EFFECT OF DIETARY THREONINE LEVEL ON PRODUCTIVITY AND CARCASS CHARACTERISTICS OF INDIGENOUS VENDA CHICKENS

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DECLARATION

I declare that this mini-dissertation hereby submitted to the University of Limpopo for the degree of Master of Science in Agriculture (Animal Production) has not been submitted by me for a degree at this or any other University, this is my own work in design and execution, and that all materials contained herein has been duly acknowledged.

Signature…………………… Date………………………..

Miss Ramuthaga Ndivhuho

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DEDICATION

This work is dedicated to my late father, Huxley Edward Ramuthaga, who always believed in me more than I did myself.

ABSTRACT

Two experiments were conducted to determine the effect of dietary threonine level on productivity and carcass characteristics of indigenous Venda chickens. In each experiment the diets were isocaloric and isonitrogenous but with different dietary threonine levels. A complete randomized design was used in both experiments, the starter (1-7 weeks old unsexed chickens) and finisher (8-13 weeks old female chickens) experiments. The treatments were CT4 (4 g of threonine/kg DM), CT5 (5 g of threonine/kg DM), CT6 (6 g of threonine/kg DM), CT7 (7 g of threonine/kg DM) and CT8 (8 g of threonine/kg DM). A quadratic type of equation was used to determine dietary threonine levels for optimal feed intake, growth rate, feed conversion ratio, live weight, metabolisable energy intake and nitrogen retention of unsexed Venda chickens aged one to seven weeks. Dietary threonine level affected (P<0.05) feed intake, growth rate, feed conversion ratio, live weight, metabolisable energy and nitrogen retention. However, feed intake, growth rate, feed conversion ratio, live weight, metabolisable energy and nitrogen retention of indigenous Venda chickens were optimized at different dietary threonine levels of 6.218, 6.437, 6.331, 6.655, 5.979 and 6.158 g/kg DM feed, respectively. Dietary threonine level did not affect (P>0.05) mortality rate of the chickens.

The treatments for the second experiment were FT4 (4 g of threonine/kg DM), FT5 (5 g of threonine/kg DM), FT6 (6 g of threonine/kg DM), FT7 (7 g of threonine/kg DM) and FT8 (8 g of threonine/kg DM). Dietary threonine level had effect (P<0.05) on feed intake, growth rate, feed conversion ratio, live weight, metabolisable energy and nitrogen retention of female Venda chickens aged eight to 13 weeks. Feed intake, growth rate, feed conversion ratio, live weight, metabolisable energy intake and nitrogen retention of chickens were optimized at dietary threonine levels of 6.054, 6.142, 6.442, 6.201, 5.72 and 6.088 g/kg DM, respectively. However, dietary threonine level had no effect (P>0.05) on pH values of crop, proventriculus, gizzard, small intestine, large intestine and caecum of female Venda chickens aged 91 days. Carcass weights of female Venda chickens were affected (P<0.05) by dietary threonine level. Carcass, breast, drumstick, thigh, gizzard and liver weights of female Venda chickens aged 91 days were optimized at dietary threonine levels of 6.183, 6.201, 5.712, 5.847, 4.820 and 6.180 g/kg DM, respectively. Dietary threonine level had effect ($P<0.05$) on crude protein and threonine contents of female Venda chicken meat. Meat crude protein and threonine contents of female Venda chickens aged 91 days were optimized at dietary threonine levels of 5.9 and 5.7 g/kg DM, respectively. Dietary threonine level had no effect ($P>0.05$) on meat flavour, tenderness and juiciness of female Venda chickens. However, meat flavour, tenderness and juiciness of female Venda chickens aged 91 days were optimized at dietary threonine levels of 5.977, 6.103 and 5.977 g/kg DM, respectively. No chicken deaths were observed.

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CHAPTER 1

INTRODUCTION

1.1 Background

About 90 to 95 % of the rural households raise some indigenous chickens, ranging from 5 to 50 birds per household (Chantalakhana and Skunmun, 2002). In recent times, indigenous chicken production has been presented as a tool for poverty reduction and food security in developing countries (Mack *et al.,* 2005). In addition, these breeds have been recognized as reservoirs for genomes and major genes conferring direct or indirect effects on productive adaptability. Indigenous Venda chicken production plays an important role in many South African rural households. Thus, indigenous Venda chickens are nutritionally, economically and culturally important in South Africa (Swatson *et al*., 2001; Norris *et al.,* 2007). However, productivity of these chickens is low, and mortality is high. Poor nutrition seems to be the main factor limiting the potential production levels of these indigenous chickens (Kingori *et al*., 2003). Feed supplementation using locally available feed ingredients to cover nutrient deficits, conventional disease control measures and proper housing strategies have been shown to improve growth rate, age at first egg and egg production, decrease mortality and lead to improved production (Okitoi *et al.,* 2000). It is, therefore, important to determine nutrient requirements of these chickens. Such data can be useful in devising strategies for improving productivity and carcass characteristics of indigenous chickens.

1.2 Problem statement

Indigenous Venda chickens are important to rural households of Limpopo Province for their economic and nutritional purposes. However, they have low productivity and high mortality rates. Their low productivity and high mortality rates are attributed to poor genetic potential, nutrition and management (Okeno *et al*., 2011). There is evidence in broiler chickens that dietary threonine level has effect on productivity of the chickens (Kidd *et al*., 1999). Threonine is an essential amino acid classified as polar; it serves as an important component of body protein and plays an important role as a precursor of lysine and serine. These amino acids are essential for growth and meat tenderness (Ojano-Diranin and Waldroup, 2002). However, such information on indigenous Venda chickens is limited.

1.3 Motivation of the study

This study will generate data on dietary threonine supplementation levels for optimal feed intake, growth rate, mortality, meat tenderness and carcass characteristics of indigenous Venda chickens. The information obtained from this study will help in improving growth rate, immune system responses and meat quality of indigenous Venda chickens. An improvement in growth rate and meat quality will, hopefully, result in increased nutrition and income for indigenous chicken farmers.

1.4 Objectives

The objectives of this study were to determine:

i. effect of dietary threonine supplementation on feed intake, growth rate, mortality, meat tenderness and carcass characteristics of indigenous Venda chickens aged between 1 and 13 weeks.

ii. optimal responses in feed intake, growth rate, mortality, meat tenderness and carcass characteristics of indigenous Venda chickens aged 1 to 13 weeks to dietary threonine supplementation.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Threonine is the third limiting amino acid after methionine and lysine in diets of broiler chickens (Han *et al.,* 1992). It is, thus, very important in poultry nutrition. The dietary amino acid concentration has to meet maintenance and tissue accretion needs of poultry, especially towards the middle and end of the growth period. Under-supply and over-supply of the amino acid will decrease performance and increase nitrogen excretion, respectively (Kidd *et al*., 2004). Threonine requirements in growing animals depend on several factors like genotype, age and sex (Muhl and Liebert, 2008). Poultry are not capable of synthesizing threonine *de novo* which makes it a nutritionally essential amino acid (NRC, 1994). Metabolic status of glycine and serine in relation to that of threonine need to be understood, because the metabolic degradation of threonine produces glycine and serine whereas nitrogen excretion through the uric acid pathway requires the availability of the glycine, glutamate and aspartate (Barbour *et al*., 2008). There is some evidence indicating that threonine deficiencies lead to poor productivity and increased susceptibility to infection while threonine excesses do not necessarily lead to increased resistance to diseases in chickens (Richard, 2005). Therefore, optimal dietary threonine requirements for chickens are important. However, such information on indigenous Venda chickens is not available. Thus, it is important to determine dietary threonine levels for optimal productivity and carcass characteristics of indigenous Venda chickens.

2.2 Biochemical functions of threonine

Threonine is an alpha amino acid with the chemical formula $HO_2CCH\ (NH_2)\ CH\ (OH)\ CH_3$ (Figure 1). This essential amino acid is classified as polar. Threonine can reside both within the interior of a protein, or on the protein surface. Together with serine, threonine is one of two proteinogenic amino acids bearing an alcohol group (Lehninger *et al*., 2000). Threonines are quite common in protein functional centres. The hydroxyl group is fairly reactive, being able to form hydrogen bonds with a variety of polar substrates. A common role for threonines within intracellular proteins is phosphorylation (Betts and Russell, 2003). Protein kinases frequently attach phosphates to threonine in order to facilitate the signal transduction processes. Threonine can often be replaced by serine, but is unlikely to be replaced by tyrosine, as the enzymes that catalyse the reactions are highly specific (Betts and Russell, 2003). Threonine is an essential amino acid that promotes normal growth by helping to maintain the proper protein balance in the body. It, also, supports cardiovascular, liver, central nervous and immune systems. Threonine helps keep connective tissues and muscles, throughout the body, strong and elastic, including the heart (Balch, 2000). Threonine can be converted to pyruvate or to alpha-ketobutyrate and eventually to succinyl-CoA, suggesting an association with the citric acid cycle (Balch, 2000). It is one of the amino acids that can be phosphorylated, which is a major mechanism by which cells control various signalling pathways. In addition, it is required for the body to synthesize two non-essential amino acids, glycine and serine, both of which play important roles in various physiological functions (Lehninger *et al*., 2000).

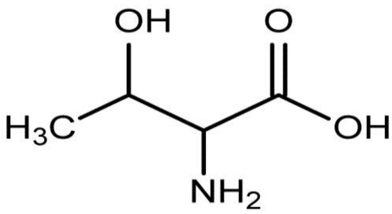

Figure 1 The structure of threonine (Lehninger *et al*., 2000)

2.3 Threonine effect on productivity of chickens

Threonine is needed for optimal immune response and gastrointestinal mucine production (Kidd, 2000). It is reported to improve the live weight gain of heat-stressed broiler chickens (Kidd, 2000). Adequate digestible threonine levels are needed to support optimum growth, because it serves an important role as a precursor of lysine and serine which are important components of meat (Ojano and Waldroup, 2002). The responses of chickens to threonine level in the diet are summarized in Table 1. Kidd *et al*. (2004) recommended a dietary digestible threonine requirement of 0.65 % to achieve optimum weight gain and breast meat weight in broiler chickens aged 3 to 6 weeks. NRC (1994) estimated that the total dietary threonine requirement for broiler chickens aged 6 to 8 weeks is 0.68 %. Kidd *et al*. (2000) reported that the dietary threonine requirement for optimum live weight and breast meat yield occurred at 0.67 % of the diet for male broiler chickens aged 6 to 8 weeks in a thermo-neutral environment (25 to 32 °C). Webel *et al*. (1996)

estimated the dietary threonine requirement of male broiler chickens aged 6 to 8 weeks to be 0.60 % for optimum live weight. Increased dietary threonine level improved nitrogen retention in broiler chicks (Dozier, 2001). However, Ojano-Diranin and Waldroup (2002) suggested that the modern rapidly growing broiler chicken may have threonine requirement greater than 0.74 % that is generally recommended by NRC (1994). It can be concluded that threonine requirement values for broiler chickens vary greatly. Dietary threonine requirement data for indigenous chickens were not found. It is, therefore, important to determine threonine requirements for optimal productivity of indigenous Venda chickens.

Table 2.01 Dietary threonine requirements (% of diet) for optimum feed intake, weight gain, feed conversion ratio and breast muscle weight of broiler chickens at different ages

Age	Intake	Weight gain	FCR	Breast muscle	Authors
1-3 weeks	–	-	0.87	-	NRC (1994)
1-3 weeks	-	0.73	0.77	-	Thomas (1986)
2-4 weeks	0.69	-	-	-	Thomas (1986)
2-4 weeks	-	-	0.76	-	Kidd et al (2004)
2-6 weeks	-	-	-	0.79	Corzo et al (2007)
3-6 weeks	-	0.65	-	0.65	Kidd et al (2004)
4-5 weeks	0.74	0.74	0.74	-	NRC (1994)
4-6 weeks	-	0.75	0.75	0.75	Kidd and Kerr (1997)
6-7 weeks	-	0.60 (males)	-	-	Webel et al (1996)
6-7 weeks	-	0.67 (males)	-	0.67	Kidd et al (2004)
6-8 weeks	-	0.68	0.68	0.68	NRC (1994)

Straková *et al*. (2003) noted that the most important components of poultry meat are mainly proteins with a high content of essential amino acids, especially arginine, leucine, isoleucine, methionine and valine in comparison to pork and beef meat. Methionine, cysteine and threonine are essential for body maintenance, being part of metabolic processes and also for cell synthesis and renewal. Cysteine participates in the synthesis of keratin in feathers (Wylie *et al*., 2001). Threonine is important not only for protein deposition, but also for mucin production and digestive processes (Ball *et al.*, 1999). Mack *et al*. (1999) and Kidd (2000) have reported that the threonine requirement for feed conversion is higher than that for weight gain in chickens. Threonine participates in protein synthesis, and its catabolism generates many products important in metabolism (Lemme, 2003). Nutrient recommendations for broiler feeds are usually appropriate to maximize growth. However, optimum dietary amino acid levels change with the production goal, such as the optimization of growth, breast meat yield, or feed conversion. For instance, optimum amino acid levels for breast meat production have been shown to be higher compared with those for whole carcasses or weight gain and seem, also, to be dependent on broiler chicken genetics (Schutte and Pack, 1995). There is evidence in broiler chickens that adequate threonine levels are needed to support optimum growth rates and meat tenderness, and reduce mortality rates (Kidd *et al.,* 1999). Feed formulation based on digestible amino acids has been shown to increase weight gain and feed intake and improve body composition in broiler chickens (Rostagno *et al*., 1995). Reduction in dietary protein levels is known to reduce performance, meat yields (Temim *et al*., 2000) and immune responses (Rama Rao *et al*., 1999) in chicken. Excess or imbalanced protein is reported to increase the dietary requirement of threonine, which helps in uric acid synthesis as a precursor for glycine (Baker et al., 1972). Therefore, Kidd and Kerr (1996) and Hussein *et a*l. (2001) reported that threonine is the most limiting amino acid in low crude protein broiler chicken's diets. As threonine requirement depends on crude protein content in the diet (Ciftci and Ceylan, 2004), the beneficial effects of threonine supplementation to low protein diets may vary compared to the optimal protein diets. Information on the effects of threonine supplementation to low crude protein diets on performance, carcass yields (Mack *et al*., 1999) and immunity (Maroufyan *et a*l., 2010) is very limited. Establishing the optimum requirement of threonine in Venda chicken diets will also help the nutritionists to formulate diets with optimum economic and ecological benefits.

2.4 Flavour, tenderness and juiciness of chicken meat

Palatability or eating quality of meat can be defined by three characteristics. These are tenderness, juiciness, and flavour or odour. In most countries, people want their meat tender, but that is not the case for many African countries, where they prefer their meat chewy (Warris, 2000). Juiciness of the meat is mainly related to the water-holding capacity of the meat or low marbling fat level. Flavour and odour are closely related. Generally flavour is linked to water-soluble materials, and odour is related to fat-soluble volatile elements. If the meat smells unpleasant, it is mostly related to the quality of the meat. It can be an indicator of the spoilage. But it is not always the case (Warris, 2000). Indigenous chickens generally have slower growth rate than commercial broiler chickens (Wattanachant *et al*., 2005).

