EVALUATION OF DIFFERENCES IN FEED UTILIZATION FOR EXOTIC AND LOCAL CHICKENS IN TANZANIA

BY

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A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIRMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN TROPICAL ANIMAL PRODUCTION OF SOKOINE UNIVERSITY OF AGRICULTURE. MOROGORO, TANZANIA.

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ABSTRACT

The study was carried out to compare the growth and food utilization attributes of broiler and local chickens. Two experimental diets were formulated to provide a low and high plane of nutrition based on the crude protein and metabolizable energy contents of the diets. Birds were weighed at the beginning and end of the experiment. Feeds given and refused were weighed daily to determine the feed intake (FI), recorded on individual-bird basis. Feeds were given in amounts that would allow for at least 15% refusal per bird per day. Daily dry matter intake (DDMI) was calculated as the difference between food offered and food refused, and the cumulative dry matter intake (CDMI) was calculated at the end of the experiment. Samples of the diets were taken and bulked daily for both dry matter and nitrogen content determination. A parallel set of adult birds (X broiler and Y Local) were used for digestibility studies, during which birds were placed in individual battery cages. The results showed that there were significant differences ($P \geq 0.05$) between the broiler and the local chickens in Weight gain (466.6±33.2 vs. 138.1±33.23); Daily rate of gain (35.9±25.0 vs. 10.6±25.1); Daily DMI (118.4±1.8 vs. 47.6±1.81) and Feed Efficiency (30.3±1.01 vs. 22.3±1.1). HE-HP diet produced birds with higher weights than LE-LP. Birds on HE-HP consumed significantly more protein and nitrogen than those on LE-LP and CP digestibility was higher for birds on HE-HP. Birds on LE-LP had a higher N retention ratio than those on HE-HP. It was concluded that commercial broilers were better performers under both feeding regimes. Where good quality feed is not a constraint, keeping the commercial strain appears to be a better option than raising local chickens.

DECLARATION

I, Fatima Gubrel Ali Mohammed, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work and that it has neither been submitted nor being concurrently submitted for degree award in any other institution.

Fatima G. A. Mohammed — 10/11/2011 — Date

(M.Sc. Candidate)

The above declaration is confirmed

Prof. A. M. Katule — 11/11/2011 — Date

(Supervisor)

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DEDICATION

This dissertation is dedicated to the almighty Allah, my parents as well as my brothers and sisters.

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LIST OF ABBREVIATIONS

%	Percentage
ANOVA	Analysis of Variance
BW	Body Weight
Ca	Calcium
CDMI	Cumulative Dry Matter Intake
CLA	Conjugated Linoleic Acid
CNI	Cumulative Nitrogen Intake
CNV	Cumulative Nitrogen Voided
CP	Crude Protein
DASP	Department of Animal Science and Production
DM	Dry Matter
DMI	Dry Matter Intake
DMV	Dry Matter Voided
EPR	Energy Protein Ratio
FC	Food Conversion
FE	Food Efficiency
FINW	Final weight
g	gram
HE-HP	High Energy, High Protein diet
INW	Initial weight
Kcal	Kilocalories
kg	Kilogram
LE-LP	Low energy, Low Protein diet

Linol	Linoleic
Ltd	Limited
Lys	Lysine
m	Meter
ME	Metabolism of Energy
Meth	Methionine
N	Nitrogen
^{o}C	Degree Celsius
P	Phosphorus
SAS	Statistical Analysis System
SUA	Sokoine University of Agriculture
TCAA	Tri-Chloro Acetic Acid

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information and Justification

The poultry production systems in Africa are mainly based on unimproved scavenging local chickens found in virtually all villages and households in rural Africa. For example, the scavenging local chickens are kept in 2.5 million households out of 3.7 million agricultural household in Tanzania (Ministry of Agriculture and Food Security, 2003). Rural smallholder farmers under scavenging management conditions raise more than 95% of the total chicken population in the country, the remaining insignificant proportion being kept under the commercial production systems. The scavenging systems are characterized by low output per bird (Kitalyi, 1995). Nevertheless, local chickens play a very important role in the supply of poultry products to rural and urban communities.

The texture of the local chicken meat and taste is preferred by most consumers in Africa and elsewhere. For example, over 70% of the poultry products and 20% of animal protein intake in most African countries comes from the local poultry production sector (Kitalyi, 1995). Although exotic birds are known to have much higher growth rate and egg production capacity than local chickens, the high productivity of exotic breeds of chickens is achieved under high feeding regimes, whereby the diets offered need to be well balanced in all nutrients. In contrast, local chickens are known to survive well on low cost feeds and poor environment (Douglas *et al.*, 1997).

Feeds account for more than 70% of the cost in commercial chicken production (Austic and Nesheim, 1990). In an effort to cut down feed costs and hence increase profit margins in the poultry industry several breeds of chickens which can utilize feed efficiently have been developed (Douglas *et al.*, 1997). It is pertinent that research on improved feed utilization should include improved commercial stock and local breeds of chickens (Ali *et al.*, 2000). It is well known that commercial strains of chickens have much higher growth rates than the unimproved local chickens. The differences in performance between these two breed types are genetically determined. Since body weight increment represents net food nutrient retention the differences in growth rate between different breeds must be rooted in the different manner the breeds utilize the food the birds eat. However, it is not quite clear at what level of food utilization the commercial birds are superior to local chickens i.e. it has not been quite established if the superiority of improved commercial stock is consistent with regard to all food utilization stages such as intake, digestion, and accumulation. Although differences between breeds for food consumption have been widely documented, very few studies in this area have involved comparisons between improved commercial breeds and unimproved local chickens of developing countries (Ali *et al.*, 2000).

Despite being inferior to commercial broiler chickens with respect to growth performance, unimproved local chickens have been shown to survive fairly well on low cost feeds and poor environment (Douglas *et al.*, 1997). It would be of interest therefore to evaluate the relative performance of both commercial and local chickens under similar feeding regimes using both high and low planes of nutrition. It would

also be of interest to establish in what aspects of food utilization (i.e. intake, digestion, utilization efficiency) the two breeds differ.

