20.96	20.27
Average carcass weight (kg)	1.78	0.60	0.90	1.20	1.40	1.38
Price/kg of carcass (supermarket)	29.00	29.00	29.00	29.00	29.00	29.00
Total carcass Sale (Birr)	51.62	17.40	26.10	34.8	40.60	40.02
Net profit	23.59	2.36	8.74	15.52	19.64	19.75

4.8. Mean abdominal fat, breast, thigh & drumstick, gizzard and liver weight

Mean abdominal fat percent of the experimental chicks are presented in Table 12. Chickens on diet 3, 4 and 2 had the highest percent of abdominal fat content. The least abdominal fat proportion was recorded for diet 1 and 6. The result from this experiment shows that there seems to be a positive correlation between the level of inclusion of MBM and an abdominal fat content; as the level increases the fat content also increases.

In the current experiment, decreasing dietary levels of SBM resulted in decrease breast yield. The commercial diet again yielded the highest proportion of breast meat cut (30.44%) followed by diet 6 (26.43%), 5 (26.27%), 4 (25.49%) and 3 (24.35%). The least percent was recorded for diet 2. Thigh and drumstick portions were also higher for the commercial diet (22.72%) but not statistically significant ($p>0.05$) from other feeding groups. In contrary, the liver and gizzard weight proportions were higher for diet 2 while liver weight was not significantly different ($p>0.05$) from diet 3, diet 4 and diet 5 (Table 12).

Table 12: Effect of treatment diets on carcass and organs weight and abdominal fat deposition and their share in live weight (%) at 49 days of age

Parameters		Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6	SEM
Live weight(g)		2423.48±146.94 ^a	907.92±101.14 ^d	1342.42±44.16 ^c	1750.68±86.87 ^b	2014.43±155.06 ^b	1951.50±81.77 ^b	72048.18
Eviscerated wt (PLWT)*	a	73.80±0.35 ^a	66.17±0.94 ^d	66.93±1.01 ^{cd}	68.57±0.67 ^{bcd}	69.21±1.04 ^{bc}	70.54±0.59 ^b	3.90
	b	1789.50±111.59 ^a	602.68±71.46 ^d	897.93±29.30 ^c	1198.90±54.34 ^b	1396.18±114.13 ^b	1376.05±55.57 ^b	37483.19
Breast (PLWT)	a	30.44±0.79 ^a	22.14±1.53 ^c	24.35±0.95 ^{bc}	25.49±0.74 ^b	26.27±0.99 ^b	26.43±0.52 ^b	5.66
	b	734.17±36.03 ^a	202.35±32.03 ^d	327.12±18.03 ^c	445.88±24.50 ^b	532.95±52.13 ^b	514.73±18.86 ^b	6322.92
Thigh + drumstick (PLWT)	a	22.72±0.24 ^a	21.51±0.38 ^{ab}	20.89±0.31 ^b	21.53±0.49 ^{ab}	20.99±0.96 ^b	22.29±0.53 ^{ab}	1.74
	b	551.06±35.46 ^a	194.40±19.86 ^d	279.87±6.69 ^c	376.17±18.21 ^b	423.27±38.93 ^b	436.13±25.19 ^b	4178.95
Liver (PLWT)	a	1.88±0.09 ^c	2.38±0.06 ^a	2.11±0.14 ^{abc}	2.09±0.12 ^{abc}	2.20±0.10 ^{ab}	2.03±0.09 ^{bc}	0.06
	b	45.55±3.91 ^a	21.48±2.15 ^d	28.50±2.56 ^{cd}	36.53±2.46 ^{bc}	44.15±3.67 ^{ab}	39.30±1.48 ^{ab}	48.17
Gizzard (PLWT)	a	1.51±0.06 ^b	1.87±0.15 ^a	1.51±0.10 ^b	1.42±0.07 ^b	1.28±0.06 ^b	1.51±0.07 ^b	0.05
	b	36.38±2.15 ^a	16.43±1.29 ^d	20.37±1.67 ^d	24.72±1.10 ^c	25.42±1.62 ^{bc}	29.42±1.88 ^b	16.42
Abdominal fat (PLWT)	a	1.75±0.14 ^d	3.75±0.43 ^{ab}	4.01±0.38 ^a	3.35±0.32 ^{ab}	2.88±0.25 ^{bc}	2.23±0.38 ^{cd}	0.66
	b	42.17±3.96 ^{ab}	32.72±3.38 ^b	53.87±5.80 ^a	59.63±7.60 ^a	57.73±6.74 ^a	43.30±7.50 ^{ab}	220.09