Little research has been conducted to study sensory characteristics as well as consumers' acceptance of indigenous chicken meat. Consumer acceptance of chicken meat depends on its eating quality, which is influenced by a number of factors ranging from the physical and chemical to the histological properties and processing and handling of meat (Alvarado and Sams, 2004). One of the textural properties, tenderness has been noted as the most important factor determining quality of meat products (Savell *et al*., 1989). Apart from that juiciness, flavour and colour are the main eating quality characteristics that do influence the consumers' overall judgment of quality (Wood *et al*., 1995). By considering the relationship between sensory attributes and consumers' liking of chicken meat samples, a producer may find it possible to manipulate the underlying factors that affect the meat sensory characteristics to maximize product acceptability. Taste, texture, juiciness, appearance and odour are five main characteristics that contribute to the overall eating quality of meat. Among these characteristics, texture is probably considered to be the most important attribute by the average consumer (Dransfield, 1994; Chrystall, 1994). For the consumer, from a sensory point of view, the most important thing is the tenderness of the meat. It increases the enjoyment while eating. Hoffmann (1995) defined meat quality as the sum of all sensory, nutritionally, hygienic-toxicological and processing technological properties of the meat. Thus, the physical criteria after slaughter are of particular importance (Ristic *et al*., 2010). The tenderness of meat is a physiological property, which can be influenced by various factors like breeding, husbandry, feeding, fattening age, slaughter technology, cooling, storing and not least by the thermic treatment (Ristic *et al*., 2010). It comprises different material properties, like bite characteristics, succulence and toughness. The toughness can be examined in different ways: biochemical, physical, mechanical and sensory (Riedl and Obermowe, 2010). Tenderness and juiciness contribute to different meat textures. Meat tenderness originates in structural and biochemical properties of skeletal muscle fibres, especially myofibrils and intermediate filaments, the endomysium and perimysium, which are composed of collagen fibrils and fibres. Meat tenderness is a dimensional attribute and is described in several stages; partial compression, first bite, chew down and residual (Meilgaard *et al*., 1999). Tenderness is also defined as the ease of mastication, which involves the initial ease of penetration by teeth, the ease with which the meat breaks into fragments and the amount of residues remaining after mastication (Lawrie, 1998). Tenderness also decreases as animal mature because of the cross-linking of collagen (Fletcher, 2002).

The tenderness of meat is the sum total of the mechanical strength of skeletal muscle tissue and its weakening during the post-mortem aging of meat (Takahashi, 1996). Tenderness tends to be influenced by contraction state of myofibrillar proteins and maturity of connective tissues (Fletcher, 2002). Myofibrillar contribution to the meat tenderness depends on the extent of shortening during rigour mortis development and proteolysis during conditioning (Warris, 2000). Connective tissues toughness is often referred to as background toughness because the tissues hardly change during the standard length of meat storage post-mortem (McCormick, 1994). Meat tenderness is largely dependent on the state of contraction of skeletal muscle fibres and the amount and extent of collagen crosslinking in the surrounding extracellular connective tissues (Sikes *et al*., 2010). The degree in which meat is cooked is very important in determination of meat tenderness (Warris, 2000). Mature indigenous Venda chickens have hard muscle as compared to those of the broiler chickens, and this is due to high collagen content (Wattanachant *et al*., 2004). Meat toughness is caused by excessive contraction during rigour mortis development after aging period, supposedly by proteolysis, non-enzymatic degradation of the cytoskeleton and the weakening of actin and or myosin interactions (Takahashi, 1996). This is determined by the pre- and post-slaughter effects on the carcasses. Juiciness in the cooked meat has two organoleptic components, first is the impression of wetness during the initial chewing, which is due to the rapid release of meat fluids. Second is the sustained juiciness resulting from the stimulatory effect of fat on the salvation. In conjunction with tenderness, juiciness accounts for the overall eating quality and consumers may confuse the two factors when making comparisons (Varnam and Sutherland, 1995). Meat flavour is another quality attribute that consumers use to determine the acceptability of chicken meat. Taste and odour contribute to the flavour of poultry meat, and it is difficult to differentiate between the two during consumption. Few factors affect poultry meat flavour during production and processing. Table 2.02 list the major components of meat quality.

Table 2.02 The major components of meat quality (Warris *et al*., 1996)

Components	Meat quality factors
Yield and gross composition	Muscle growth and size
	Ratio of fat to lean meat
Appearance and technological characteristics	Chemical composition and marbling of lean meat
	Fat texture and colour
	Colour and water holding capacity of lean meat
Palatability	Texture and tenderness
	Juiciness
	Flavour
Wholesomeness	Chemical and microbial safety
	Nutritional quality
Ethical quality	Acceptable animal husbandry

Thus it is not only difficult to produce a flavour defect, but it is difficult to enhance flavour during production and processing (Fletcher, 1997). Minor effects on meat flavour are related to bird strain, environmental conditions, diet, chilling, scalding temperatures, product packaging and storage; however, these effects are too small for consumers to notice them (Fletcher, 2002). Age of the bird at slaughter affects the flavour of the meat. A very large number of compounds have been identified as potential contributors to meat flavour. However, it is probable that only a relative few of these effects are important. A compound’s contribution to flavour depends on two things: first, how much is produced and second, the odour threshold (Lawrie, 1998). Generally consumers decide to purchase meat based on its appearance. The colour of the meat greatly affects its saleability. Also, its water-holding capacity is also important to the consumer. It can be said that appearance and technological characteristics are connected. The importance of water-holding capacity can be classified into three sections; firstly, poor water holding-capacity can be connected to the appearance of the meat. Water-holding capacity is obvious to the consumer when examining the packaging in the retail stores. Poor water-holding capacity results in the drip remaining in the package resulting in a negative appearance of the meat. Secondly, the drip loss is connected to the weight of the meat. In processed meats, poor water-holding capacity may reduce water retention and, therefore, yield of product is reduced. Finally, the juiciness of the meat after cooking is also affected by the water-holding capacity. Poor water-holding capacity meat may be dry or taste may be negatively affected. Besides colour and water-holding capacity, there is also a relationship between appearance and marbling fat. This is also an important factor for determining appearance of the meat (Warris, 2000).

2.5 Conclusion

Indigenous chickens play an important role in the rural households as a source of income and nutrition. The information on the effect of dietary threonine supplementation on feed intake, digestibility, growth rate and mortality and carcass characteristics of broiler chickens is extensive but not conclusive. However, no such information was found on indigenous Venda chickens. It is, therefore, important to determine the effect of dietary threonine level on productivity and carcass characteristics of indigenous Venda chickens.

CHAPTER 3

MATERIALS AND METHODS

3.1 Study site

This study was conducted at the University of Limpopo Experimental Farm, South Africa. The farm is located about 10 km north-west of the Turfloop campus. The ambient temperatures around the study area range between 5 and 28 °C during winter seasons and between 20 and 36 °C during summer seasons. The mean annual rainfall is between 446.8 and 468.4 mm (Shiringani, 2007).

3.2 Preparation of the house

The experimental house was cleaned properly with water and a disinfectant (Jeyes fluid, NTK Company, Polokwane) and then fumigated with formalin. The house was left for two weeks after cleaning to break the life cycle of any disease causing organisms that were not killed by the disinfectant. After proper drying, the experimental house was divided into 20 floor pens of 2.0 m^2 each. Fresh saw dust and wood shavings were placed on the floor to a level of 7 cm.

3.3 Acquisition of materials and chickens

All the required materials (chemicals, medicines and vaccines) for the experiment were purchased from NTK Company in Polokwane before the commencing of the experiment. The diets were formulated and produced by Voorslagvoere Company Mokopane, South Africa.

3.4 Experimental designs, treatments and procedures

The study was conducted at the University of Limpopo in South Africa. The first experiment was used to determine the effect of dietary threonine level on feed intake, growth rate, mortality, and carcass characteristics of indigenous Venda chickens aged between 1 and 7 weeks. The chicks were randomly assigned to 5 treatments with four replications, each replicate having 4 birds. Thus, 20 floor pens were used in total. A complete randomized design (SAS, 2008) was used. The daily lighting program was 23 hours. The birds were offered feed and fresh water *ad libitum*. The experimental diets were isocaloric and isonitrogenous, but with different threonine levels. The treatments were as indicated in Table 3.01. Feed composition of the diets is indicated in Table 3.02.

Table 3.01 Dietary treatments for Experiment 1

Diet Code	Diet description
CT_4	Unsexed Venda chickens on an 18 % CP diet having 4 g of threonine/kg DM
CT_5	Unsexed Venda chickens on an 18 % CP diet having 5 g of threonine/kg DM
CT_6	Unsexed Venda chickens on an 18 % CP diet having 6 g of threonine/kg DM
CT_7	Unsexed Venda chickens on an 18 % CP diet having 7 g of threonine/kg DM
CT_8	Unsexed Venda chickens on an 18 % CP diet having 8 g of threonine/kg DM

The diet composition of the chickens is presented in Table 3.02.

Table 3.02 Diet composition of grower mash for indigenous Venda chickens

	Treatment				
Feed	CT_4	CT_5	CT_6	CT_7	CT_8
Maize (%)	40.69	40.69	40.69	40.69	40.69
Wheat (%)	15	15	15	15	16
Lucerne meal (%)	5.8	6.8	6.3	5.8	5.8
Soya bean meal (%)	21.83	18	17.23	18.93	18.63
Fish meal (2-8% fat) (%)	5	5	5	5	5
Maize gluten meal (%)	3.43	3.40	4.33	4.26	4.19
Full fat (%)	2.19	2.13	2.13	2.11	2.18
Soya oil (%)	3	5	5	5	5.41
DI sodium phosphate (%)	0.11	0.11	0.11	0.11	0.11
Calcium carbonate (%)	0.86	0.86	0.86	0.86	0.86
Salt (%)	0.18	0.18	0.18	0.18	0.18
DI calcium phosphate%	1.47	1.47	1.47	1.47	1.47
DL- Methionine (%)	0.20	0.20	0.20	0.20	0.20
L-Lysine (%)	0.20	0.20	0.20	0.20	0.20
Threonine (%)	0.04	0.05	0.06	0.07	0.08
Total	100	100	100	100	100
Nutrients					
Crude protein (%)	18	18	18	18	18
Energy (MJ/kg DM)	12	12	12	12	12

The second experiment was used to determine the effect of dietary threonine level on feed intake, digestibility, growth, mortality and carcass characteristics of indigenous Venda chickens aged between seven to 13 weeks. A complete randomize design (SAS, 2008) having 5 treatments, replicated four times with four birds per replicate. Each pen was having an area of 2.0 m^2. The chickens were fed an 18 % CP diet that satisfied their nutritional requirements according to the NRC (1994). The daily lighting program was 23 hours. The birds were offered feed and fresh water *ad libitum* throughout the experimental period. The treatments were as presented in Table 3.03

Table 3.03 Dietary treatments for Experiment 2

Diet Code	Diet description
FT_4	Female Venda chickens on a 18 % CP diet having 4 g of threonine/kg DM
FT_5	Female Venda chickens on a 18 % CP diet having 5 g of threonine/kg DM
FT_6	Female Venda chickens on a 18 % CP diet having 6 g of threonine/kg DM
FT_7	Female Venda chickens on a 18 % CP diet having 7 g of threonine/kg DM
FT_8	Female Venda chickens on a 18 % CP diet having 8 g of threonine/kg DM

3.5 Data collection

The initial live weights of the chickens were taken at the beginning of the experiment. Average live weight per bird was measured at weekly basis by weighing the chickens in each pen, and the total live weight was divided by the number of birds in the pen to find the average live weight per chicken. The determined live weights were used to calculate the growth rates of the chickens. Weekly mean feed intakes were determined until the termination of the experiment. Daily mean live weights and feed conversion ratios were calculated from weekly measurements. Daily mean growth rates and feed conversion ratios were calculated from the above measurements. Digestibility was measured when the chickens were between 84 and 91 days old. Digestibility was conducted in specially designed metabolic cages having separated watering and feeding troughs. Four birds were randomly selected from each replicate and transferred to metabolic cages for the measurement of apparent digestibility. A three-day acclimatization period was allowed prior to a three-day collection period.

Droppings voided by each bird were collected on a daily basis at 09:00 hours. Care was taken to avoid contamination from feathers, scales, debris and feeds. At 91 days of age all the remaining indigenous Venda chickens per pen were slaughtered. Breast meat yield, wing, thigh and drumstick weights were weighed. At the end of each slaughtering, meat samples from each breast part and thighs of the slaughtered bird were taken and stored in the refrigerator until analysed for dry matter, nitrogen and sensory tasting.

3.6 Sensory evaluation

Meat samples which had been frozen at 4 °C were thawed for 24 hours in a cooler room for sensory evaluation. The samples were broiled on an oven rack set for 160 °C and allowed to preheat for 20 minutes. The meat samples were broiled for approximately 50 minutes and turned every 25 minutes. Tongs were used for turning to avoid piercing that could let the moisture escape. The samples were cut into 1.5 cm thick according to their treatments and replicates. Lemon juice and water were used to rinse and cleanse the palate before moving to the next samples. Each member of the panel had a chance to taste all the samples. The panel consisted of 20 University of Limpopo postgraduate students. The meat was then evaluated for its tenderness, juiciness and flavour using a 5-point ranking scale (Table 3.05).

Table 3.04 Evaluation scores used by the sensory panel

	Sensory Attributes		
Score	Tenderness	Juiciness	Flavour
1	Too tough	Much too dry	Very bad flavour
2	Tough	Dry	Poor flavour
3	Neither tough nor tender	Neither dry nor juicy	Neither bad nor good flavour
4	Tender	Juicy	Good flavour
5	Too tender	Too juicy	Very good flavour

3.7 Chemical analysis

Dry matter contents of feeds, feed refusals, excreta and meat samples were determined by drying the samples at 105 °C for 24 hours. Nitrogen contents of feeds, feed refusals, faeces and meat samples were determined by a micro Kjedahl method (AOAC, 2008). Ion- exchange chromatography was used to determine the threonine contents contained in the experimental chicken feeds, feed refusals, faeces and meat samples (LATS, University of Limpopo, Polokwane) according to the methods described by AOAC (2008).

3.8 Statistical analysis

Effect of threonine supplementation level on feed intake, digestibility, growth rate, mortality rate, feed conversion ratio and carcass characteristics of indigenous Venda chickens were analyzed using the General Linear Model (GLM) procedure of the statistical analysis of variance (SAS, 2008). Duncan test for multiple comparisons was used to test the significance of difference between treatment means ($P<0.05$) (SAS, 2008). The responses in optimum feed intake, live weight, growth rate, feed conversion ratio, carcass characteristics, meat tenderness, flavour and taste changes to dietary threonine supplementation were modelled using the following quadratic equation:

$$Y = a + b_1 x + b_2 x^2$$

Where Y= optimum feed intake, live weight, growth rate, feed conversion ratio, carcass weight, breast meat and meat tenderness; a= intercept; b= coefficients of the quadratic equation; x= level of threonine supplementation and $-b_1/2b_2$ = x value for optimum response. The quadratic equation was preferred because it gave the best fit.

The relationship between optimal responses in feed intake, feed conversion ratio, growth rate, live weight, carcass weight, dry matter digestibility, metabolisable energy and nitrogen retention across the two experiments and dietary threonine supplementation levels were modelled using a linear regression equation in the form of:

$$Y = a + bx$$

Where y= optimal feed intake, feed conversion ratio, growth rate, live weight, dry matter digestibility, metabolisable energy and nitrogen retention; a= intercept; b= coefficient of the linear equation, x= dietary threonine supplementation level.

CHAPTER 4

RESULTS

Results of the nutrient composition of the grower diets are presented in Table 4.01. The diets were isocaloric and isonitrogenous but with different levels of dietary threonine, ranging from 4 to 8 g/kg DM.