1.2 Justification

The importance of improving productivity of local chickens need not be over-emphasised. However, appropriate interventions require good understanding of possible outcomes that should yield desired performance biologically as well as financially. Whereas commercial broiler chickens have been developed for high performance under optimum condition of breeding and general management, unimproved chickens have evolved under environmental and nutritional stress. There is a paucity of information regarding the assessment of local chickens compared to commercial broiler chickens under similar environmental and nutritional conditions, hence the need for the present study.

1.3 Objectives

1.3.1 Main objective

To compare growth, and food utilization attributes of broiler chickens and local of chickens.

1.3.2 Specific objectives

i. To determine the relative growth performance and food efficiency of broiler and local chickens.

ii. To compare the relative efficiency of two diets differing in energy and protein content with regard to supporting growth and food utilization of chickens.

iii. To assess the importance of genotype x diet interaction on growth and food utilization in chickens.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Genetic Differences Between Local and Exotic Chickens

On the global perspective, the poultry industry has undergone many changes over the last 50 years in which the industry has matured from a backyard flock enterprise to sophisticated mass production of poultry meat and eggs (Barbatoi, 1999). Most of the global growth in poultry production systems has been registered in the western developed nations and in Israel. Emergent new economies of China and the Far East have practically caught up with the West i.e. in quantities produced (Mattocks, 2002). However, in both China and the Far East, local chickens raised by smallholder traditional ways contribute over 60% of domestic meat and egg supply.

Poultry productivity in developing countries including Africa and South America is affected by factors collectively referred to as inadequate husbandry practices. Thus management and environmental effects such as feeding, diseases and climatic factors are most limiting (Makkar, 2003). Local chickens are the most common types of poultry raised in the rural areas of African countries. Approximately 80 percent of poultry in Africa are raised in rural areas where they contribute substantially to egg and meat production. For instance, 99 % of the total chicken population in the East African countries are under free-range system. This means the local chickens, unlike the intensively raised chickens, live and produces in a broad spectrum of socio-economic and physical production environment. This environment includes feeding, and health management, which interact with human culture (Gondwe and Wollny, 2007).

Almost all families in developing countries keep chicken flocks with an average size of about 10 adult chickens, but varying from 5 to 50 birds (Subapriya *et al.*, 2007). The flocks contain birds of different species and varying ages. These husbandry practices are characterized by low input/low output production but contribute significantly to household food security. For example, Tanzania has about 36 million chickens, of which almost 95% are local breeds and the rest are exotic breeds (Msoffe *et al.*, 2005). Most of the local chickens are reared by rural households under scavenging system, and poor managements. Meanwhile, some programmes focus on transforming the poultry sector of Tanzania from a conventional subsistence activity into a commercial business have been underway in order to provide employment and income for rural smallholder producers, and in particular for women.

On the other hand, Uganda also has a big reservoir of local poultry, whereby out of the estimated 23.5 million chickens 84.2% are free-range local types reared under free range system which presents generally low production of both meat and eggs. However, some crossbreds, which have been obtained between exotic breeds and Ugandan local chickens, produced 3-4 times more eggs than the local birds and were twice as heavy (2.5-3 kg) as the local birds at the age of 22 weeks (Subapriya *et al.*, 2007). Formal knowledge about chicken production in developing countries is improving but is still limited. The common limitation resides in the management, and production performance (McAinsh *et al.*, 2004).

Therefore, there is a need to pay closer attention to the merits of the local chickens in Africa. Focus on Africa is important because of the general perception that

performance of local chickens can only be improved through crossbreeding (Hancook, 2007). There has been indiscriminate crossbreeding of local chicken with exotic breeds in order to get more meat and eggs (Subapriya *et al.*, 2007). Nonetheless, this indiscriminate crossing has not always yielded satisfactory results because uncontrolled long term crossbreeding may lead to loss of genetic diversity of the local chicken population.

The low productivity of the free range local chickens has always been considered to be due to their low genetic potential (Geraert *et al.*, 1993; Kitalyi, 1995). In the past most of the previous efforts to improve the productivity of the local chickens were directed towards improvement of the genetic potential through crossbreeding with exotic breeds (Katule, 1990). So far these efforts have not borne much fruit, and hence the productivity of the birds remains low. Currently, very little is known about the genetic makeup of local chickens. However, more recent studies have reported wide ranges in production parameters among the local chicken ecotypes indicating that the potential for high productivity might be there, but it has not been tapped through selective breeding (Msoffe *et al.*, 1998).

There is a tremendous potential for genetic improvement of local chickens due to large genetic variation in production traits. However, accurate estimates of genetic and phenotypic parameters are a pre- requisite for the establishment of any sustainable genetic improvement programme. There is need for evaluation and determination of the performance of different chicken genotypes. Lwesya *et al.* (2004) stated that the local fowl is extremely well adapted to the tropics and resistant

to poor management and feed restriction. The diversity within the local stock gives room for selection focused on specific characters. The local chickens have comparative advantage in characters such as survival on low plane of nutrition, resistance to diseases and tolerance to seasonal shortages of feeds and water. Where crossbreeding is advocated, there must be sufficient evidence that the good merits of the local chicken are not compromised (Barbatoi, 1999).

2.2 Factors Affecting Requirement by Poultry

Genetically breeds or strains of birds have different average body sizes, growth rates, production, levels, and will also absorb and utilize nutrient from feed with different levels of efficiency, leading to different nutrient requirements. As the genetic content of commercial birds is constantly changing so are their nutrient requirements. Consequently, breeders of commercial poultry provide information on the specific nutrient requirements for the bird they sell (Falconer, 1989).

Age dependent nutrient requirements are related to both body weight and the stage of maturity. Prior to sexual maturity the sexes have only small differences in their nutrient requirements so that males and female can usually be fed the same composite diet to achieve acceptable growth rates. Differences in nutrient requirements are large following the onset of sexual maturity and different diet formulations are then required for each sex. The reproductive state and the level of egg production in hens and sexual activity in males will affect nutrient requirement (Subapriya *et al.*, 2007). Poultry have increased energy requirements to maintain normal body temperature in cold ambient temperatures and the opposite is true in hot ambient temperatures. The process of digestion of food produces body heat and the

amount of heat produced will vary according to the nutrient composition of the diet This is called the heat increment of the diet. In cold temperatures, it may be desirable to formulate diets with higher heat increment and the opposite in hot temperatures.