^{abcd} Means within a row followed by different superscripts are significantly different (p<0.05)

Values are means ± standard errors; SEM= Standard errors of mean square

a= percent live weight proportion of the organ; b= organ weight in gram; *Eviscerated weight includes the edible carcass, neck of the bird, Gizzard and liver.

5. DISCUSSION

The feed intake and body weight gain of broilers were higher for commercial diet both in the starter and finisher periods. In contrary, the reduced feed intake as well as body weight gain were observed for diet 2 (diet containing the highest level (26%) of MBM). This was due to the increasing levels of MBM, which depresses intake. This finding is in agreement with other previous reports on different species of animals. Liu (2000) indicated that 10 or 15% inclusion of MBM depressed broiler chick performance as compared to a soybean meal diet. Salmon (1977) reported reduced weight gains as MBM increased from 7.5 to 15% in turkey diets. Evans and Leibholz (1979) found that pig performance was linearly depressed as MBM was replaced soybean meal at increasing levels from 2.5 to 10% in corn-based diets. Amino acid deficiency especially of lysine is the main factor to be considered in the low chick performance when using 15% MBM in the diet (Liu, 2000; Summers *et al.*, 1964).

Next to commercial ration a better feed intake and weight gain was recorded for the diet containing 19.5%SBM and 6.5%MBM in the starter phase. This is may be due to the synergetic effect of two or more protein sources in the diet, which encourages more feed intake than feeding SBM or MBM separately. This result is in agreement with Sibbald (1975) and McDonald *et al.* (1995) who reported that a combination of different protein source has associative effect in amino acid complementarity that satisfy requirements of the broilers better and improve performance. The lower feed intake in full SBM ration (diet 6) may be due to relatively higher fiber content as compared to diet 1 and diet 5 in the starter phase especially in the 2nd and 3rd weeks of age. But the difference between chickens in diet 5 and 6 was not statistically significant in feed intake in the 1st, 2nd, 3rd, 6th and 7th weeks of age. Similarly the weight gain of diet 5 and diet 6 were not significant ($p>0.05$) in week 1, 4, 5, 6, and 7. This indicates that a full SBM diet could practically substitute fully MBM in the above specified weeks mainly in the finisher phase and totally substitute the higher inclusion levels of MBM in all weeks. This result is in agreement with Arafa *et al.* (2001) who reported that the effect of feeding diets containing all-vegetable protein versus mixture of vegetable and animal protein sources on feed consumption, live body weight gain and feed conversion ratio of broiler chicks were not significantly different from those of the fish meal diet.

The economic results of broiler production are highly dependent on the efficiency of conversion of feed to product (Washburn, 1980). Chicken on diet 1, 5 and 6 were not statistically ($p>0.05$) significant in their FCR value for the whole period of growth this indicates that both diets are interchangeably used for broiler ration with lower production costs. The feed efficiency declined in all treatments as the birds grew up. This finding is in agreement with that of Milton (2003) and MAFRA (2008). This is mainly because heavy birds use increasing quantities of feed to maintain their body mass, and less is used for growth. The feed efficiency was poor for the group's fed MBM containing diets above 6.5%. This might be due to the low lysine level in the ration (Leeson and Summers, 2001).