Results of the effect of dietary threonine level on feed intake, growth rate, feed conversion ratio, live weight, metabolisable energy, nitrogen retention and mortality of unsexed Venda chickens aged one to seven weeks are presented in Table 4.02. Dietary threonine level had no effect (P>0.05) on mortality of unsexed Venda chickens. Venda chickens on a diet containing 6 g of threonine per kg DM had higher (P<0.05) feed intakes than those on diets containing 4, 5, 7 or 8 g of threonine per kg DM. Chickens on a diet containing 7 g of threonine per kg DM had higher (P<0.05) feed intakes than those on diets having 4, 5 or 8 g of threonine per kg DM. Similarly, chickens on diets having 5 or 8 g of threonine per kg DM had higher (P<0.05) feed intakes than those on a diet containing 4 g of threonine per kg DM. However, chickens on diets containing 5 or 8 g of threonine per kg DM had similar (P>0.05) feed intakes. Unsexed Venda chickens on diets containing 6 or 7 g of threonine per kg DM had higher (P<0.05) growth rates than those on diets containing 4, 5 or 8 g of threonine per kg DM. Similarly, chickens on a diet containing 8 g of threonine per kg DM had higher (P<0.05) growth rates than those on diets having 4 or 5 g of threonine per kg DM. However, chickens on diets containing 4 or 5 g of threonine per kg DM had similar (P>0.05) growth rates. Similarly, chickens on diets containing 6 or 7 g of threonine per kg DM had the same (P>0.05) growth rates. Unsexed Venda chickens on diets containing 6 or 7 g of threonine per kg DM had better (P<0.05) feed conversion ratios (FCR) than those on diets containing 4, 5 or 8 g of threonine per kg DM. Similarly, Venda chickens on diets having 5 or 7 g of threonine per kg DM had better (P<0.05) FCR than those on a diet containing 4 g of threonine per kg DM. However, chickens on diets containing 6 or 7 g of threonine per kg DM had similar (P>0.05) feed conversion ratios.

Venda chickens on a diet containing 6 g of threonine per kg DM had higher (P<0.05) live weights than those on diets having 4, 5, 7 or 8 g of threonine per kg DM. Chickens on diets containing 7 or 8 g of threonine per kg DM had better (P<0.05) live weights than those on diets having 4 or 5 g of threonine per kg DM. Chickens on a diet containing 5 g of threonine per kg DM had higher ($P>0.05$) live weights than those on a diet having 4 g of threonine per kg DM. However, chickens on diets containing 7 or 8 g of threonine per kg DM had similar ($P>0.05$) live weights. Venda chickens on a diet containing 5 or 6 g of threonine per kg DM had better ($P<0.05$) metabolisable energy intakes than those on diets having 4, 7 or 8 g of threonine per kg DM. Similarly, chickens on a diet containing 8 g of threonine per kg DM had higher ($P<0.05$) metabolisable energy intakes than those on diets having 4 or 7 g of threonine per kg DM. However, chickens on diets containing 5 or 6 g of threonine per kg DM had similar ($P>0.05$) metabolisable energy intakes. Similarly, Venda chickens on diets containing 4 or 7 g of threonine per kg DM had the same ($P<0.05$) metabolisable energy intakes. Venda chickens on a diet containing 6 g of threonine per kg DM had higher ($P<0.05$) nitrogen retention than those on diets having 4, 5, 7 or 8 g of threonine per kg DM. Venda chickens on a diet containing 7 g of threonine per kg DM had higher ($P<0.05$) nitrogen retention than those on diets having 4, 5 or 8 g of threonine per kg DM. Similarly, chickens on a diet containing 7 g of threonine per kg DM had better ($P<0.05$) nitrogen retention values than those on diets having 4, 5 or 8 g of threonine per kg DM. However, chickens on diets containing 4, 5 or 8 g of threonine per kg DM had similar ($P>0.05$) nitrogen retention values.

Feed intake, growth rate, FCR, live weight, ME and nitrogen retention of unsexed Venda chickens aged one to seven weeks were optimized at dietary threonine levels of 6.218 ($r^2 = 0.666$), 6.437 ($r^2 = 0.643$), 6.331 ($r^2 = 0.914$), 6.655 ($r^2 = 0.920$), 5.979 ($r^2 = 0.535$) and 6.158 ($r^2 = 0.645$) g/kg DM, respectively (Figures 4.01, 4.02, 4.03, 4.04, 4.05 and 4.06, respectively and Table 4.03).

Table 4.01 Nutrient composition of diets (the units are in g/kg DM feed except dry matter as g/kg feed and metabolisable energy as MJ/kg DM feed)

	Treatment				
Variable	CT_4	CT_5	CT_6	CT_7	CT_8
Dry matter	923	923	923	923	923
Energy	12	12	12	12	12
Crude protein	180	180	180	180	180
Calcium	5	5	5	5	5
Sodium	2	2	2	2	2
Lysine	10	10	10	10	10
Methionine	8.4	8.4	8.4	8.4	8.4
Threonine	4	5	6	7	8

Table 4.02 Effect of dietary threonine level on feed intake (g/bird/day), growth rate (g/bird/day), feed conversion ratio (FCR) (g feed/g live weight gain), live weight (g/bird aged 49 days), metabolisable energy (MJ/kg DM), nitrogen retention (g/bird/day) and mortality (%) of unsexed Venda chickens aged one to seven weeks

	Treatment					
Variable	CT_4	CT_5	CT_6	CT_7	CT_8	SE
Feed intake	26^{d}	30^{c}	41^{a}	32^{b}	30^{c}	1.162
Growth rate	14^{c}	14^{c}	21^{a}	20^{a}	16^{b}	0.707
FCR	4.5^{a}	4.3^{b}	4.0^{c}	4.1^{c}	4.3^{b}	0.044
Live weight	410^{d}	445^{c}	460^{a}	450^{b}	451^{b}	3.971
ME	9.4^{c}	10.0^{a}	10.1^{a}	$9.5b^{c}$	9.6^{b}	0.067
N-retention	1.3^{c}	$1.4b^{c}$	1.8^{a}	1.5^{b}	$1.4b^{c}$	0.043
Mortality	0.34	0.33	0.32	0.33	0.32	0.003

^{a,b,c,d} : Means in the row not sharing a common superscript are significantly different (P<0.05)

SE : Standard error

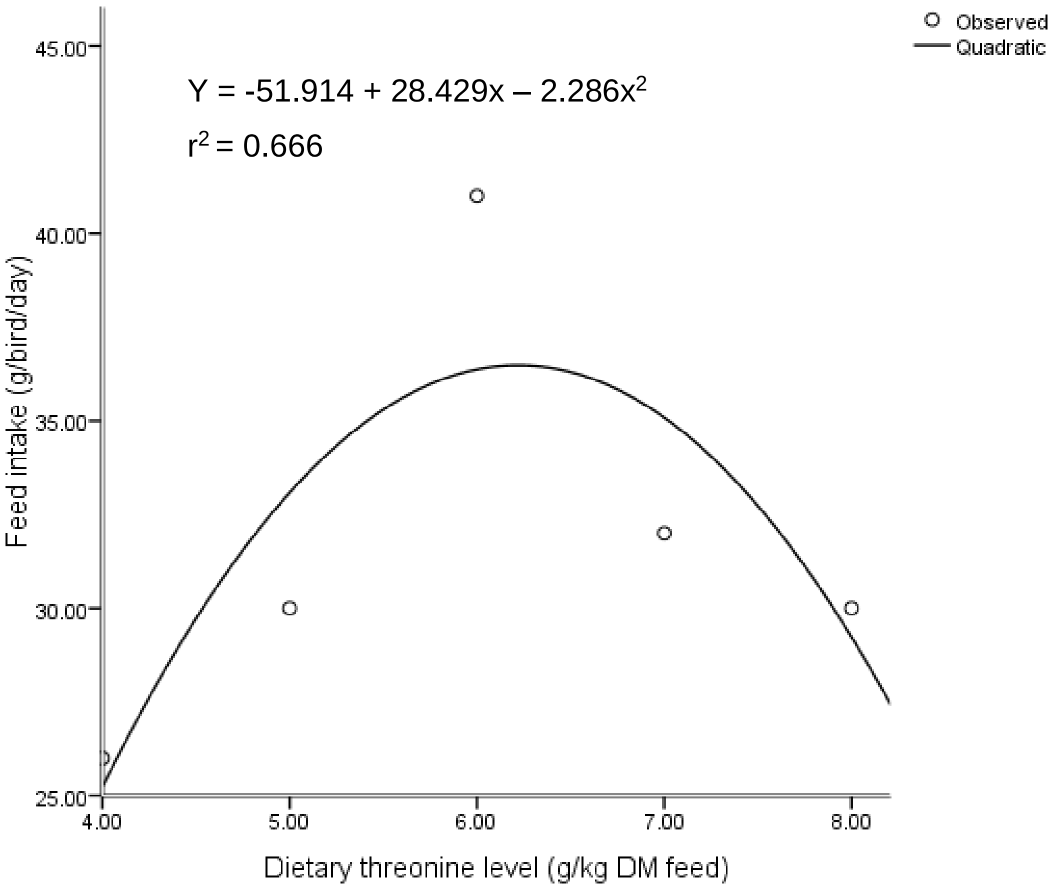

Figure 4.01 Effect of dietary threonine level on feed intake of unsexed Venda chickens aged one to seven weeks

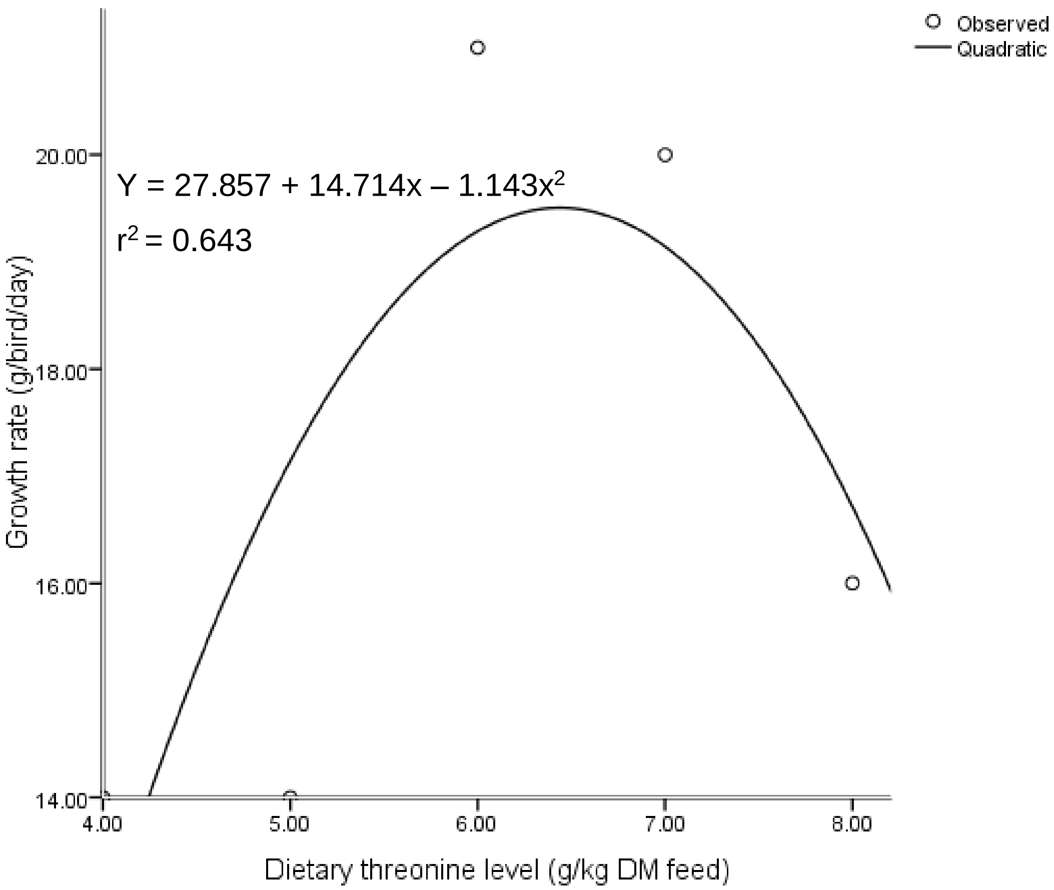

Figure 4.02 Effect of dietary threonine level on growth rate of unsexed Venda chickens aged one to seven weeks

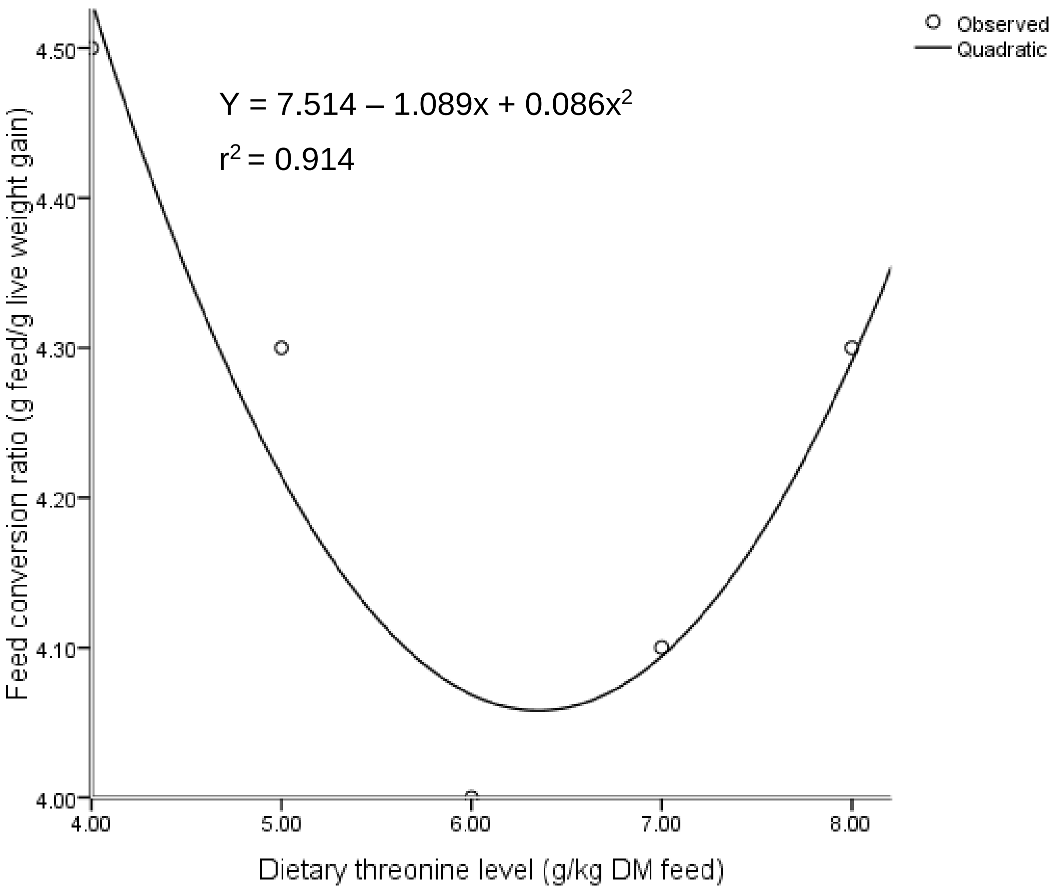

Figure 4.03 Effect of dietary threonine level on feed conversion ratio of unsexed Venda chickens aged one to seven weeks