The housing system and the type of housing will influence the level of activity of the birds and therefore their energy requirements. Furthermore, birds experiencing disease challenge may benefit from an increase in the intake of some nutrients, most commonly vitamins. The optimal nutrient composition of the diet will vary according to production aims, such as optimizing weight gain or carcass composition, egg number or egg size. Poultry that are raised for breeding purposes may need to have their energy intake restricted to ensure that they do not become obese.

2.3 Influence of Genetic Differences on Feed Efficiency in Chickens

The genetic basis for efficiency of feed utilization has been reported for a number of species including chickens. The effect of growth rate, appetite, diet, temperature, and other factors that may affect efficiency of feed utilization in chickens have been studied in some detail. The mechanisms for differences in efficiency of feed utilization may be related to differences in dietary requirement for specific nutrients, such as energy and protein utilization, or ability to absorb nutrients. It has been shown also that genetic difference in requirement or utilization may be effected by a number of specific nutrients e.g. manganese, thymine, riboflavin, and amino acids. There have been suggestions of genetic differences in energy and protein utilization usually between very divergent strains of chickens. Broiler strains (meat type) may require less productive energy than egg type strains. The broiler strains generally

require more productive energy than local chickens due to their high food intake, food utilization, and genetic factors (Washburn *et al.*, 2010).

2.4 Dietary Influence on Chicken Performance

The performance of any breed or strain of poultry depends on good management and proper supply of a balanced diet. However good a breed or strain one may have it would fail to show its optimum performance when subjected to poor nutrition (Christopher *et al.*, 2007). Poultry can be managed, under different feeding systems, depending on feed availability. Poultry feeds should be designed to contain all the key components i.e. protein, energy, vitamins, and other nutrients necessary for proper growth, egg production and health of the birds.

2.4.1 Effect of dietary energy level

Good growth rates can be achieved with a wide range of energy levels because of the ability of the bird to adjust the amount of feed consumed to maintain a constant energy intake. Generally, maximum growth rate will not be achieved with ration for starting chicks containing below 2645kcal ME/kg. Broiler chickens are usually fed rations higher in energy content than are replacement pullets. In broiler chickens production, maximum growth rate is usually essential so that broiler chickens can reach market weight in the shortest time (Austic *et al.*, 1990).

Energy intake is considered to be a fundamental factor in broiler chickens production, not only because it affects growth rate and carcass characteristics but also because it is indirectly involved in metabolic diseases (Omoruyi *et al.*, 1999). The dietary energy level for broiler chickens has been investigated by many researchers Sartika (2005) showed that broiler chicken feed intake increases linearly

with decreasing dietary energy level. Albuquerque *et al.* (2003) also observed a reduction in feed intake due to higher dietary energy density. In addition, Sartika (2005) found that broiler chickens fed free-choice on diets with either 2700 or 3300 kcal metabolizable energy/kg presented the same growth rate and constant energy consumption.

In poultry dietary energy-contributing ingredients are a major cost component; despite that optimal fat energy level is important for lowering feed cost per unit of poultry product. So far many studies have been conducted to examine the effects of dietary energy on the growth of broiler chickens. Increasing dietary energy level could improve feed conversion rate of broiler chickens by reducing feed intake. However, high dietary energy causes deposition of excess abdominal fat or carcass fat in broiler chickens and this fat is usually considered to be a waste product when birds are processed. This represents an economic loss for poultry producers (Fan *et al.*, 2008). Energy deposition is the result of energy intake on one hand and energy expenditure on the other and it is controlled by a variety of mechanisms (Collin *et al.*, 2003). Genetic factors, exogenous factors such as environmental conditions interact strongly with the control and regulation of the energy flow.

With regard to the dietary macronutrient ratio, protein has the highest oxidation rate, followed by carbohydrates and fat. This corresponds to their ability to induce satiety, but is reciprocal to their storage capacity in mammals. In chickens, dietary composition also has a major impact on energy metabolism and body composition. Diets with a high metabolizable energy content or high energy to protein ratio induce

energy deposition as fat (Collin *et al.*, 2003). Commercial broiler breeder strains, selected for rapid growth and high meat yields, do not adequately regulate voluntary feed intake commensurate with their energy needs. Consequently, these birds must be given a limited amount of feed to avoid overconsumption that can lead to excessive accumulation of energy stores (fat tissue), an undesirable body weight, body composition, and a series of health-related complications(i.e., leg problems, reduced reproductive efficiency, etc.). Therefore, it is important to understand the regulation of feed intake and energy balance in birds to develop and manage commercial lines of poultry (Richards and Weglarz, 2007).

According to Agab and Osman (2001), a change in the energy content of broiler diet normally results in an inverse change in the total amount of feed consumed and therefore influence the intake of essential nutrients. The authors found that different levels of energy in a diet can influences other nutrients intake. Therefore, deficiency of nutrients may occur in poultry by increasing the energy content in diet. In contrast, feed intake as well as nutrient utilization is increased by low level of energy in the diet. Broiler chickens have traditionally been fed relatively high-energy diets, because, in addition to promoting efficient feed utilization, it also maximizes growth rate. Carcass composition may be influenced by energy and protein levels in diets. More profitable production systems and better carcass yield might be achieved by an adjustment of the dietary energy level (Washburn *et al.*, 2010)

Result from same studies have shown that the increment of the energy level in chicken diet through adding specific fatty acids such as omega-3 fatty acids and

conjugated linoleic acid (CLA) can improve performance and decrease incidences of inflammatory response in growing birds (Collin *et al*., 2003). Omega-3 fatty acids from fish oil were shown to enhance the antibody response of chicks to sheep red blood cells (Pesti, 2009). However. they suppressed rates of lymphocytes proliferation after mutagen stimulation. Conjugated linoleic acid is a naturally occurring substance in dairy products (Aydin, 2007). According to Baiao and Lara (2005) the addition of fat to diets, besides supplying energy, improves the absorption of fat-soluble vitamins, diminishes the dustiness of the food, increases the palatability of the rations, and increases the efficiency of the consumed energy (lower caloric increment). Furthermore, it reduces the passage rate of the digested food in the gastrointestinal tract, which allows a better absorption of all nutrients present in the diet.