The water consumption in relation to feed intake was not significantly different ($p>0.05$) between chicken on diets 1, 5 and 6 for the whole period of production. But birds allocated to diet 6 numerically consumed more water. This is probably due to the high potassium content of SBM than MBM. This is in agreement with the findings of James and Wheeler (1949) and Brookes (2001), who reported that a high content of potassium induces water consumption. Similarly, diet 6 was composed of plant origin ingredients which may again induce water requirement. According to Vieira and Lima (2005), SBM can have up to four times more potassium than the animal by-products used in poultry feeds such as meat and bone meal, poultry and pork by-product, and feather meal. Potassium as well as sodium are recognized to positively affect water intake. The report of Smith *et al.* (2000) supports similar effects of potassium in feed and water intake in poultry.

The mortality rate in the current experiment were not significantly different ($P>0.05$) among treatment rations in the starter, finisher and whole period of rearing, but numerically, the highest mortality were observed for diet 2 and diet 3 (5.58%) in the starter phase and (7.84%) in the whole period of growth for each. In contrary, no mortality was recorded both in the starter and finisher phase in experiment diet 1 and only in the starter phase in experimental diet 5. The total mortality from all birds housed until the end of the slaughter age was 5.23%. This is more or less similar with the previous reports. Anonymous (1984) reported that well managed broilers, vaccinated against known diseases and given quality feed, should not suffer losses in excess of 4 to 5% mortality to market age. ACP (2006) also defined a benchmark standard of 5% mortality irrespective of slaughter age. These two reports are slightly lower than the mortality recorded from diet 2 and 3 groups.

The final judge in any feeding program is the economics of the operation; reduction in feed cost is basic for profitability of broiler operations. The economic analysis results indicated that both practices, feeding diets with lower inclusion level of MBM and without MBM, provided positive net benefits at all levels per kg of body weight gain. The highest body weight gain with lower feed cost for 1-49 day of growth were obtained from diet 5 (19.5% SBM and 6.5% MBM containing diet) and diet 6 (26% SBM containing diets). The costs associated with diet 5 (6.91Birr) and diet 6 (7.05Birr) were not statistically different ($p>0.05$); so relatively formulating a ration with 19.5% SBM and 6.5% MBM (diet 5) and 26% SBM safely minimized the feed cost per kg of live weight gain, respectively. The highest net benefit however, obtained from diet 1 (23.59Birr) followed by Diet 5 (19.64 birr) and diet 6 (19.75Birr) per chicken.

Higher relative proportion of abdominal fat was observed for the diets containing greater than 6.5%MBM (diets 2, 3 and 4) in the ration. This might be due to the higher energy-protein ratio in the diets, due to high refusals of MBM in the given diet. It was reported previously that the smaller the energy-protein ratio is the less fat will be deposited (Rezaei *et al.*, 2004; Farrel, 1974; Bartov *et al.*, 1974; Lesson *et al.*, 1988; Yashamita *et al.*, 1975). The other reason for high fat deposition might be the low lysine level in high inclusion level of MBM in the experimental diets (Leeson and summers, 2001). Rezaei *et al.* (2004) reported a trend of reduction in fat pad percentage due to increased Lysine level.

The highest breast meat was observed in diet 1 followed by diet 4, 5 and 6. This could be due to the fact that the commercial diet may had synthetic amino acid like lysine, whereas the lower level inclusion of MBM and a full soybean meal diet may also fulfill these amino acids for the birds. Increasing Lysine level in diet increased breast meat percentage significantly as shown in other researches (Bilgili *et al.*, 1992; Gorman and Balnave, 1995; Han and Baker, 1994; Kidd *et al.*, 1998). Breast muscle development is also affected by sex, age, breed and genetics (Moran and Bilgili, 1990; Acar *et al.*, 1991; Bilgili *et al.*, 1992; Gorman and Balnave, 1995; Han and Baker, 1991).

6. CONCLUSION AND RECOMMENDATIONS

The result of this study clearly showed that from the groups fed the whole period in terms of its biological efficiency and economic response, diet 1 showed superior performance over the other treatments during the starter and finisher phase. From the MBM and SBM combination diets, diet 5 in both parameters showed a better efficiency for the first 3 weeks of age; similarly, in the finisher phase MBM could safely and economically be substituted with total SBM both in their feed efficiency and economic return.