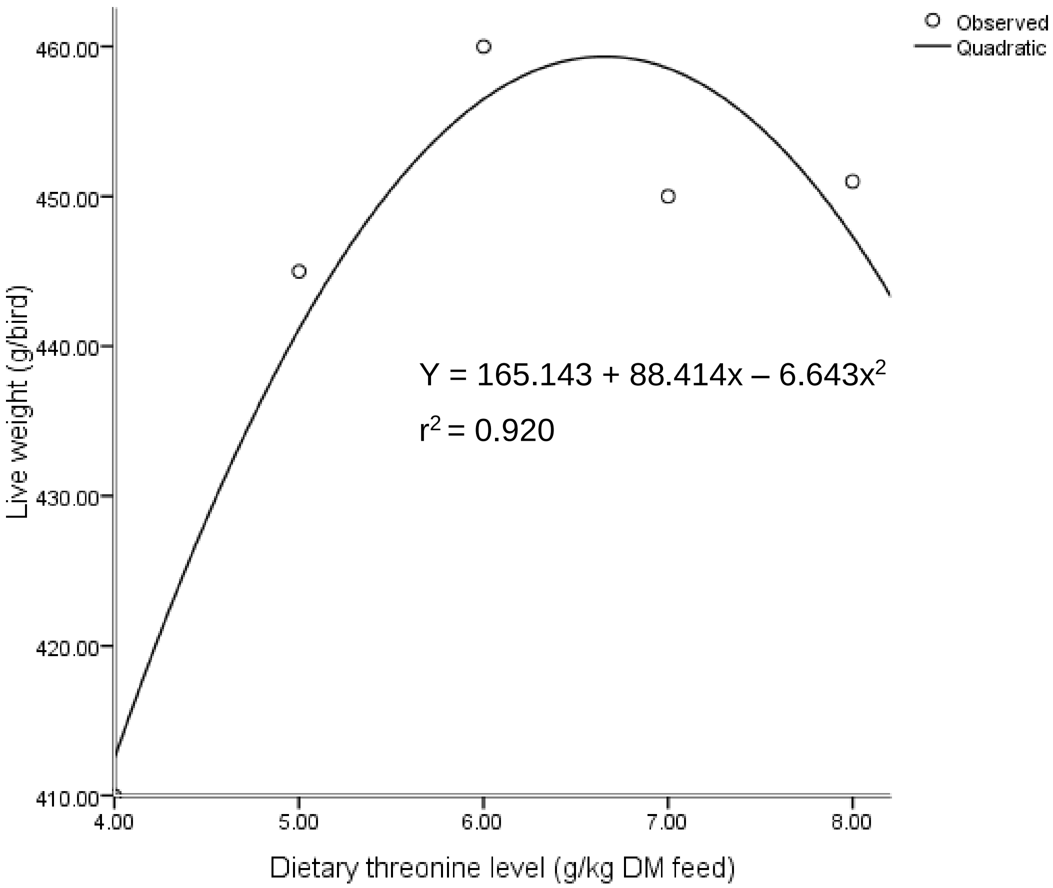

Figure 4.04 Effect of dietary threonine level on live weight of unsexed Venda chickens aged one to seven weeks

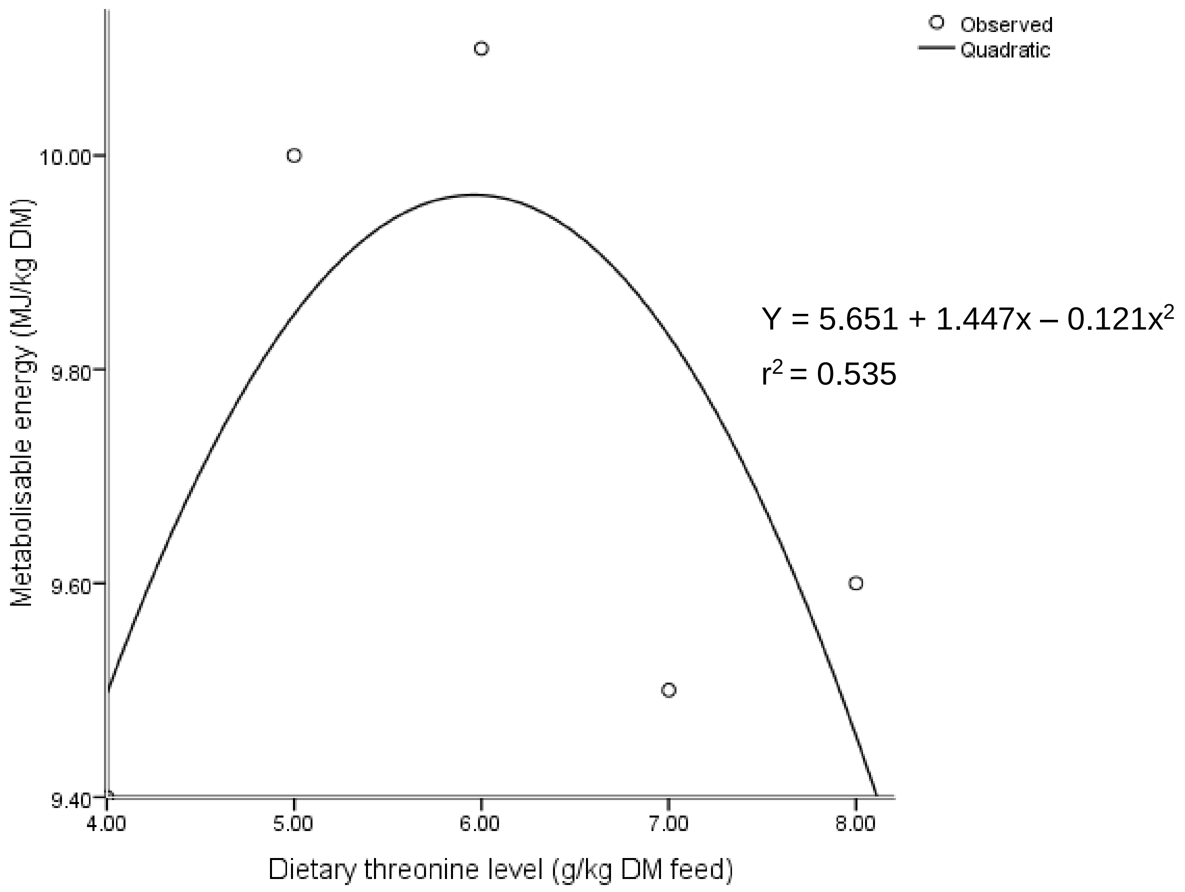

Figure 4.05 Effect of dietary threonine level on metabolisable energy intake of unsexed Venda chickens aged seven weeks

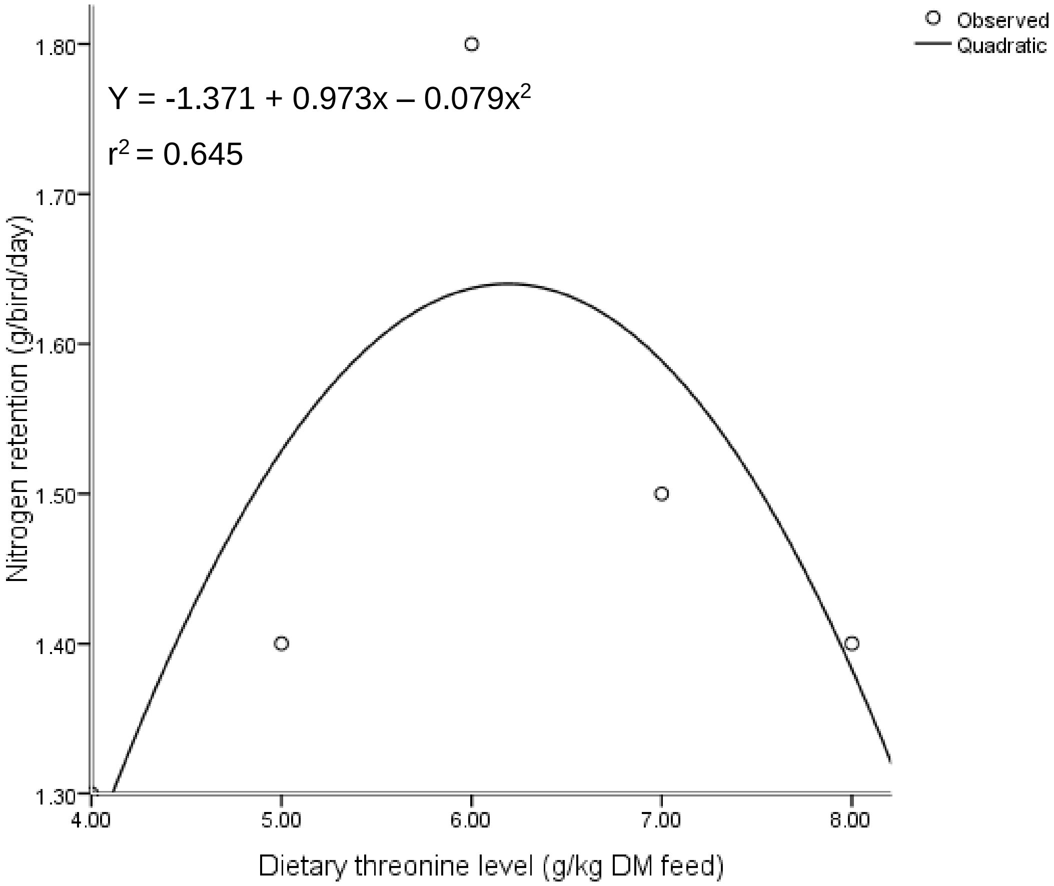

Figure 4.06 Effect of dietary threonine level on nitrogen retention of unsexed Venda chickens aged seven weeks

Table 4.03 Dietary threonine levels for optimal feed intake (g/bird/day), growth rate (g/bird/day), feed conversion ratio (FCR) (g feed/g live weight gain), live weight (g/bird aged 49 days), metabolisable energy (ME) (MJ/kg DM), nitrogen retention (g/bird/day) and mortality (%) of unsexed Venda chickens aged one to seven weeks

Variable	Formula	r^2	Threonine level*	Optimal Y-value
Feed intake	$Y = -51.914 + 28.429x - 2.286x^2$	0.666	6.218	36.48
Growth rate	$Y = 27.857 + 14.714x - 1.143x^2$	0.643	6.437	19.50
FCR	$Y = 7.514 - 1.089x + 0.086x^2$	0.914	6.331	4.07
Live weight	$Y = 165.143 + 88.414x - 6.643x^2$	0.920	6.655	459.33
ME	$Y = 5.651 + 1.447x - 0.121x^2$	0.535	5.979	9.98
N-retention	$Y = -1.371 + 0.973x - 0.079x^2$	0.645	6.158	1.623

* : Threonine level for optimal variable

Results of the effect of dietary threonine level on feed intake, growth rate, feed conversion ratio, live weight, metabolisable energy and nitrogen retention of female Venda chickens aged 50 to 91 days are presented in Table 4.04. Female Venda chickens on a diet containing 6 g of threonine per kg DM had higher (P<0.05) feed intakes than those on diets containing 4, 5, 7 or 8 g of threonine per kg DM. Female Venda chickens on diets containing 5 or 8 g of threonine per kg DM had higher (P<0.05) feed intakes than those on diets having 4 or 7 g of threonine per kg DM. Similarly, Female Venda chickens on a diet containing 4 g of threonine per kg DM had better (P<0.05) feed intakes than those on a diet having 7 g of threonine per kg DM. Chickens on diets containing 5 or 8 g of threonine per kg DM had similar (P>0.05) feed intakes. Female Venda chickens on a diet containing 6 g of threonine per kg DM had higher (P<0.05) growth rates than those on diets containing 4, 5, 7 or 8 g of threonine per kg DM. However, female chickens on diets containing 4, 5, 7 or 8 g of threonine per kg DM had similar (P>0.05) growth rates. Female Venda chickens on a diet containing 7 g of threonine per kg DM had better (P<0.05) feed conversion ratios than those on diets containing 4, 5, 6 or 8 g of threonine per kg

DM. Female Venda chickens on a diet containing 6 g of threonine per kg DM had better ($P<0.05$) feed conversion ratios than those on a diet having 4 g of threonine per kg DM. Female chickens on diets containing 6 or 7 g of threonine per kg DM had similar ($P>0.05$) feed conversion ratios. Female Venda chickens on diets containing 5, 6 or 8 g of threonine per kg DM had similar ($P>0.05$) feed conversion ratios. Similarly, chickens on diets having 4, 5 or 8 g of threonine per kg DM had the same ($P>0.05$) feed conversion ratios. Female Venda chickens on a diet containing 6 g of threonine per kg DM had higher ($P<0.05$) live weights than those on diets containing 4, 5, 7 or 8 g of threonine per kg DM. Female Venda chickens on diets containing 7 g of threonine per kg DM had higher ($P<0.05$) live weights than those on diets having 4, 5 or 8 g of threonine per kg DM. Similarly, chickens on a diet containing 8 g of threonine per kg DM had better ($P<0.05$) live weights than those on diets having 4 or 5 g of threonine per kg DM. Chickens on a diet containing 5 g of threonine per kg DM had better ($P<0.05$) live weights than those on a diet having 4 g of threonine per kg DM. Female Venda chickens on diets containing 5 or 6 g of threonine per kg DM had higher ($P<0.05$) metabolisable energy intakes than those on diets containing 4, 7 or 8 g of threonine per kg DM. However, chickens on diets containing 5 or 6 g of threonine per kg DM had similar ($P>0.05$) metabolisable energy intakes.

Chickens on diets having 4, 7 or 8 g of threonine per kg DM had the same ($P>0.05$) metabolisable energy intakes. Female Venda chickens on a diet containing 6 g of threonine per kg DM had higher ($P<0.05$) nitrogen retention values than those on diets containing 4, 5, 7 or 8 g of threonine per kg DM. Venda chickens on a diet containing 5 g of threonine per kg DM had higher ($P<0.05$) nitrogen retention values than those on diets having 4, 7 or 8 g of threonine per kg DM. Similarly, chickens on a diet containing 8 g of threonine per kg DM had better ($P<0.05$) nitrogen retention values than those on diets having 4 or 7 g of threonine per kg DM. However, chickens on diets containing 4 or 7 g of threonine per kg DM had similar ($P>0.05$) nitrogen retention values. No chicken deaths were recorded.

Feed intake, growth rate, FCR, live weight, ME intake and nitrogen retention of female Venda chickens aged 50 to 91 days were optimized at dietary threonine levels of 6.218 ($r^2 = 0.666$), 6.437 ($r^2 = 0.643$), 6.331 ($r^2 = 0.914$), 6.655 ($r^2 = 0.920$), 5.979 (r^2 = 0.535) and 6.158 (r^2 = 0.645) g/kg DM, respectively (Figures 4.07, 4.08, 4.09, 4.10, 4.11 and 4.12, respectively and Table 4.05).

Table 4.04 Effect of dietary threonine level on feed intake (g/bird/day), growth rate (g/bird/day), feed conversion ratio (FCR) (g DM feed/g live weight gain), live weight (g/bird aged 91 days), metabolisable energy (ME) (MJ/kg DM) and nitrogen retention (g/bird/day) of female Venda chickens aged 50 to 91 days.

	Treatment					
Variable	CT_4	CT_5	CT_6	CT_7	CT_8	SE
Feed intake	67.5^c	70.4^b	86.0^a	67.2^d	70.4^b	1.600
Growth rate	15^b	16^b	20^a	16^b	16^b	0.443
FCR	4.5^a	4.4^{ab}	4.3^{bc}	4.2^c	4.4^{ab}	0.030
Live weight	1200^e	1250^d	1400^a	1264^b	1252^c	15.394
ME	9.98^b	10.23^a	10.23^a	9.98^b	9.98^b	0.028
N-retention	1.30^d	1.38^b	1.68^a	1.30^d	1.36^c	0.033

$^{a, b, c, d, e}$: Means in the same row not sharing a common superscript are significantly different (P<0.05).