2.4.2 Effects of dietary protein level

Proteins are required in an animal's body to form many structures and tissues (for example, muscle, skin, feathers, beak, and claw sand many blood proteins). Proteins are also important for body building, body repair, reproduction, growth, production, body immunity, and for the formation of active compounds such as enzymes and hormones (Kleyn, 2000). Proteins are composed of different combinations of amino acids. There are dietary essential amino acids which must to be included bird's diet. Other amino acids the bird can convert themselves from the ten essential amino acids. In addition to the ten essential amino acids and three that can be accepted only from limited substrates, poultry need a quantity of amino acids to synthesize the other eight that are needed to synthesize body proteins (Pesti, 2009).

The concept of a requirement for dietary protein has been controversial since the discovery that proteins are composed of amino acids and that some amino acids are dietary essentials for maximum growth and performance. It is understood that decreasing a diets cost by reducing amino acid density does not necessarily mean increased profit (Qotbi *et al.*, 2011). It has been reported that high levels of dietary lysine, methionine, and threonine can improve the body weight and meat yield in commercial broiler chickens (Rezaei *et al.*, 2004). However, yield and increase in fat deposition may occur when feeding broiler chickens low crude protein diets. It is of utmost importance that live performance and meat yields are maximized relative to profitability and not to minimal cost .The need for amino acids depends on the level of production in broiler chickens. It is important in order to allow flocks to express their full potential at minimal nutrient expense. The studies from (Corzo *et al.*, 2005) showed that reducing dietary protein may be a way of increasing live production profitability. However, a reduction in amino acids may lead to a reduction in live performance and meat yield. Results from studies where broiler chickens were fed low crude protein diets indicated decreased meat yields and increased fat deposition. On the other hand, moderate excesses of dietary crude protein and amino acids (i.e. methionine, lysine, and threonine) above recommended levels .have been reported to increase breast meat yield even during hot environmental conditions (Corzo *et al.*, 2005).

According to Rezaei *et al.* (2004) excess dietary protein also increases heat production and water consumption which increases moisture content of litter. The authors also reported that reducing the crude protein content of broiler chicken

rations by 2% in starter period did not affect body weight gain. The amino acid requirement in broiler rations increases linearly with dietary crude protein. Lysine is recognized as the second limiting amino acid in rations based on corn and soybean meal. Therefore, it is advisable to supplement poultry diet with crystalline lysine if the crude protein content of the diet is low (Rezaei *et al.*, 2004).

Diets low in protein content but fortified with methionine and lysine have been reported to perform well as those fed a diet higher in protein (Jensen and Colnago, 1991). Feeding low crude protein diet has also been reported to improve the performance of birds kept in hot temperatures (Thim *et al.*, 1997). In this study dietary crude protein content was reduced from 23 to 20% while maintaining optimal essential amino acids profile. Qotbi *et al.* (2011) observed that supplementing maize-based diets with fresh green feeds containing high crude protein (170–220 g/ kg DM) could contribute significantly to meeting the protein requirements of broilers for growth.

2.4.3 Effects of other nutrients

Like other nutrients, minerals are essential for normal physiological processes of chickens. They are constituents of hundreds of proteins involved in intermediary metabolism, hormone secretion pathways, and immune defence systems (Bao *et al.*, 2007).

The major minerals of importance in broiler ration are calcium and phosphorous. These minerals are needed for the formation of the skeletal system. In the ration the requirement of minerals ranges between 1.8 – 2.0% of the total ration (Driver *et al.*,

2005). The quantity of phosphorus required by broiler chickens is dependent on the age of the bird and as the broiler birds get older, the requirement for phosphorus decreases (Syrena, 2005). Phosphorus is essential for animals to attain their optimum genetic potential in growth and feed efficiency as well as skeletal development. (Applegate, 2008).

Calcium on the other hand is required during the different phases of production (Driver *et al.*, 2005). High levels of calcium may reduce the energy value of the diet by chelating a portion of the available lipid fraction, thus rendering some lipids unavailable for absorption (Pepper *et al.*, 1955). Decreasing the amount of calcium in the broiler diet may improve performance and increase profitability. Other minerals which are needed are potassium, sodium, iron, copper, zinc, magnesium, manganese, chloride and selenium.

The other nutrients that are equally important included vitamins. Vitamins are required for proper metabolic functioning of the animal body. For example, vitamin A is required for normal night vision, development of the epithelial tissue, respiration and digestive system (Leeson, 2007). Vitamin B6 is essential in more than one hundred enzymatic reactions, including protein metabolism, biosynthesis of lipids and the balance of sodium and potassium. In addition, vitamin B6 facilitates the release of glycogen and stimulates antibody production (Blalock *et al.*, 1984; Kannan and Jain, 2004). Vitamin D plays a role in the absorption of calcium and phosphorus from the gastro-intestinal tract, and hence is involved in the formation of bones and eggshell. Vitamin E plays an important role in blood formation and is required for

normal fertility, antibody production and maintenance of cell membrane integrity. Vitamin K is necessary for the synthesis of proteins required for blood clotting i.e. for controlling haemorrhage and maintaining healthy tissue. Vitamin B12 (cyanocobalamin) is needed in several enzyme systems where it plays a role as a prosthetic group (Lesson, 2007).Vitamin C (ascorbic acid) plays a role in oxidation-reduction reactions of the cell and is also responsible for the maintenance of intercellular tissue such as collagen (Pepper *et al.*, 1955).

2.5 Genotype x Environment Interactions in Chickens

Animal performance is a function of both the genotype and the environment. However, this simple relationship holds only if the environmental deviations and genotypic values are independent of each of other (Falconer, 1989). Should there be a correlation or an interaction between the two, then modification would be needed to include either a covariance or an interaction term. The latter, widely referred to as genotype x environment interaction, has been a subject of great concern in livestock production. The significance of genotype and environment interaction lies in the fact that superior genotypes in one environment are not necessarily the best in another environment. Feeding levels, housing, rearing system, stocking density, geographical location and management are some of the factors that have been extensively studied for their interaction with genotype (Barbatoi, 1999).

The term genotype x environment interaction is most commonly used to describe situations where different genotypes (breeds, lines, strains, progeny groups) respond differently to different environments. The environmental factors are numerous, the most important of which being climate, altitude, nutrition, housing systems, and

exposure to diseases (Horn *et al.*, 1984). The differences between the various genotypes in their responses to different environments not only include changes in mean performance in the measured traits but also include variability in performance in a given trait of interest. Genotype x environment interactions in commercial broiler chicken s constitute about 0-5 percent of the total phenotypic variance in the most important traits (Horn, 1982).