From these conclusions, the following points are recommended:

- On farm evaluation of the compatibility of SBM and their economic significance should be verified at a larger scale;
- To completely replace animal origin protein sources and improve amino acid balance in the diet, another plant source protein should be investigated;
- The nutrient content of seeds vary depending on the type of climate and nutrient content of the soil, so evaluation of the amino acid profile and nutrient content of Ethiopian SBM is required;
- The level of MBM included in this experiment perform better is 6.5%, but the higher levels significantly depressed growth performance. This suggests that MBM should not be used at a higher level than 6.5% of the diet.

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8. ANNEX

Annex Table 1-Nutrient composition of starter diet used in the experiment (obtained by calculation)

	Experimental groups					
	1	2	3	4	5	6
Dry matter%	-	89.61	89.38	89.13	88.89	88.66
Protein, %	-	22.20	22.21	22.05	22.01	22.02
Crude fiber%	-	2.72	3.18	3.56	4.00	4.46
ME(kcal/kg)	-	3023.20	3002.85	2992.55	2975.55	2955.20
Calcium %	-	3.17	2.52	1.87	1.22	0.58
Total phosphorus %	-	1.66	1.38	1.09	0.80	0.52
EE %	-	8.85	8.01	7.15	6.30	5.46

Annex Table 2-Nutrient composition of starter diet used in the experiment (obtained by calculation)

	Nutrient composition by calculation					
	Experimental groups					
	1	2	3	4	5	6
Dry matter%	-	89.23	88.98	88.74	88.49	88.24
Protein %	-	19.76	19.65	19.55	19.44	19.34
Crude fiber %	-	1.68	2.09	2.50	2.91	3.32
ME (kcal/kg)	-	3157.10	3143.45	3129.80	3116.15	3102.50
Calcium %	-	3.10	2.45	1.80	1.15	0.50
Total phosphorus %	-	1.56	1.27	0.98	0.69	0.40
EE %	-	8.45	7.60	6.74	5.88	5.02

Annex Table 3-ANOVA for daily body weight gain for starter, finisher and whole period of growth

	Source	Sum of Squares	df	Mean Square	F	Sig.
Initial weight	Between Groups	.105	5	.021	.462	.797
	Within Groups	.544	12	.045		
	Total	.648	17			
Weight gain g/bird/day for the first 21 days	Between Groups	502.170	5	100.434	82.064	.000
	Within Groups	14.686	12	1.224		
	Total	516.857	17			
Mean daily weight gain(g/bird) (22-49 days)	Between Groups	4111.595	5	822.319	160.878	.000
	Within Groups	61.337	12	5.111		
	Total	4172.932	17			
weight gain g/bird/day(1-49 days)	Between Groups	2091.507	5	418.301	180.816	.000
	Within Groups	27.761	12	2.313		
	Total	2119.268	17			

Annex Table 4-ANOVA for Mean daily feed intake for 1-21, 22-49 and 1-49days of age

	Source	Sum of Squares	df	Mean Square	F	Sig.
Mean daily Feed intake (g/bird 1-21 day)	Between Groups	570.833	5	114.167	28.914	.000
	Within Groups	47.383	12	3.949		
	Total	618.216	17			
Mean daily Feed intake (g/bird 22-49 day)	Between Groups	12578.232	5	2515.646	103.617	.000
	Within Groups	291.339	12	24.278		
	Total	12869.571	17			
Mean daily Feed intake (g/bird 1-49 day)	Between Groups	5289.272	5	1057.854	94.298	.000
	Within Groups	134.618	12	11.218		
	Total	5423.890	17			

Annex Table 5-ANOVA for Feed conversion ratio for 1-21, 22-49 and 1-49days of age