SE : Standard error

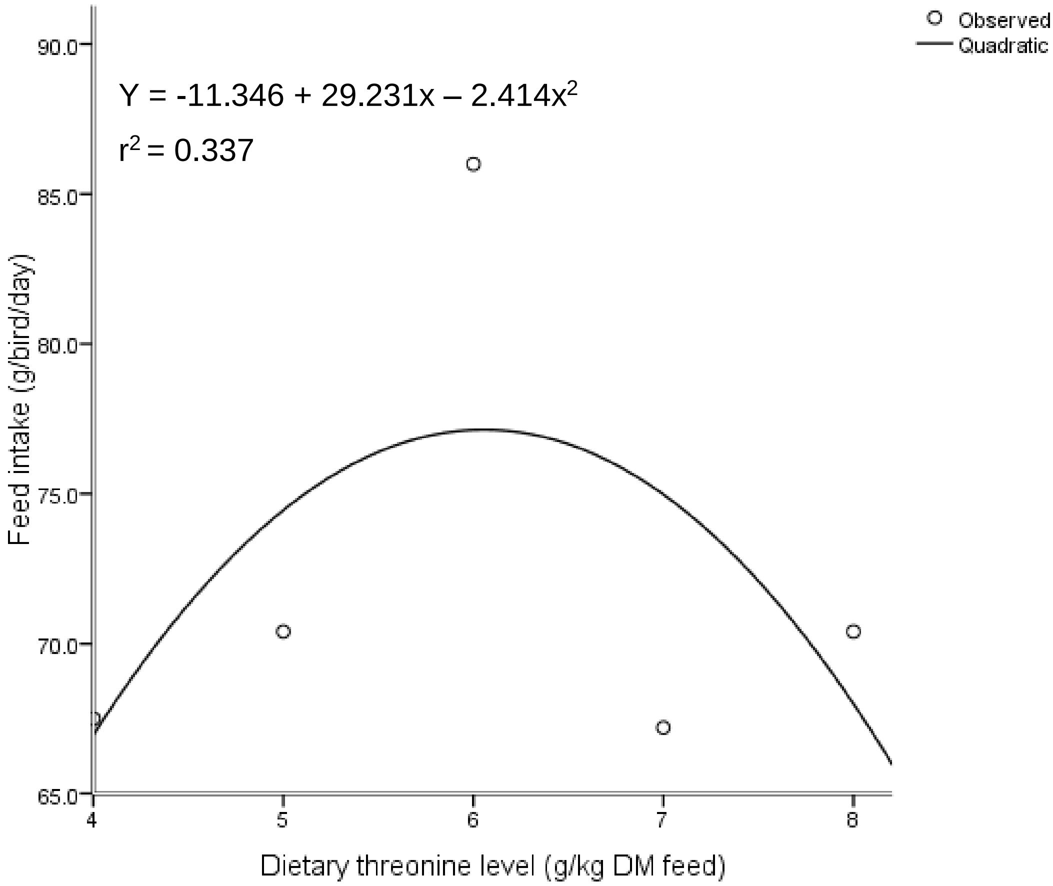

Figure 4.07 Effect of dietary threonine level on feed intake of female Venda chickens aged 50 to 91 days

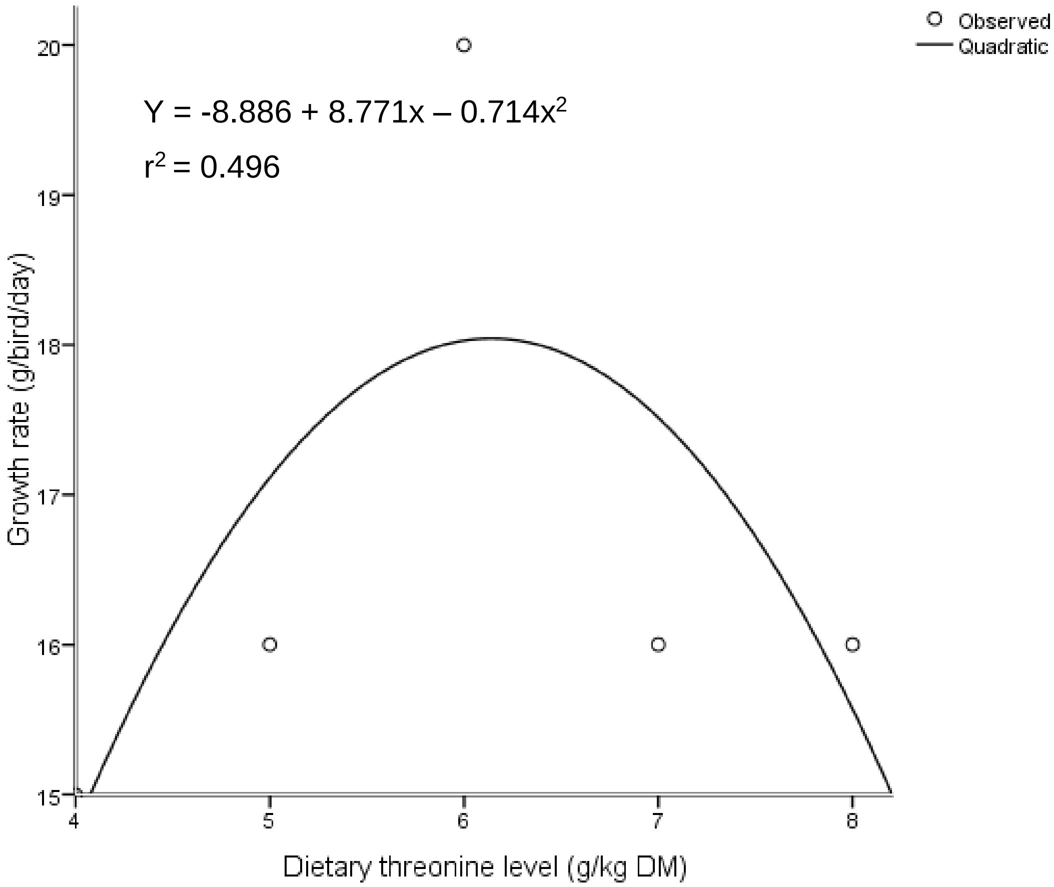

Figure 4.08 Effect of dietary threonine level on growth rate of female Venda chickens aged 50 to 91 days

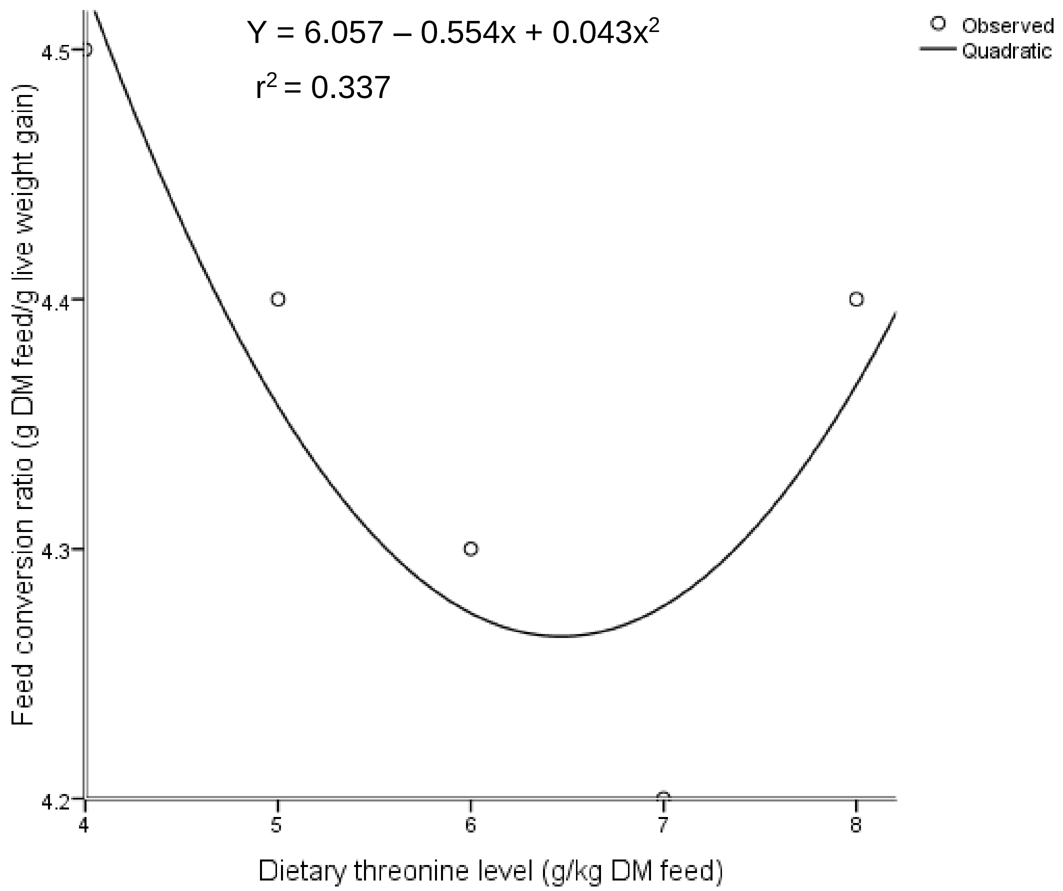

Figure 4.09 Effect of dietary threonine level on feed conversion ratio of female Venda chickens aged 50 to 91 days

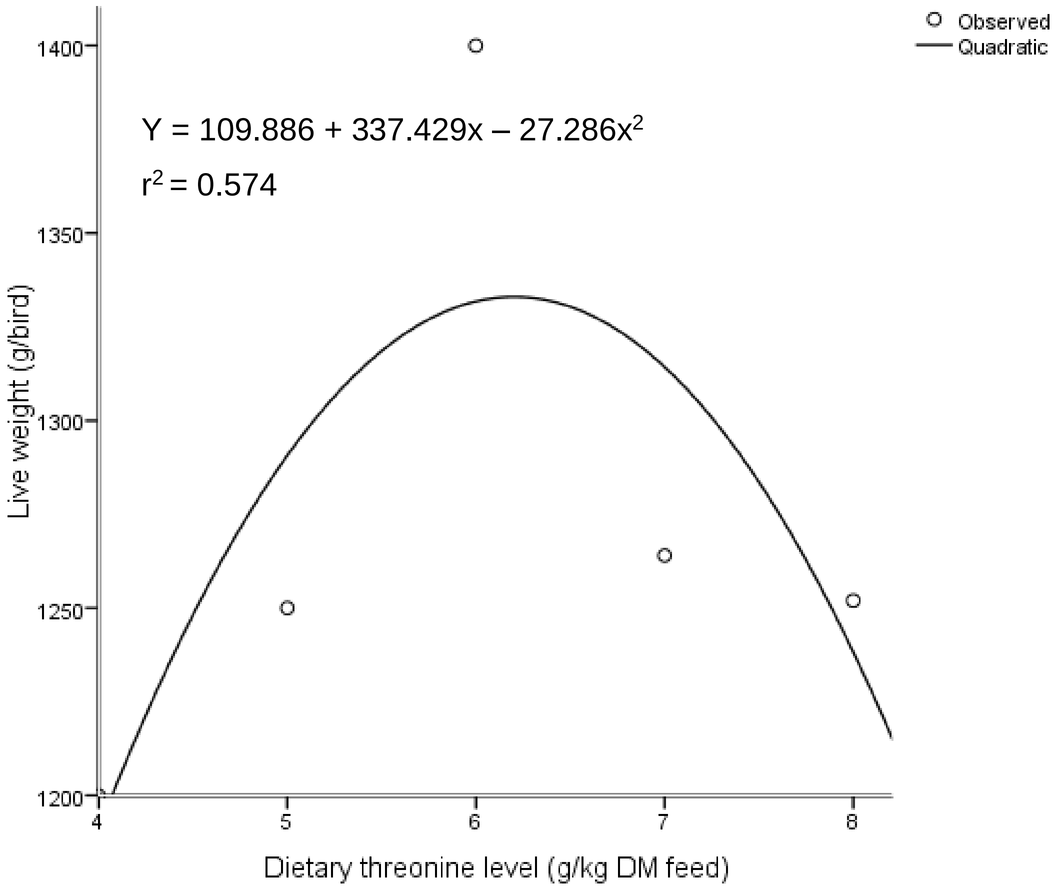

Figure 4.10 Effect of dietary threonine level on live weight of female Venda chickens aged 91 days

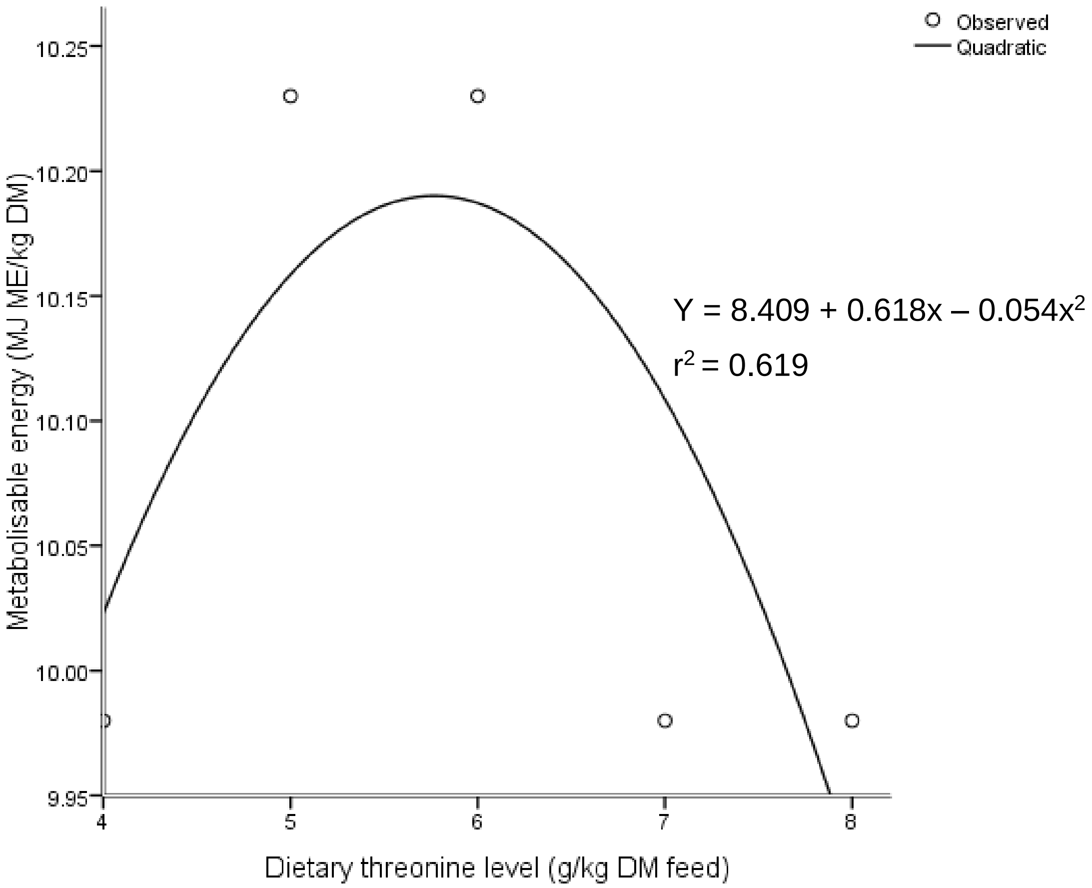

Figure 4.11 Effect of dietary threonine level on metabolisable energy intake of female Venda chickens aged 13 weeks