Harsh environmental conditions result in important economic losses for the chicken industry in tropical countries. Heat exposure impairs broiler chickens performance, especially during the growing and finishing periods, as their ability to dissipate heat decreases according to body size. The primary consequence of heat exposure is reduction in feed intake, feed conversion ratio, and body weight in broiler chickens. thereby leading to lower efficiency and low profitability of poultry meat production in hot climates (El-Full *et al.*, 2010). This is a physiological response in order to decrease metabolic heat production and maintain body homeostasis (Koh and Macleod, 1999). However, heat exposure also impairs survival rate (Bonnet *et al.*, 1997). Reduced feed consumption, lower breast yield and higher fat deposition have been observed in broiler chickens exposed to heat (Geraert *et al.*, 1996).

Genetic differences can be identified at two levels in respect to whether the variation is between or within breeds or genetic stocks (Cahaner, 1990). By the same extension environments can be categorized into micro and macro- environments. While macro-environments are unique and do not necessarily differ in their average effect on a given trait, microenvironments can rarely be identified due to their chance occurrence (Ali *et*

al., 2000). However, the effects of some of these microenvironments such as the social hierarchy can be so influential and hence cause variation in the consumption of feed and water among individuals within the same pen or flock (Koh and Macleod, 1999).

2.6 Genotype X Nutrition Interaction in Chickens

Genotype x nutrition interaction effects are often age dependent on growth and correlated traits. In commercial broiler chickens and local chickens nutritional and genotype x nutrition interaction effects are much more significant and of practical importance in younger birds (Falconer, 1989).

Results from many studies have demonstrated the existence of genotype x nutrition interactions. For example Horn *et al.* (1984) tested five different commercial broiler strains fed diets of high and low nutrient levels up to 49 days of age. The mean live weights of males and females across genotypes respectively were 1.93 and 1.53 kg on the high plane of nutrition, and 1.55 kg and 1.41 kg on the low plane of nutrition. The variation in body weight as percentage of the variation was 9% due to genotype, 41% due to feeding and 33% due to sex. Genotypes x feeding level interactions were not significant, while, sex x feeding level interactions were highly significant. The live weights of males across genotypes were reduced by 20.7% when raised on low plane of nutrition, while in females the depression in growth reached only 7.7% leading to the highly significant sex x nutrition interactions, and thus indicating different nutritional requirement for growth between males and females compared the performances of three genotypes of guinea fowls (local, commercial, and crossbreeds) in growth rate, feed intake, carcass composition, and carcass quality by using three different planes of nutrition's (high, intermediate, and low) (Horn *et al.*,

1984). The results revealed that the birds under low and intermediate diets had significantly lower body weights than birds under the high diet. There was no significant difference observed in feed intake, but there were differences in food conversion. *Ali et al.* (2000) and Barbatoi (1999) concluded that to obtain the maximum improvement in genotype-nutritional interactions, there are two areas in which to work i.e. the genetic improvement of the birds, and the genetic improvement of the plants that supply the ingredients for the feeds.

CHAPTER THREE

3.0 Materials and Methods

3.1 Location of the Experiment

The experiment was conducted at the Department of Animal Science and Production (DASP), Sokoine University of Agriculture, Morogoro Tanzania. The experimental site lies at an altitude of 500 – 600m above sea level and receives 600 to 1000mm rainfall per annum. Day temperature at the experimental site ranges from 20 to 27°C during the coolest months, of April to August and 30 to 35°C during October to January.

3.2 The Experimental Design

3.2.1 Experimental animals and layout of the experiment

Two breeds of chickens were used for the experiment, i.e. a commercial broiler type purchased from InterChick Ltd in Dar-Es-Salaam, and a local type. The eggs for hatching local chicks were collected from neighbouring farmers and hatched at the university farm. All chicks were vaccinated against Newcastle disease at three days of age, and against gumboro disease at ten days of age. During the first five weeks all chicks were brooded on the floor and on the same feed and environmental conditions.

After five weeks of age the birds were transferred to individual battery cages. Forty birds of each strain were divided into two groups (Table 1). The two groups of each breed were randomly allocated to two diets (Table 2): high energy- high protein (HE-HP) diet which was formulated to contain about 2523.5 KcalME/Kg and about 22% CP, and low energy low protein (LE-LP) diet formulated to contain about 2012.2 KCalME/Kg and about 16.2%CP (Table 3).

Table 1: Layout of the experiment

Genetic groups	Dietary-treatment and number of bird		
	HE-HP	LE - LP	Total
Local	20	20	40
Broiler	20	20	40
Total	40	40	80

Where:
HE - HP = High energy and protein diet
LE - LP = Low energy, low protein diet.

Table 2: Gross composition of the experimental diets

Ingredients	HE-HP (%)	LE-LP (%)
Maize	21.9	21.3
Sorghum	24.8	21.3
Maize bran	8.9	17.8
Soybean	23.2	13.1
Sunflower	8.3	19.6
Fish	9.7	3.4
Blood	0. 0	0.0
DCP	1.1	1.2
Bone	1.1	1.2
Limestone	1.1	1.2
Total	100	100

Table 3: Calculated nutrients composition of the experimental diets

Diets	ME (Kcal/Kg)	CP%	EPR	Lys%	Meth%	Ca%	P%	Linol%
High	2523.5	22.8	109.9	1.23	0.73	1.08	0.33	0.77
Low	2012.2	16.2	123.1	0.69	0.53	3.0	1.57	0.63

Where:
ME = Metabolizable Energy, CP = Crude Protein, EPR = energy protein ratio, Lys = Lysine, Meth = Methionine, Ca = Calcium, P = Available phosphor, Linol = Linoleic.

3.2.2 Experimental procedure and data collection

At the end of the adaption period all the birds were weighted and thereafter the birds were weighed weekly, early in the morning before issuing out the food, up to the end of the data collection period. The remaining feed from the previous days offer was weighted each morning and the arithmetic difference between the quantity offered and that remaining was recorded as intake for the previous 24 h period. This is after adjusting for the dry matter content of the feeds offered and the refusals. The food intake was recorded on individual bird basis. It was observed that the amount of feed offered to allow for at least 15% refusal was 140 and 70g/bird per day for the broiler and local chickens respectively. Hence the amount of feed offered was adjusted accordingly. Daily dry matter intake (DMI) was calculated as the difference between food offered and food refused taking into consideration the respective dry matter content of the offered and refused food. The DMI for the entire experimental period was summed up to get the cumulative dry matter intake (CDMI). Meanwhile, samples of the diets were taken and bulked every morning at feeding time for both dry matter and nitrogen content determination.