	Source	Sum of Squares	df	Mean Square	F	Sig.
Feed conversion ratio 1-21 days/bird	Between Groups	4.614	5	.923	77.577	.000
	Within Groups	.143	12	.012		
	Total	4.757	17			
Feed conversion ratio 22-49 days/bird	Between Groups	2.562	5	.512	32.261	.000
	Within Groups	.191	12	.016		
	Total	2.752	17			
Feed conversion ratio 1-49 days/bird	Between Groups	2.937	5	.587	75.218	.000
	Within Groups	.094	12	.008		
	Total	3.031	17			

Annex Table 6- ANOVA for Mean daily water intake (ml/bird) 1-21, 22-49 and 1-49days of age

	Source	Sum of Squares	df	Mean Square	F	Sig.
Water intake /bird/ day 1-21 day	Between Groups	5009.645	5	1001.929	96.041	.000
	Within Groups	125.187	12	10.432		
	Total	5134.832	17			
Mean daily water intake (ml/bird) (22-49 day)	Between Groups	104456.651	5	20891.330	197.355	.000
	Within Groups	1270.277	12	105.856		
	Total	105726.927	17			
mean daily water intake 1-49 days ml per bird	Between Groups	44003.427	5	8800.685	206.125	.000
	Within Groups	512.349	12	42.696		
	Total	44515.776	17			

Annex Table 7 ANOVA for Water: feed ratio 1-21, 22-49 and 1-49 days

	Source	Sum of Squares	df	Mean Square	F	Sig.
Water : feed ratio (1-21 day)	Between Groups	.849	5	.170	22.775	.000
	Within Groups	.089	12	.007		
	Total	.938	17			
Water : feed ratio 22-49day	Between Groups	.834	5	.167	20.065	.000
	Within Groups	.100	12	.008		
	Total	.934	17			
water to feed ratio 1-49 days	Between Groups	.823	5	.165	25.515	.000
	Within Groups	.077	12	.006		
	Total	.900	17			

Annex Table 8-ANOVA for feed cost/ kg of weight gain for 1-21, 22-49 and 1-49 days

	Source	Sum of Squares	df	Mean Square	F	Sig.
Feed cost per kg of gain(1_21 day)	Between Groups	26.121	5	5.224	51.228	.000
	Within Groups	1.224	12	.102		
	Total	27.345	17			
Feed cost per kg of gain (22_49 day)	Between Groups	13.789	5	2.758	19.533	.000
	Within Groups	1.694	12	.141		
	Total	15.484	17			
Feed cost per kg of gain (1_49 day)	Between Groups	15.170	5	3.034	43.512	.000
	Within Groups	.837	12	.070		
	Total	16.006	17			

Annex Table 9- ANOVA for carcass characteristics and organ percent to live weight at 49th day of age

		Sum of Squares	df	Mean Square	F	Sig.
Live wt	Between Groups	8624011.259	5	1724802.252	23.940	.000
	Within Groups	2161445.327	30	72048.178		
	Total	10785456.586	35			
Eviscerated weight to live weight proportion	Between Groups	226.292	5	45.258	11.591	.000
	Within Groups	117.134	30	3.904		
	Total	343.426	35			
Breast weight to live weight proportion	Between Groups	226.620	5	45.324	8.002	.000
	Within Groups	169.928	30	5.664		
	Total	396.548	35			
Thigh weight to live weight proportion	Between Groups	15.648	5	3.130	1.802	.143
	Within Groups	52.093	30	1.736		
	Total	67.741	35			
Liver weight to live weight proportion	Between Groups	.871	5	.174	2.744	.037
	Within Groups	1.905	30	.063		
	Total	2.776	35			
Gizzard weight to live weight proportion	Between Groups	1.128	5	.226	4.521	.003
	Within Groups	1.498	30	.050		
	Total	2.626	35			
Abdominal fat to live weight proportion	Between Groups	23.267	5	4.653	7.049	.000
	Within Groups	19.805	30	.660		
	Total	43.072	35			

SIGNED DECLARATION

I under sign, declaring that this is my original work and has not been presented for degree at any other university and that all source of material used for the thesis have been duly acknowledged.

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