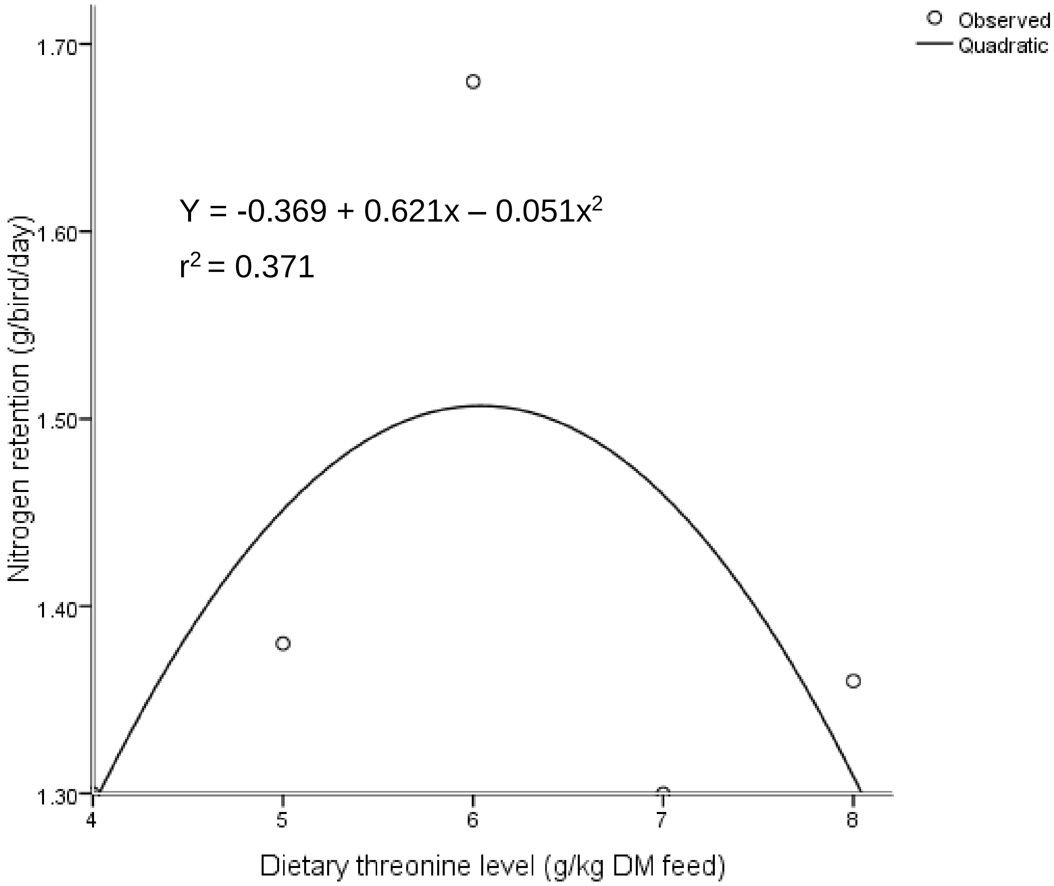

Figure 4.12 Effect of dietary threonine level on nitrogen retention of female Venda chickens aged 13 weeks

Table 4.05 Dietary threonine levels for optimal feed intake (g/bird/day), growth rate (g/bird/day), live weight (g/bird aged 49 days), feed conversion ratio (FCR) (g DM feed/g live weight), metabolisable energy (ME) (MJ/kg DM) and nitrogen retention (g/bird/day) of female Venda chickens aged 50 to 91 days

Variable	Formula	r^2	Threonine level *	Optimal Y-level
Feed intake	$Y = -11.346 + 29.231x – 2.414x^2$	0.337	6.054	77.14
Growth rate	$Y = -8.886 + 8.771x – 0.714x^2$	0.496	6.142	18.05
FCR	$Y = 6.057 – 0.554x + 0.043x^2$	0.337	6.442	4.27
Live weight	$Y = 206.686 + 363.229x – 29.286x^2$	0.595	6.201	1332.96
ME	$Y = 8.409 + 0.618x – 0.054x^2$	0.619	5.72	10.18
N-retention	$Y = -0.369 + 0.621x – 0.051x^2$	0.371	6.088	1.52

* : Threonine level for optimal variable

Results of the effect of dietary threonine level on pH values of gastrointestinal organs of female Venda chickens aged 91 days are presented in Table 4.06. Dietary threonine level had no effect (P>0.05) on pH of crop, proventriculus, gizzard, small intestine, large intestine and caecum of female Venda chickens.

Table 4.06 Effect of dietary threonine level on the pH values of gastrointestinal organs of female Venda chickens aged 91days

	Treatment					
Organs	CT_4	CT_5	CT_6	CT_7	CT_8	SE
Crop	4.70	4.80	4.90	4.70	4.60	0.035
Proventriculus	4.10	4.20	4.30	4.10	4.00	0.033
Gizzard	3.30	3.40	3.50	3.30	3.20	0.028
Small intestine	5.80	6.00	6.10	6.00	5.90	0.027
Large intestine	6.60	6.80	6.90	6.80	6.70	0.028
Caecum	6.50	6.70	6.70	6.60	6.50	0.020

SE : Standard error

Results of the effect of dietary threonine level on carcass characteristics of female Venda chickens aged 91 days are presented in Table 4.07. Venda chickens on a diet containing 6 g of threonine per kg DM had higher (P<0.05) carcass weights than those on diets containing 4, 5, 7 or 8 g of threonine per kg DM. Venda chickens on diets containing 7 g of threonine per kg DM had higher (P<0.05) carcass weights than those on diets having 4, 5 or 8 g of threonine per kg DM. Similarly, chickens on a diet containing 5 or 8 g of threonine per kg DM had better (P<0.05) carcass weights than those on a diet having 4 g of threonine per kg DM. However, chickens on diets containing 5 or 8 g of threonine per kg DM had similar (P>0.05) carcass weights. Female Venda chickens on a diet containing 6 g of threonine per kg DM had higher (P<0.05) breast meat weights than those on diets containing 4, 5, 7 or 8 g of threonine per kg DM. Venda chickens on diets containing 7 g of threonine per kg DM had higher (P<0.05) breast meat weights than those on diets having 4, 5 or 8 g of threonine per kg DM. Similarly, chickens on a diet containing 5 or 8 g of threonine per kg DM had better (P<0.05) breast weights than those on a diet having 4 g of threonine per kg DM. However, chickens on diets containing 5 or 8 g of threonine per kg DM had similar (P>0.05) breast meat weights. Female Venda chickens on a diet containing 6 g of threonine per kg DM had higher (P<0.05) drumstick meat weights than those on diets containing 4, 5, 7 or 8 g of threonine per kg DM. Venda chickens on diets containing 5 g of threonine per kg DM had higher (P<0.05) drumstick meat weights than those on diets having 4, 7 or 8 g of threonine per kg DM. Similarly, chickens on a diet containing 4 g of threonine per kg DM had better (P<0.05) drumstick meat weights than those on diets having 7 or 8 g of threonine per kg DM. However, chickens on diets containing 7 or 8 g of threonine per kg DM had similar (P>0.05) drumstick meat weights.

Venda chickens on a diet containing 6 g of threonine per kg DM had higher (P<0.05) thigh meat weights than those on diets containing 4, 5, 7 or 8 g of threonine per kg DM. Venda chickens on a diet containing 4 g of threonine per kg DM had higher (P<0.05) thigh meat weights than those on diets having 5, 7 or 8 g of threonine per kg DM. Similarly, chickens on a diet containing 7 g of threonine per kg DM had better (P<0.05) thigh meat weights than those on diets having 5 or 8 g of threonine per kg DM. However, chickens on diets containing 5 or 8 g of threonine per kg DM had similar (P>0.05) thigh meat weights. Venda chickens on a diet containing 6 g of threonine per kg DM had higher (P<0.05) gizzard weights than those on diets containing 4, 5, 7 or 8 g of threonine per kg DM. The chickens on diets containing 4 or 5 g of threonine per kg DM had higher (P<0.05) gizzard weights than those on diets having 7 or 8 g of threonine per kg DM. Similarly, chickens on a diet having 7 g of threonine per kg DM had better (P<0.05) gizzard weights than those on a diet having 8 g of threonine per kg DM. However, chickens on diets containing 4 or 5 g of threonine per kg DM had similar (P>0.05) gizzard weights. Female Venda chickens on a diet containing 6 g of threonine per kg DM had higher (P<0.05) liver weights than those on diets containing 4, 5, 7 or 8 g of threonine per kg DM. Similarly, Venda chickens on a diet having 7 g of threonine per kg DM had higher (P<0.05) liver weights than those on diets with 4, 5 or 8 g of threonine per kg DM. Chickens on a diet containing 8 g of threonine per kg DM had better (P<0.05) liver weights than those on diets having 4 or 5 g of threonine per kg DM. However, chickens on a diet containing 5 g of threonine per kg DM had higher (P<0.05) liver weights than those on a diet having 4 g of threonine per kg DM.

Carcass, breast, drumstick, thigh, gizzard and liver weights of female Venda chickens aged 91 days were optimized at dietary threonine levels of 6.183 (r^2 = 0.574), 6.201 (r^2= 0.573), 5.712 (r^2 = 0.519), 5.847 (r^2 = 0.285), 4.820 (r^2 = 0.855) and 6.180 (r^2 = 0.574) g/kg DM, respectively (Figures 4.13, 4.14, 4.15, 4.16, 4.17 and 4.18, respectively and Table 4.08).

Table 4.07 Effect of dietary threonine level on carcass characteristics (g) of female indigenous Venda chickens aged 91 days

Variable	Treatment					SE
	CT_4	CT_5	CT_6	CT_7	CT_8	
Carcass	1032^d	1075^c	1218^a	1087^b	1076^c	14.471
Breast	237^d	247^c	280^a	250^b	248^c	3.335
D/stick	114^c	118^b	134^a	109^d	108^d	2.168
Thigh	124^b	118^d	146^a	120^c	118^d	2.446
Gizzard	24.6^b	24.7^b	25.0^a	23.0^c	22.5^d	0.232
Liver	20.6^e	21.5^d	24.4^a	21.7^b	21.5^c	0.289

$^{a, b, c, d, e}$: Means in the same row not sharing a common superscript are significantly different ($P<0.05$).

SE : Standard error

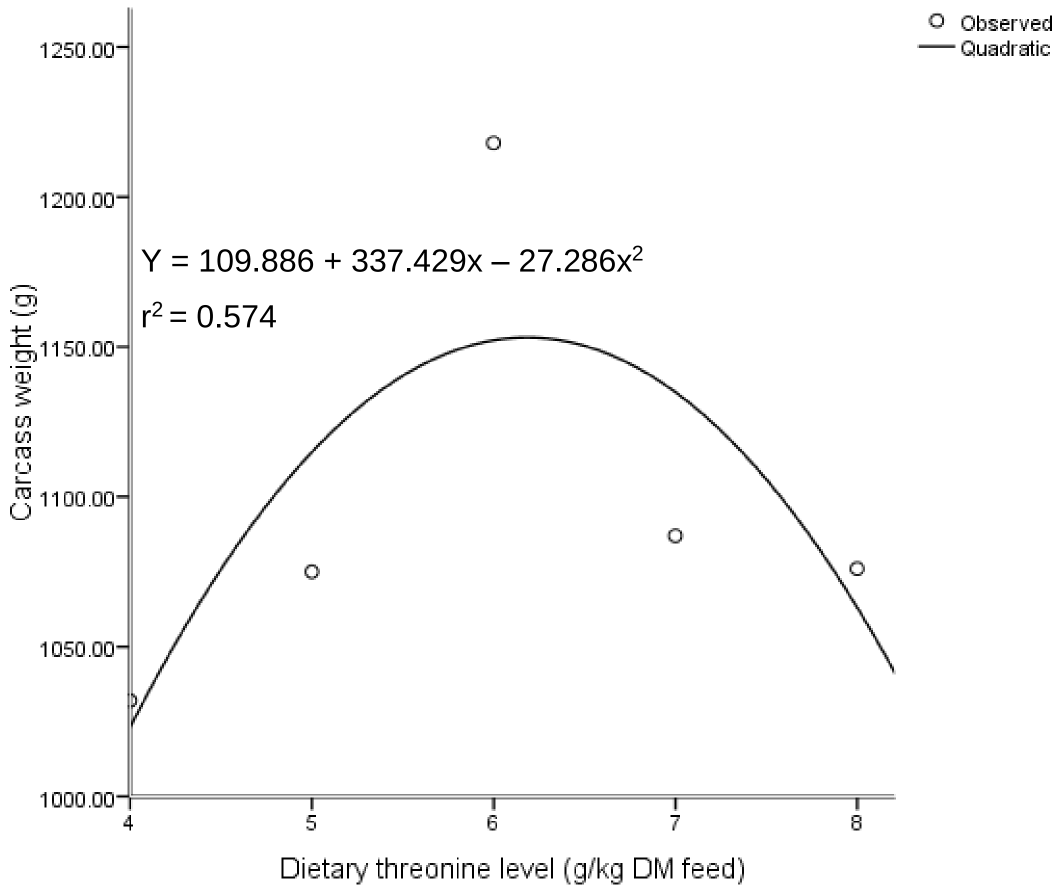

Figure 4.13 Effect of dietary threonine level on carcass weight of female Venda chickens aged 91 days

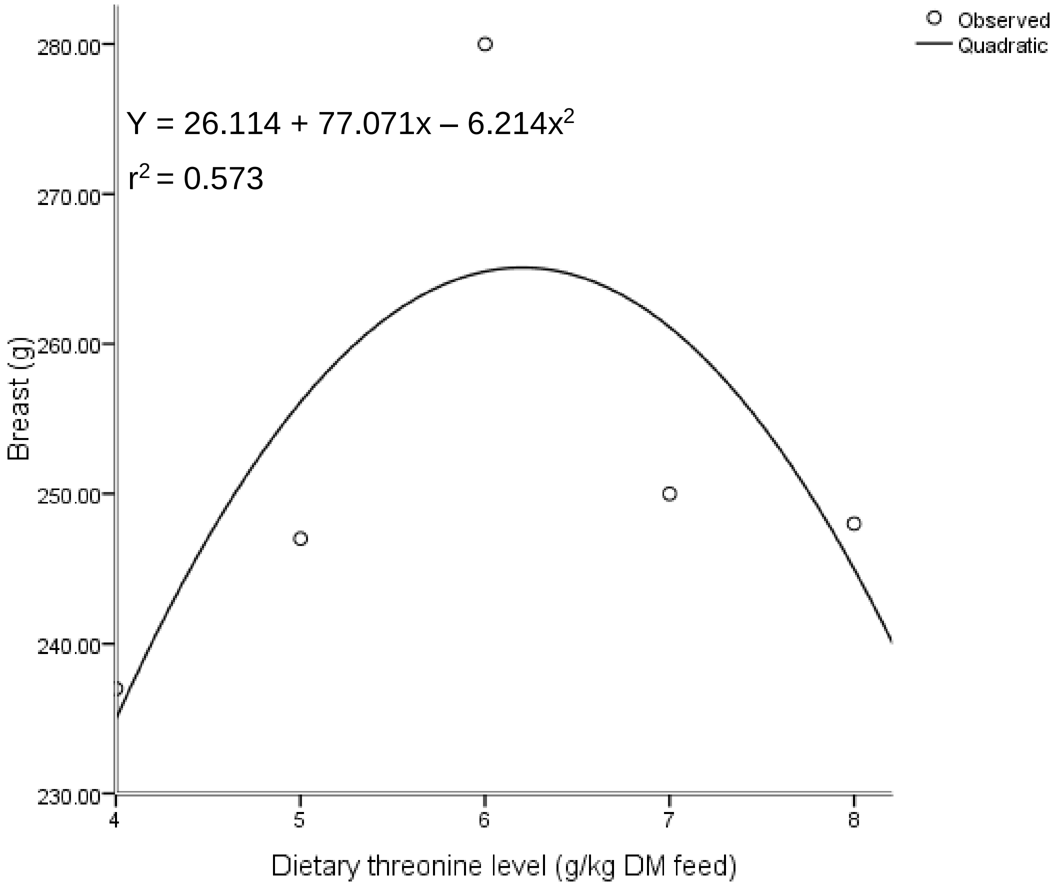

Figure 4.14 Effect of dietary threonine level on breast meat weight of female Venda chickens aged 91 days