Furthermore, faecal collection from each individual bird was done by using plastic sheets placed below each cage to capture the droppings. The droppings from each bird were collected and weighted each morning before feeding the birds. Samples of droppings voided from each bird were divided into two parts i.e. one part being used for determination of dry matter content of the faeces while the remaining part was bulked and frozen for chemical analysis. The daily faecal output was multiplied by the dry matter content of the faeces to get the daily dry matter voided (DMV). The

DMV for the entire experimental period was obtained by summing up the daily dry matter voided (CDMV).

3.2.3 Determination of nitrogen content in faeces and feeds

From the feed and faecal samples bulked and frozen during the entire experimental period, sub –samples equivalent to about 15% of the total collection for each bulked sample were drawn for determination of nitrogen. Faecal samples for determination of nitrogen were prepared first by mixing a thawed sample with trichloro acetic acid (TCA) and decanting the supernatant after centrifugation in order to remove the uric acid. This was followed by determination of faecal nitrogen in the residues using the standard Kjeldahl procedure, which was also used to determine the nitrogen content of the feed samples.

3.2.4 Estimation of apparent and nitrogen digestibility

Apparent digestibility of DM was calculated in the equation (1):

$$Apparent\ Dig = \frac{(CDMI - CDMV)\ X100}{CDMI} \qquad \text{.......(1)}$$

Where:

CDMI = Cumulative feed dry matter intake

CDMV = Cumulative faecal dry matter voided

The ingested nitrogen was calculated by multiplying the cumulative dry matter intake by the percentage nitrogen in the food, while the faecal nitrogen voided was calculated by multiplying, the cumulative dry matter voided in faeces by the nitrogen content of the faeces (i.e. after removal of uric acid). From the above quantities nitrogen digestibility was calculated as shown in equation (2):

$$Nitrogen\ digest\ (\%) = \frac{(CNI - CNV) \times 100}{CNI} \quad \ldots\ldots (2)$$

Where:

CNI = Cumulative nitrogen intake in food

CNV = Cumulative nitrogen voided in faeces

Cumulative body weight gain of a chicken was calculated as the difference between the final weight and the initial body weight of the chicken. Food conversion efficiency was calculated in equation (3):

$$FCE = \frac{FINW - INW}{CDMI} \times 100 \quad \ldots\ldots (3)$$

Where:

FINW = Final body weight

INW = Initial body weight

CDMI = Cumulative dry matter intake

3.3 Data Analysis

The data collected was analysed using the SAS (1997) General Linear Models procedure based on the following mathematical model:

$$Y_{ijk} = \mu + B_i + D_j + (BD)_{ij} + E_{ijk} \quad \ldots\ldots (4)$$

Where:

Y_{ijk} = response of k^{th} individual bird from the i^{th} breed and j^{th} diet;

μ = general mean common to all birds in the experiment;

B_j = effect of the i^{th} breed (i = 1, 2)

D_j = effect of the j^{th} diet (j = 1, 2)

$(BD)_{ij}$ = interaction between the i^{th} breed and j^{th} diet.

E_{ijk} = random effect peculiar to each bird

CHAPTER FOUR

4.0 RESULTS

4.1 Overview

The results from the present study have shown that there were significant differences ($P \leq 0.05$) in initial weight, growth rate, final weight, food intake, feed efficiency and nitrogen retention, between the two breeds of chickens (Appendix 1). No significant differences ($P > 0.05$) were observed between the two experimental diets for all parameters tested except for crude protein intake and crude protein digestibility Significant breed*diet interactions were recorded for crude protein intake and digestibility (Appendix 1).

4.2 Effect of Breed of Chicken on Growth and Feed Utilisation

Table 4 shows the least square means for growth performance and feed utilisation variable for the two groups of chickens. Broilers under both planes of diets had significantly ($P \leq 0.05$) superior overall weight gain as well as daily gain to the local chickens. The average daily gain for broilers was about three times higher than that of the local chickens. The broilers were also heavier than local chicken at the beginning of feeding experiment. However, when related to initial weight, the percentage average weight gains were similar for the two breeds (i.e. 30%).

The dry matter intake as well as feed conversion efficiency was significantly different ($P \leq 0.05$) and broiler had higher cumulative feed intake by as much as 60% compared to local chickens. Feed conversion efficiency of broiler chickens was 26% higher compared to that of local chickens (Table 4). On apparent digestibility there

Table 4: Least square means for growth and food utilization variables of Chickens summarized by breeds

Variables	Least square means*	
	Broiler	Local
Initial weight (g)	1529.0 ± 29.21[a]	451.4 ± 29.21[b]
Final weight (g)	1995.6 ± 37.21[a]	589.5 ± 37.21[b]
Weight gain	466.6 ± 33.23[a]	138.1 ± 33.23[b]
Daily gain (g)	35.9 ± 25.72[a]	10.6 ± 25.72[b]
Daily DMI (g)	118.4 ± 1.85[a]	47.6 ± 1.85[b]
Total DMI (g)	1538.7 ± 13.36[a]	618.2 ± 13.36[b]
Feed Efficiency (%)	30.3 ± 1.01[a]	22.3 ± 1.01[b]
Apparent digestibility (%)	70.7 ± 0.82[a]	73.3 ± 0.82[a]
CP intake (g)	296.9 ± 2.90[a]	122.2 ± 2.90[b]
CP digestibility (%)	91.3 ±0.41[a]	86.9 ±0.41[b]
N intake (g)	43.38 ± 0.47[a]	16.9 ±0.47[b]
N retention (g)	0.3 ± 0.02[a]	0.22 ± 0.02[a]
N retention/N intake	0.69 ± 0.02[a]	1.3 ± 0.02[b]

Least square means with different superscript letters within a row are significant different ($P \leq 0.05$).

was no significant difference between broiler and local chickens, but the difference between digested CP was significant in favour of broilers (Table 4). Crude protein (CP) intake in broiler was nearly two third higher that in the local chicken group. Similarly, broiler had higher nitrogen intake than local chickens. However, nitrogen retention was not significantly different. Moreover, on expressing nitrogen retention as a proportion of nitrogen intake, local chickens exhibited higher values.