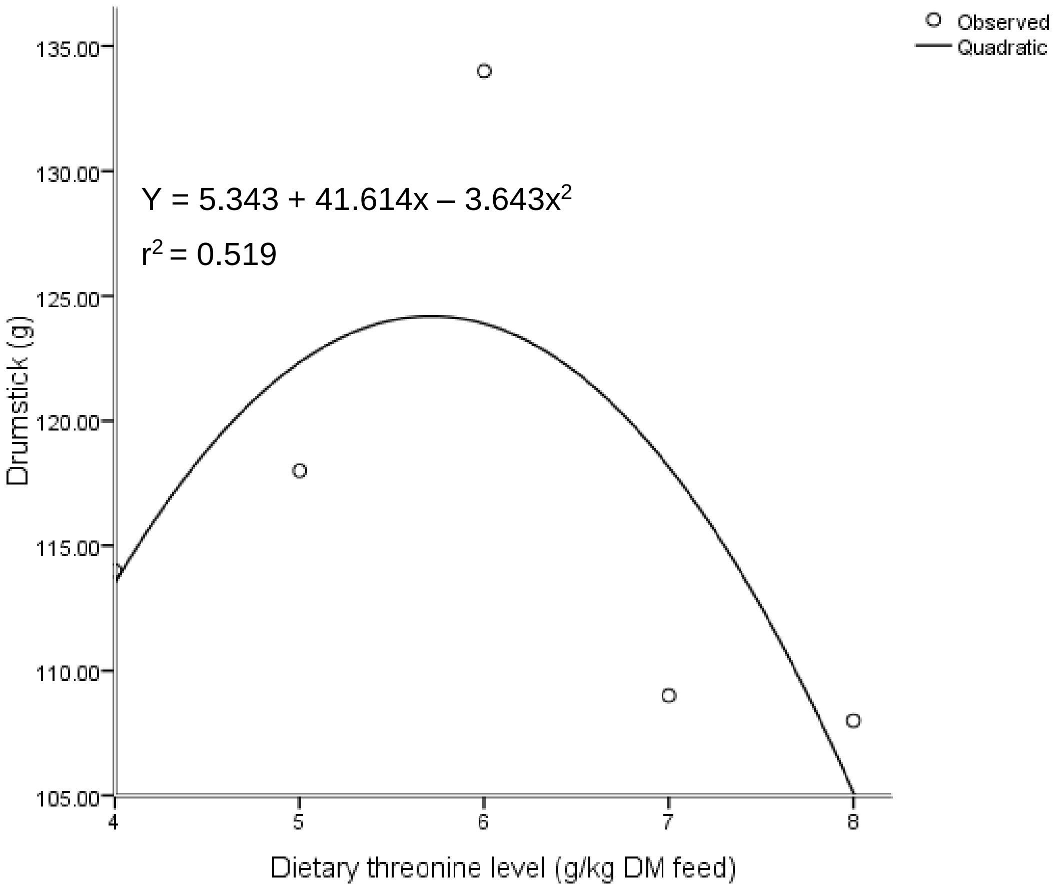

Figure 4.15 Effect of dietary threonine level on drumstick meat weight of female Venda chickens aged 91 days

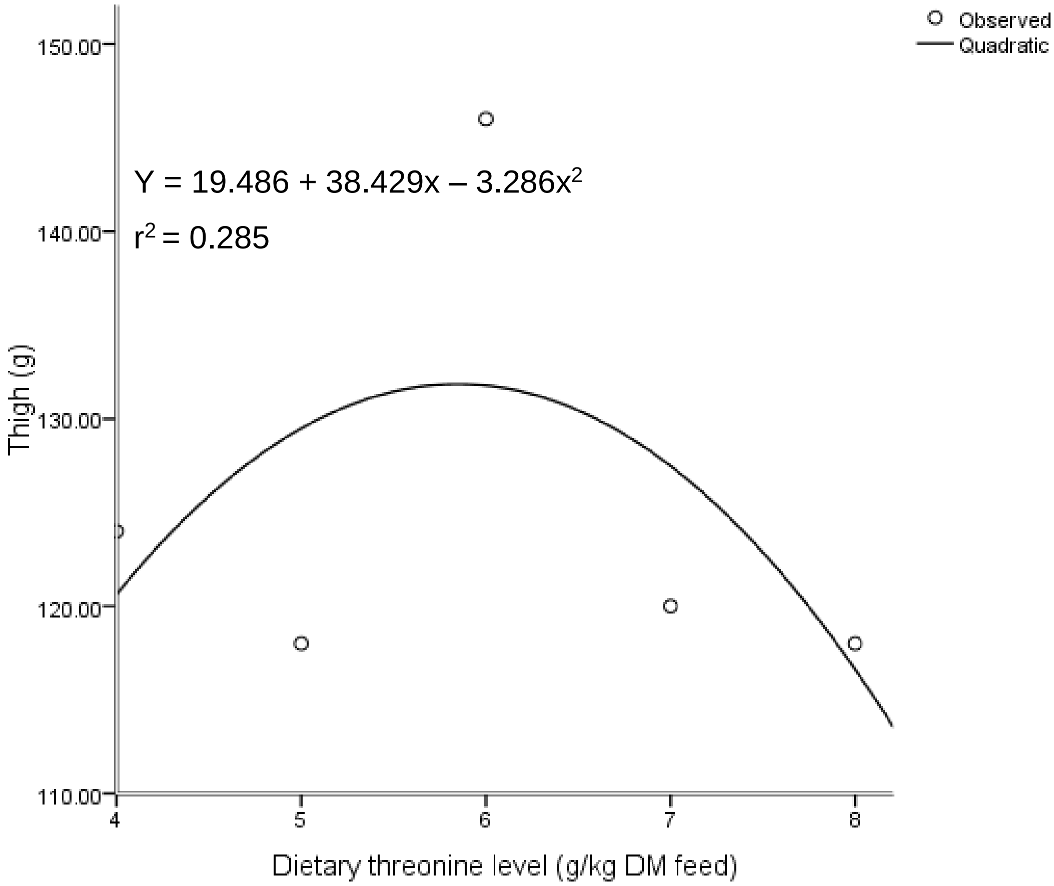

Figure 4.16 Effect of dietary threonine level on thigh meat weight of female Venda chickens aged 91 days

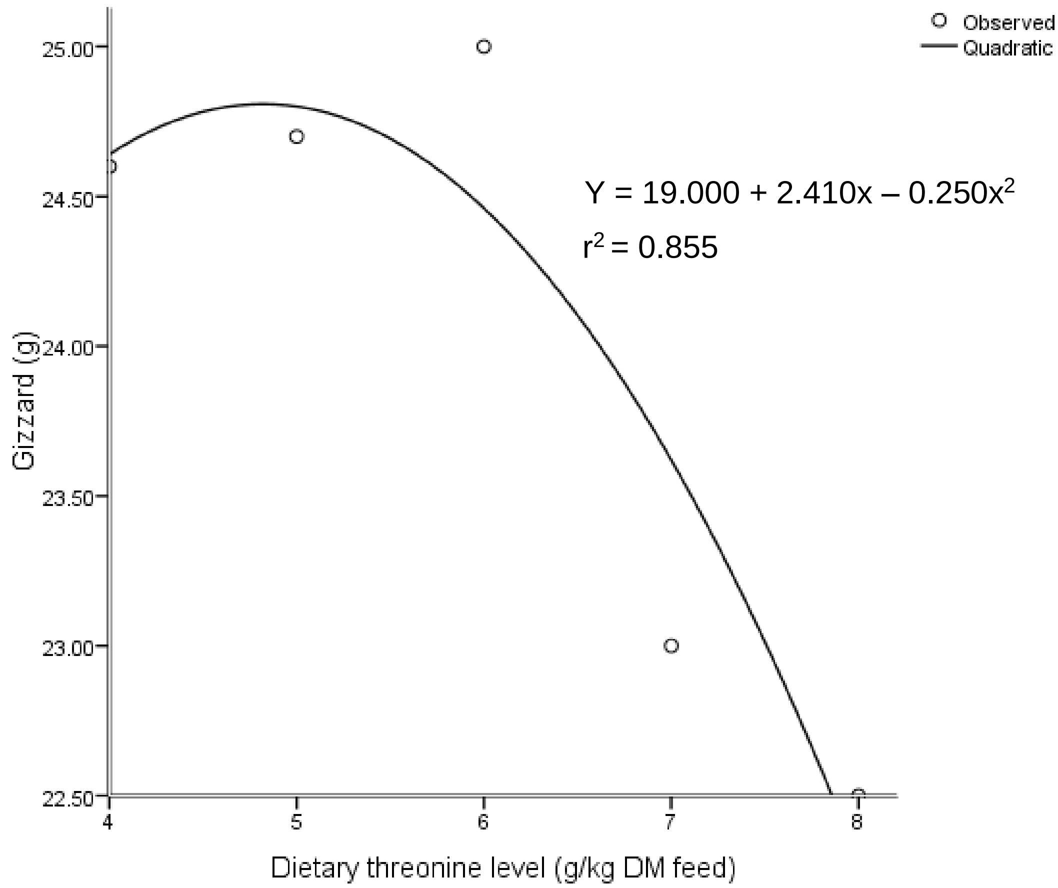

Figure 4.17 Effect of dietary threonine level on gizzard meat weight of female Venda chickens aged 91 days

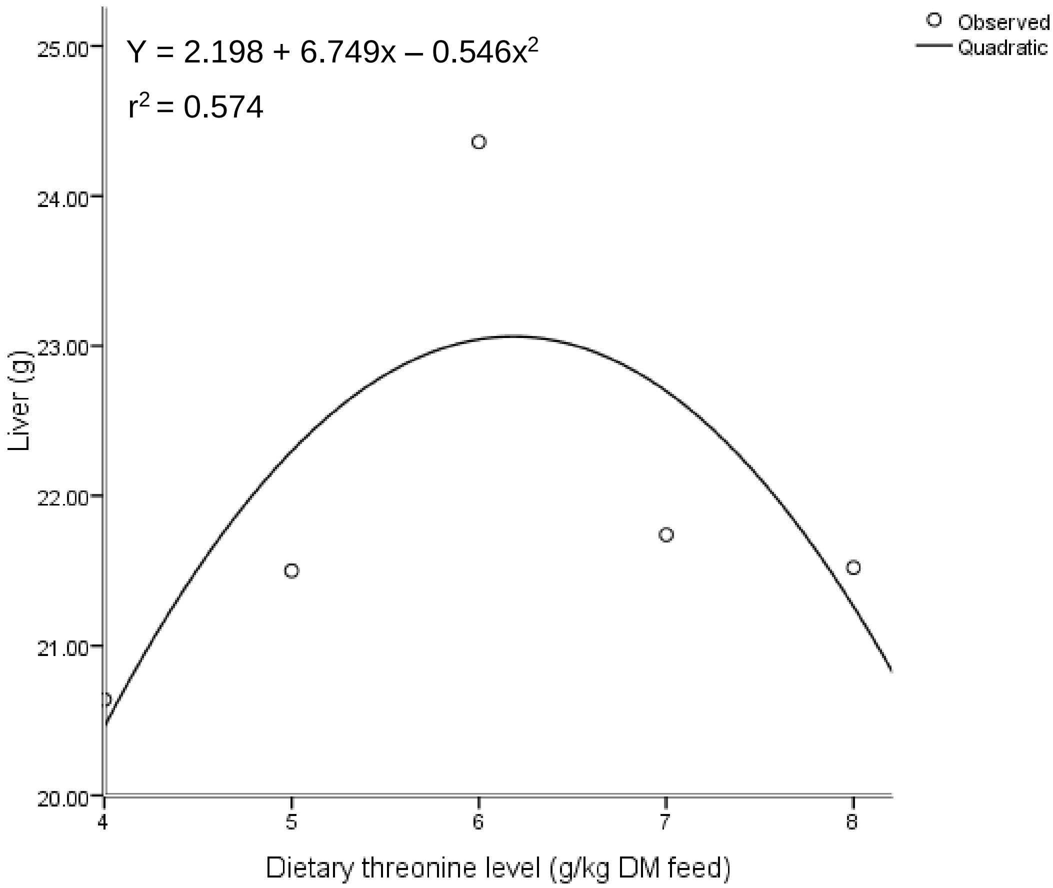

Figure 4.18 Effect of dietary threonine level on liver meat weight of female Venda chickens aged 91 days

Table 4.08 Dietary threonine levels for optimal carcass, breast, drumstick, thigh, gizzard and liver weights of female Venda chickens aged 91 days

Trait	Formula	r^2	Threonine Level *	Optimal Y-Value
Carcass	$Y = 109.886 + 337.429x – 27.286x^2$	0.574	6.183	1153.09
Breast	$Y = 26.114 + 77.071x – 6.214x^2$	0.573	6.201	265.09
D/stick	$Y = 5.343 + 41.614x – 3.643x^2$	0.519	5.712	124.18
Thigh	$Y = 19.486 + 38.429x – 3.286x^2$	0.285	5.847	131.84
Gizzard	$Y = 19.000 + 2.410x – 0.250x^2$	0.855	4.820	24.81
Liver	$Y = 2.198 + 6.749x – 0.546x^2$	0.574	6.180	23.05

* : Threonine level for optimal variable

Results of the effect of dietary threonine level on meat protein and threonine contents of female Venda chickens aged 91 days are presented in Table 4.09. Venda chickens on a diet containing 6 g of threonine per kg DM had higher ($P<0.05$) meat crude protein contents than those on diets containing 4, 5, 7 or 8 g of threonine per kg DM. Chickens on a diet containing 7 g of threonine per kg DM had higher ($P<0.05$) meat crude protein contents than those on diets having 4, 5 or 8 g of threonine per kg DM. Similarly, chickens on a diet having 5 g of threonine per kg DM had higher ($P<0.05$) meat crude protein contents than those on diets containing 4 or 8 g of threonine per kg DM. Chickens on a diet containing 4 g of threonine per kg DM had more ($P>0.05$) meat crude protein contents than those on a diet having 8 g of threonine per kg DM.

Female Venda chickens on a diet containing 6 g of threonine per kg DM had higher ($P<0.05$) meat threonine contents than those on diets having 4, 5, 7 or 8 g of threonine per kg DM. Female chickens on a diet containing 5 g of threonine per kg DM had higher ($P<0.05$) meat threonine contents than those on diets having 4, 7 or 8 g of threonine per kg DM. Similarly, chickens on a diet having 4 g of threonine per kg DM had higher ($P<0.05$) threonine contents than those on a diet containing 4 or 8 g of threonine per kg DM. Female Venda chickens on a diet containing 7 g of threonine per kg DM had higher (P<0.05) meat threonine contents than those on a diet having 8 g of threonine per kg DM. Crude protein and threonine contents of female Venda chickens aged 91 days were optimized at dietary threonine levels of 5.9 (r^2 = 0.827) and 5.7 (r^2 = 0.745) g/kg DM, respectively (Figures 4.19 and 4.20, respectively and Table 4.10).

Table 4.09 Effect of dietary threonine level on meat crude protein and threonine contents (g/100g) of Venda chickens aged 91days

	Treatment					
Variables	CT_4	CT_5	CT_6	CT_7	CT_8	SE
Crude protein	67.01^d	67.64^c	69.51^a	68.44^b	66.41^e	0.249
Threonine content	2.86^c	2.94^b	2.99^a	2.84^d	2.81^e	0.015

SE : Standard error

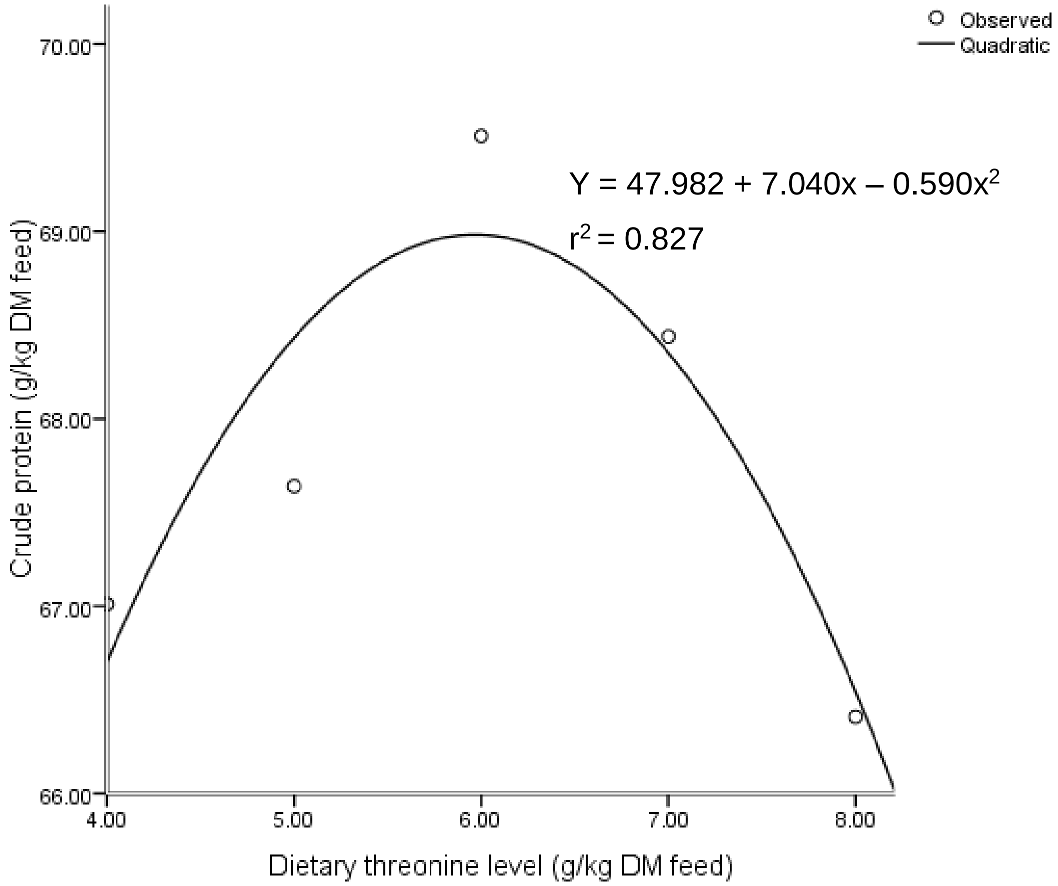

Figure 4.19 Effect of dietary threonine level on meat crude protein contents of Female Venda chickens aged 91 days

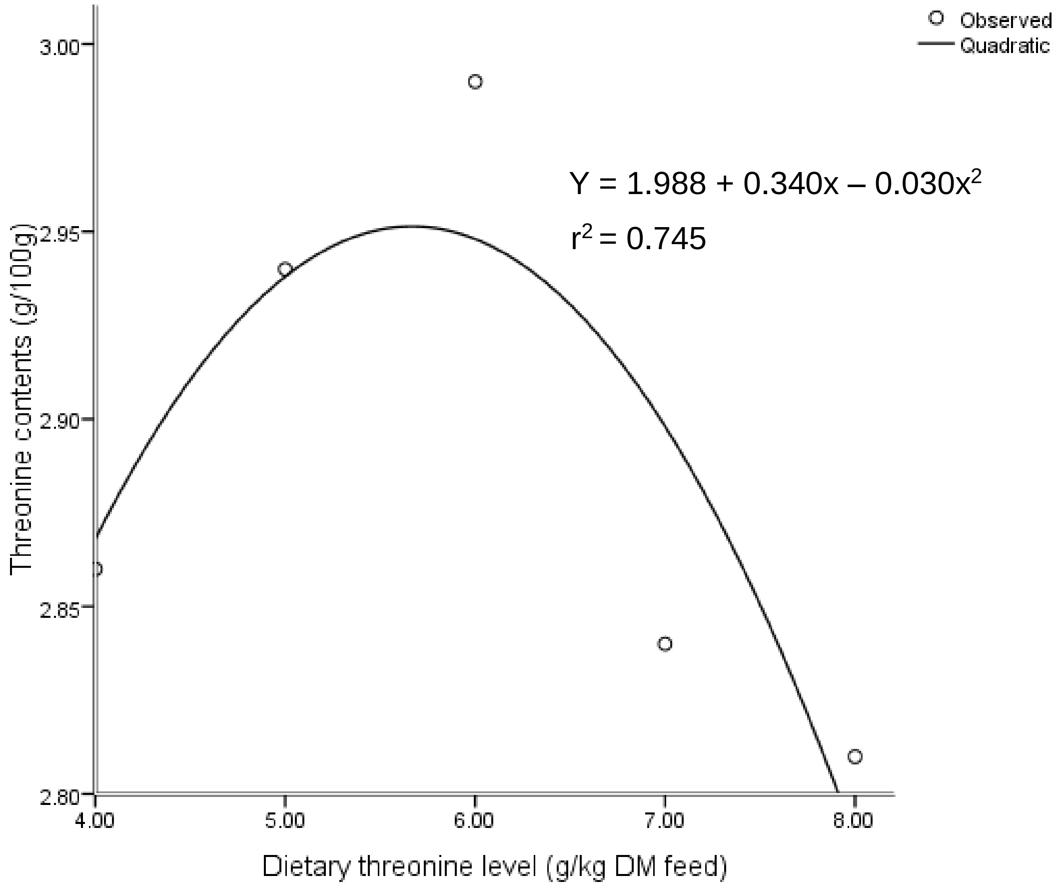

Figure 4.20 Effect of dietary threonine level on meat threonine contents of female Venda chickens aged 91 days

Table 4.10 Dietary threonine levels for optimal meat crude protein and threonine contents of female Venda chickens aged 91 days

Variable	Formula	r^2	Threonine level*	Optimal Y-value
Crude protein	$Y = 47.982 + 7.040x – 0.590x^2$	0.827	5.9	68.98
Threonine contents	$Y = 1.988 + 0.340x – 0.030x^2$	0.745	5.7	2.96

* : Threonine level for optimal variable

Dietary threonine level had no effect (P>0.05) on meat flavour, tenderness and juiciness of female Venda chickens (Table 4.11).

Table 4.11 Effect of dietary threonine level on meat flavour, tenderness and juiciness of female Venda chickens aged 91 days

	Treatment					
Variable	CT_4	CT_5	CT_6	CT_7	CT_8	SE
Flavour	3.40	3.50	3.60	3.50	3.40	0.078
Tenderness	3.20	3.25	3.40	3.30	3.20	0.076
Juiciness	3.00	3.10	3.20	3.10	3.10	0.088

SE : Standard error

CHAPTER 5

DISCUSSION, CONCLUSION AND RECOMMENDATION

5.1 Discussion

Dietary threonine level improved live weight of unsexed Venda chickens aged one to seven weeks. This was possibly due to the increase in feed intake, growth rate, feed conversion ratio, metabolisable energy and nitrogen-retention with increase in threonine content level up to the optimal level. The increase in live weight at seven weeks of age is similar to the findings of Dozier *et al*. (2000) and Rezaeipour *et al*. (2012) in broiler chickens. Dozier *et al*. (2000) reported that an increase in the concentrations of the dietary threonine to 0.74 % optimized live weight of male broiler chickens aged 42 days. Rezaeipour *et al*. (2012) reported that the effect of different inclusion rates of dietary L-threonine on weight gain, feed intake and feed conversion ratio of broiler chickens was statistically significant. Thus, higher levels of L-threonine in the diets improved feed conversion ratio and weight gain of broiler chickens. The increase in live weight observed in the present study is contrary to the findings of Kidd and Kerr (1997) who reported no improvement in live weights of broiler chickens fed diets supplemented with crystalline threonine. Ojano-Dirain and Waldroup (2002) and Kidd *et al*. (2003) observed no improvement in feed conversion ratio with supplementation of threonine to the diets. However, Dozier *et al.* (2000) and Rezaeipour *et al.* (2012) observed improvements in feed intake, feed conversion ratio and metabolisable energy in broiler chickens with increase in dietary threonine level.

In the present study feed intake, growth rate, feed conversion ratio, live weight, metabolisable energy and nitrogen retention were optimized at different dietary threonine levels of 6.218, 6.437, 6.331, 6.655, 5.979 and 6.158 g/kg DM. Lemme (2001) reported that depending on the performance criteria chosen, the optimum dietary threonine levels for 20 to 42 day-old broiler chickens to achieve 95 % of the asymptotic response for the body weight and feed conversion ratio were 0.66 and 0.68 %, respectively, compared to the 0.74 % dietary threonine level suggested by NRC (1994) for 21 to 42 day-old broiler chickens. Kidd and Kerr (1997) reported that the threonine requirement of 0.74 % of diet reported by NRC (1994) for broiler chickens aged 21 to 42 days is too high. However, Dozier *et al*. (2001) indicated that threonine supplementation of the diet did not affect body weight gain, while Lehmann *et al*. (1997) indicated that different threonine levels of 0.82, 0.88, 0.94, 1.00, 1.06

and 1.12 % improved body weight gains. Lemme (2001) reported that the optimum dietary threonine levels for 20 to 42 day-old broiler chickens for body weight gain was 0.66 %, compared to the 0.74 % suggested by NRC (1994) for 21 to 42 day-old broiler chickens.

Dietary threonine level had no effect on mortality of unsexed Venda chickens aged one to seven weeks. These findings are consistent with results of Kidd *et al*. (1997) who reported that no differences in mortality was observed when broiler chickens were fed an L-threonine supplement.

Dietary threonine level affected feed intake, growth rate and feed conversion ratio of female Venda chickens aged 8 to 13 weeks. Thus, diet intake, growth rate and feed conversion ratio were optimized at dietary threonine levels of 6.054, 6.142 and 6.442 g/kg DM, respectively. No similar results on indigenous chickens were found. However, NRC (1994) recommended a higher threonine level of 7.4 g/kg DM for dietary intake of broiler chickens aged 28 to 35 days. Similarly, Tugay *et al*. (2009) recommended a higher dietary threonine level of 7.5 g/kg DM for optimal intake of broiler chickens aged 22 to 42 days. Thomas (1986), also, recommended a higher threonine level of 6.9 g/kg DM for optimal intake of broiler chickens aged 14 to 28 days. Growth rate of Venda chickens increased with increase in dietary threonine level until a level of 6.142 g/kg DM for optimal growth rate was attained. Thereafter, there was a decrease in growth rate with increase in dietary threonine level. Kidd *et al*. (2004) recommended a dietary digestible threonine requirement of 0.65 % to achieve optimal growth rate in broiler chickens aged 3 to 6 weeks. NRC (1994) recommended a dietary threonine level of 7.4 g/kg DM for optimal growth rate of broiler chickens aged 6 to 8 weeks. Similarly, Kidd *et al*. (2004) and Kidd and Kerr (1997) recommended higher dietary threonine levels of 6.7 and 7.5 g/kg DM for optimal growth rate of broiler chickens aged 6 to 7 and 4 to 6 weeks, respectively. However, Webel *et al*. (1996) recommended a lower dietary threonine level of 6 g/kg DM for optimal growth rate of broiler chickens aged 6 to 7 weeks.

Kidd and Kerr (1997) recommended a higher threonine level of 7.5 g/kg DM for broiler chickens aged 4 to 6 weeks than the 6.442 g/kg DM observed in the present study for feed conversion ratio of female Venda chickens aged 8 to 13 weeks.

Similarly, NRC (1994) and Khan *et al*. (2006) recommended higher dietary threonine levels of 7.4 and 7.28 g/kg DM, respectively, for optimal feed conversion ratio of broiler chickens aged 4 to 5 weeks. NRC (1994) recommended a dietary threonine level of 6.8 g/kg DM for optimal feed conversion ratio of broiler chickens aged 6 to 8 weeks. A dietary threonine level of 6.201 g/kg DM was observed in the present study for optimal live weight of Venda chickens aged 8 to 13 weeks. Kidd *et al*. (2000) recommended that the dietary threonine requirement for optimal live weight occurred at 6.7 g/kg DM of the diet for male broiler chickens aged 6 to 8 weeks in a thermo-neutral environment (25 to 32 °C). Webel *et al*. (1996) recommended a lower dietary threonine requirement of male broiler chickens aged 6 to 8 weeks of 6 g/kg DM for optimal live weight. In the present study, dietary threonine levels of 5.72 and 6.09 g/kg DM optimized metabolisable energy intake and nitrogen retention of Venda chickens aged 8 to 13 weeks. However, McDonald *et al*. (2011) recommended higher dietary threonine levels of 7.3 and 6.5 g/kg DM for metabolisable energy intake and nitrogen retention for broiler chickens aged 4 to 6 weeks.

Dietary threonine level did not have any effect on pH values of gastrointestinal organs of female Venda chickens aged 91 days. However, the pH values were optimized at dietary threonine levels of 5.7, 5.7, 5.7, 6.2, 6.2 and 5.9 g/kg DM for the crop, proventriculus, gizzard, small intestines, large intestines and caecum of female Venda chickens aged 91 days, respectively. The present study showed that dietary threonine level had effect on weights of carcass parts of Venda chickens aged 91 days. However, the parts were optimized at different dietary threonine levels of 6.183, 6.201, 5.712, 5.847, 4.820 and 6.180 g/kg DM for carcass, breast, drumstick, thigh, gizzard and liver weights of Venda chickens, respectively. The present results are lower than the findings of Lemme (2001) who reported a dietary threonine level of 7.4 g/kg DM for optimal carcass part weights of 20 to 42 days old broiler chickens. NRC (1994) suggested that a threonine level of 7.4 g/kg DM optimized carcass weight of 21 to 42 days old broiler chickens. Ciftci and Ceylan (2004) reported that an increase in dietary threonine increased breast meat yield of broiler chickens. Dozier *et al*. (2001) also found that an increase in dietary threonine level increased drumstick weights in female broiler chickens aged 42 to 56 days.

Results of the present study indicated that dietary threonine level affected protein and threonine levels in meat of Venda chickens aged 91 days. It is known that threonine is an important constituent of broiler chicken meat. Meat protein and threonine contents were optimized at dietary threonine levels of 5.9 and 5.7 g/kg DM, respectively. Ciftci and Ceylan (2004) reported that an increase in dietary threonine increased meat composition of broiler chickens aged 3 to 6 weeks. However, no similar studies were found on Venda chickens. Dietary threonine level had no effect on meat sensory attributes of female Venda chickens aged 91 days. However, meat flavour, tenderness and juiciness were optimized at dietary threonine levels of 5.977, 6.103 and 5.977 g/kg DM, respectively. Amino acids play major roles in eliciting the characteristics of juiciness and flavour of foods (Kobayashi *et al*., 2009). Lawrie (2006) identified three compounds (free glumatic acid, 5'-inosinic acid and potassium ion) as the taste active components in chicken meat extracts. Glutamic and 5'-inosinic acid are favourites among consumers as they constitute a characteristic taste of chicken meat (Lawrie, 2006).

5.2 Conclusion

Dietary threonine level had effect on feed intake, growth rate, feed conversion ratio, live weight, metabolisable energy intake and nitrogen retention of unsexed Venda chickens aged one to seven weeks. However, these variables were optimized at different dietary threonine levels. This means threonine levels for optimal productivity will depend on the particular variable in question. Dietary threonine level had no effect on mortality rates of the chickens.

Dietary threonine level had similar effects on production parameters of Venda chickens aged eight to 13 weeks to those observed in unsexed Venda chickens aged one to seven weeks. However, dietary threonine levels for optimal productivity of the variables were higher in unsexed chickens than in female Venda chickens aged eight to 13 weeks. This may, possible, be due to higher threonine demand in younger Venda chickens.

Dietary threonine level had no effect on pH levels, meat flavour, tenderness and juiciness of female Venda chickens aged eight to 13 weeks. However, dietary threonine level affected carcass characteristics, meat crude protein and threonine contents of female Venda chickens aged eight to 13 weeks.

5.3 Recommendation

Different dietary threonine levels optimized different production parameters. It is, thus, recommended that when formulating diets for Venda chickens dietary threonine levels should depend on the parameters of interest.

CHAPTER 6

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