4.3 Effect of Diet on Growth and Feed Utilisation

Table 5 shows the least square means for feed utilization by broilers and local chicken fed two types of feeds. There was significant effect of diet on final weight but not on overall or daily gain. The HE-HP diet produced birds with higher final body weights than those fed LE-LP diet.

Table 5: Least square means for growth and food utilization variable of Chickens summarized by diets

Variables	Least square means*	
	HE –HP diet	LE –LP diet
Initial weight (g)	1017.9 ±29.14[a]	962.5 ±29.14[b]
Final weight (g)	1321.2 ± 37.16[a]	1263.9 ±37.16[b]
Weight gain	303.3 ± 33.1[a]	301.2 ± 33.1[a]
Daily gain (g)	23.3 ± 25.79[a]	23.2 ± 25.79[a]
Daily DMI (g)	82.8 ± 1.98[a]	83.1± 1.98[a]
Total DMI (g)	1076.4 ± 13.39[a]	1080.0 ± 13.39[a]
Feed Efficiency (%)	28.2± 1.03[a]	27.9 ± 1.03[a]
Apparent digest (%)	71.2 ± 0.89[a]	72.9± 0.89[a]
CP intake (g)	237.4 ± 2.89[a]	181.8 ± 2.89[b]
CP digest (%)	88.1±0.44[a]	90.2 ± 0.44[b]
N intake (g)	33.4 ± 1.28[a]	26.2 ±1.28[b]
N retention (g)	0.26±0.02[a]	0.25 ± 0.02[a]
N retention /N intake	0.77± 0.02[a]	0.95 ± 0.02[b]

* Least square means with different superscript letters within a row are significantly different ($P \leq 0.05$)

The results further show that there were no significant difference between the diets in terms of dry matter intake, feed conversion efficiency and apparent digestibility. In terms of CP intake, birds fed HE-HP ate significantly more protein and nitrogen than those on LP-LE diet. However, the LE-LP diet had significantly higher CP digestibility than the HE-HP diet. Further analysis shows that nitrogen retention was not significantly different between the two diets although on expressing the N retention as a percentage of intakes, the LE-LP diet had higher ratio than HE-HP diet (Table 5).

4.4 The Effect of Breed X Diet Interaction on Crude Protein (CP) Intake and Digestibility

The interactions between breeds and diets were not significant for most of the traits mentioned except CP intake and CP digestibility. Table 6 presents the least square

means for CP intake and digestibility for different breed-diet combinations. It can be observed that, for both diets, broiler chickens had significantly superior CP intake compare the local chickens. There were significant differences between broilers under HE-HP diets and those of LE-LP diets in terms CP digestibility. Moreover, broilers under LE-LP diets had significantly superior CP digestibility than the local chickens (Table 6). However, there were no significant difference between broiler and local chickens given LE-LP diets in terms of CP digestibility (Table 6).

Table 6: Least square means for crude protein intake and digestibility of broiler and local chickens on different plane of feeding

Main Effects		Least square means*	
Diets	Breeds	CP intake (g)	CP digestibility (%)
HE - HP	Broiler	337.45 ± 4.08^{a}	89.03 ± 0.63^{a}
	Local	137.29 ± 4.08^{b}	87.07 ± 0.63^{a}
LE - LP	Broiler	256.47 ± 4.08^{a}	93.59 ± 0.63^{b}
	Local	107.13 ± 4.08^{b}	86.87 ± 0.63^{a}

*Least square means with different superscript letter within diet and Column are significantly different ($P \leq 0.05$).

CHAPTER FIVE

5.0 DISCUSSION

5.1 The Experimental Diets

Feeds constitute over 60% of cost of production in poultry farming. It is on this account that a combination of ingredients is critical in formulation of optimal diets. In the current study, efforts were made to utilize principal ingredients used for compounding poultry feeds in Tanzania. Both formulations used produced feeds that contained energy and protein in amounts that are within the tabulated daily requirements for broiler chicken. It was expected that the local chickens, due to their small size would have their nutrient requirements surpassed.

5.2 Effects of Breed on Performance of Chickens

5.2.1 Effects of breeds on growth

Findings from this study show that the broiler breed receiving either of the experimental diets had significantly ($P \leq 0.05$) superior daily body gain than the local chickens. This was so because broiler chickens have been selected for fast growth. The superiority of broiler birds to local chickens with respect to body weight could be attributed mainly to the superior genetic potential for growth. The results of this study were similar to what have been reported by Ali *et al.* (2000) who observed the performance of three breeds of chickens, i.e. the exotic hybrids, the Local x Exotic crosses and the local ecotypes in Tanzania.

5.2.2 Effect of breeds on feed intake, digestibility and feed utilization by chickens

Daily dry matter intake recorded as percent of metabolic body weight of broiler chickens ranged from 7.9 to 10.3, while that of local chicken ranged from 10.7 to 14.1%. This level of intake corresponds closely to the values reported by Babafunso (2004) respectively in Senegal and Nigeria for chickens rose, under confinement. In Kenya, Kingori *et al.* (2010) reported the intake by non-supplemented scavenging birds to be substantially lower than those observed in the present study. At 9 to10 weeks of age, commercial broiler chickens are expected to consume at least 110g/day, a level corresponding to approximately 7.3% of their final carcass weight of 1.5 kg suggesting that the broiler chickens in this study were consuming adequate amounts of dry matter (DM) (Tadelle *et al.*, 2003). The local chickens at 11 weeks of age had a DM intake of about 48 g/day equivalent to about 14.1% of their metabolic body weight. This amount is higher than that reported by Okitoi and Mukisira (2001) for scavenging chicken of similar age in Kenya.

Comparisons between local and broiler types of chickens for digestibility and feed utilization efficiency showed that the former had significantly higher capacity in digesting the diets than the latter. This superiority however, was not reflected in feed efficiency, wherein the commercial broilers demonstrated a highly superior efficiency ($P \leq 0.05$). Doeschate *et al.* (1993) and Grasteau *et al.* (2004) have reported similar observations while comparing different chicken strains. Most authorities have shown that there is an inverse relationship between level of intake and digestibility (Janmohammadi *et al.*, 2011). The Local chickens in this study were

consuming less than a half the amount consumed by the commercial broiler chickens, a fact that may account for their higher apparent digestibility.

The feed conversion efficiency of the commercial broiler strain was about 1.5 times higher than that of the local strain. This was expected as commercial broiler breed are specifically selected for faster growth. The study by Grasteau *et al.* (2004) reported that chicken strains selected for high growth rate would normally exceed in performance the un-selected strains even when offered poor diets. In this study, the higher performance of the broilers was recorded in both the high protein high energy and low protein low energy diets.

5.2.3 Effects of breeds on crude protein intake, nitrogen digestibility and nitrogen retention

The daily crude protein intake per unit of DMI (g CP/g DMI) for both the broiler and the local chicken was similar (0.19g/g DMI) despite the larger quantity of gross total crude protein intake recorded for broiler chickens. The local chicken were nearly twice more efficient in nitrogen retention for every unit of nitrogen consumed. This capacity was consistent for both diets. The Local chickens have evolved under environments of nutritional stress and have developed mechanisms for rapid compensatory growth when available food permits (Newport, 1979; Hancock, 2007). Comparative studies by Cahaner and Leenstra (1992) on broiler chickens raised under nutritional stress showed that those selected for slow growth were less affected by the stress than the fast growing lines. By similar extension one may expect the local chicken to sustain higher efficiencies despite their lower weight gain.

5.3 Effects of Diets on Performance of Chickens

Findings from this study show there were no significant differences in total dry matter intake between the HE-HP and LE-LP diets. However, the difference in energy and protein densities may not have been large enough to show any effects on intake. The physiological mechanisms by which poultry respond to different dietary protein and energy concentrations are not known, although several possible mechanisms have been proposed (National Research Council, 1994). Although poultry generally adjust feed consumption to achieve a minimum energy intake from diets containing different nutrient levels these adjustments are not always precise. Data from a large number of broiler chicken experiments showed that changes in feed intake were not inversely proportional to changes in dietary energy and protein level, especially when broilers were fed moderate- to high-energy diets (Pousga *et al.*, 2005). Naturally such effects will have a bearing on nutrient digestibility particularly the protein fraction (Sundrum, 2001).

Chickens are known to mitigate their energy intake by adjusting feed intake depending on the energy density of the diet (Bremer, 1983). Jurgens (2002) found that energy-protein ratio of food is an important factor to analyse chickens energy intake. The diets used in the present study contain ratio of 109.9 and 123.1 for the high energy high protein (HE-HP) and low energy low protein diet (LE-LP), respectively. At these ratios it is unlikely that intake of other nutrients would be adversely affected. Kalio *et al.* (2006) found that energy protein ratio of 135 gave better results compared to that of 160. Moreover, under high summer temperatures (>

30°C) it is important that broiler chickens are offered diets high in energy and protein (Kalio *et al.*, 2006).

5.4 Effects of Genotype-Diet Interaction on Crude Protein Intake and Digestibility

Table 6 indicates the least square means for crude protein intake, crude protein digestibility, and nitrogen retention by two breeds of chickens fed two different planes of nutrition. With regard to crude protein intake, the results show that there were significant differences between the two breeds, and that the broiler breed in both planes of diets had significant higher intake than the local. Similar observation have been reported by Ali *et al.* (2000),who observed that exotic breeds had high daily body gain compare to the local and crossbreed chickens due to their higher genetic potential, more feed intake, and high feed digestibility. However, this result is different from what has been reported by Horn *et al.* (1984) on commercial broiler chickens strains fed diets of high and low nutrient levels. The results of the present study were similar to what was reported by Tadelle *et al.* (2003) on two types of broiler chickens on CP intake. However, at higher level of crude protein one of the strains stopped responding and even showed a decline in growth rate, whilst the other strain continued to respond.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

i) Findings from this study show that the commercial broiler chickens perform better than the local chicken under all planes of nutrition. However, local chickens responded better when given diet high in protein and energy.

ii) The commercial broilers consumed about twice more feed than the local chicken at all level of energy and protein densities in the diet. This was closely associated to their superior body mass. However, the local chickens were better able than the commercial broilers to digest and retain the protein component of the diet.

iii) There were significant interaction between genotype and diet on crude protein intake and crude protein digestibility. CP intake and CP digestibility were significantly lower in local chickens fed LE-LP diet. However, no significant difference was observed in terms of CP digestibility between broiler and local chicken fed on HE-HP diet.

6.2 Recommendations

1. It is recommended that commercial broiler chicken should be given higher priority over local chicken wherever good quality diets are available.

2. Where local chickens are the preferred stock it is more prudent to raise them on high quality diets than on low quality diets.

3. The local chicken may be regarded as adequate for subsistence farming systems wherein they may have multiple cultural roles, but should not be considered as substitute to commercial strains.

4. It would be useful to conduct trials under farmstead conditions to fully verify the comparative merits of local chickens against those derived from commercial strains.

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APPENDIX

Appendix 1: Analysis of variance (ANOVA) for various feed utilization summarized by breeds and diets

Traits	Effects	Significances
INWT	Breeds	***
	Diets	ns
	Breeds*diets	ns
FNWT	Breeds	***
	Diets	ns
	Breeds*diets	ns
CDMINT	Breeds	***
	Diets	ns
	Breeds*diets	ns
APDIG	Breeds	*
	Diets	ns
	Breeds*diets	ns
CPINT	Breeds	***
	Diets	***
	Breeds*diets	***
CPDIG	Breeds	***
	Diets	**
	Breeds*diets	**
ADG	Breeds	***
	Diets	ns
	Breeds*diets	ns
DDMIN	Breeds	***
	Diets	ns
	Breeds*diets	ns
FEDEF	Breeds	***
	Diets	ns
	Breeds*diets	ns
NRT	Breeds	***
	Diets	ns
	Breeds*diets	ns

Where:
INWT = initial weight, FINWT = final weight, CDMINT = cumulative dry matter intake, APDIG = apparent digestibility, CPINT = Crude protein intake, ADG = average daily gain, DDMIN = daily dry matter intake, FEDEF = the efficiency of the food, and NRT = nitrogen retention. * Significant, ** high significant, *** very high significant differences, ns not significant differences or there no differences between the two comparatives, number of breeds two local and broiler chickens, and two diets low and high diet in protein and energy level contents.